Maastrichtian – Upper Eocene Ostracoda of the Subfamily Trachyleberidinae from Iraq, Jordan and Syria

BY

SAAD S.J. AL-SHEIKHLY, B.Sc.

A Thesis submitted for the degree of Doctor of Philosophy in the Department of Geology, University of Glasgow.

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To :

- the memory of my mother .
- my father .
- my darling wife .

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SUMMARY

The Ostracoda of the subfamily TRACHYLEBERIDINAE from the Maastrichtian - Upper Eocene of Iraq (Jabel Sinjar, Anah Well-2, Mityaha Well-1, Makhul Well-2, and Chemchemal Well-2 Sections), Jordan (Tell-Burma Section), and Syria (selected samples from Bir Qdeim and Maaloula Sections) have been studied in detail.

It is represented by 11 genera, 6 subgenera and 50 species. Two new genera (Allecosta and Ordoniya) and two new subgenera (Acanthocythereis (Canthylocythereis) and Ordoniya (Pharkidata)) are proposed. Of the 50 species described, 37 are new. The genus Paracosta has been divided into two subgenera: Paracosta (Paracosta) Siddiqui and Paracosta (Paleocosta)Benson; with 41 species, including 7 new species from the Middle East, together with other species previously described from South America, Africa, and Asia and often assigned to other genera. Paracosta (Paracosta) shows dispersal from Nigeria during the Upper Maastrichtian and Palaeocene, towards northern South America and to North Africa and the Middle East, and farther east towards Pakistan during the M.-U. Eocene, and finally to Southern Europe during the Oligocene. Paracosta (Paleocosta) was restricted to the Eocene of the Middle East.

Five provsional Ostracod Biozones for the Middle East are proposed; one of Maastrichtian age, one Palaeocene and three of Eocene age. An attempt has been made to study the palaeogeography of the Middle East, because the ostracod faunas here are good indicators of the Mediterranean and Indopacific bioprovincialities.

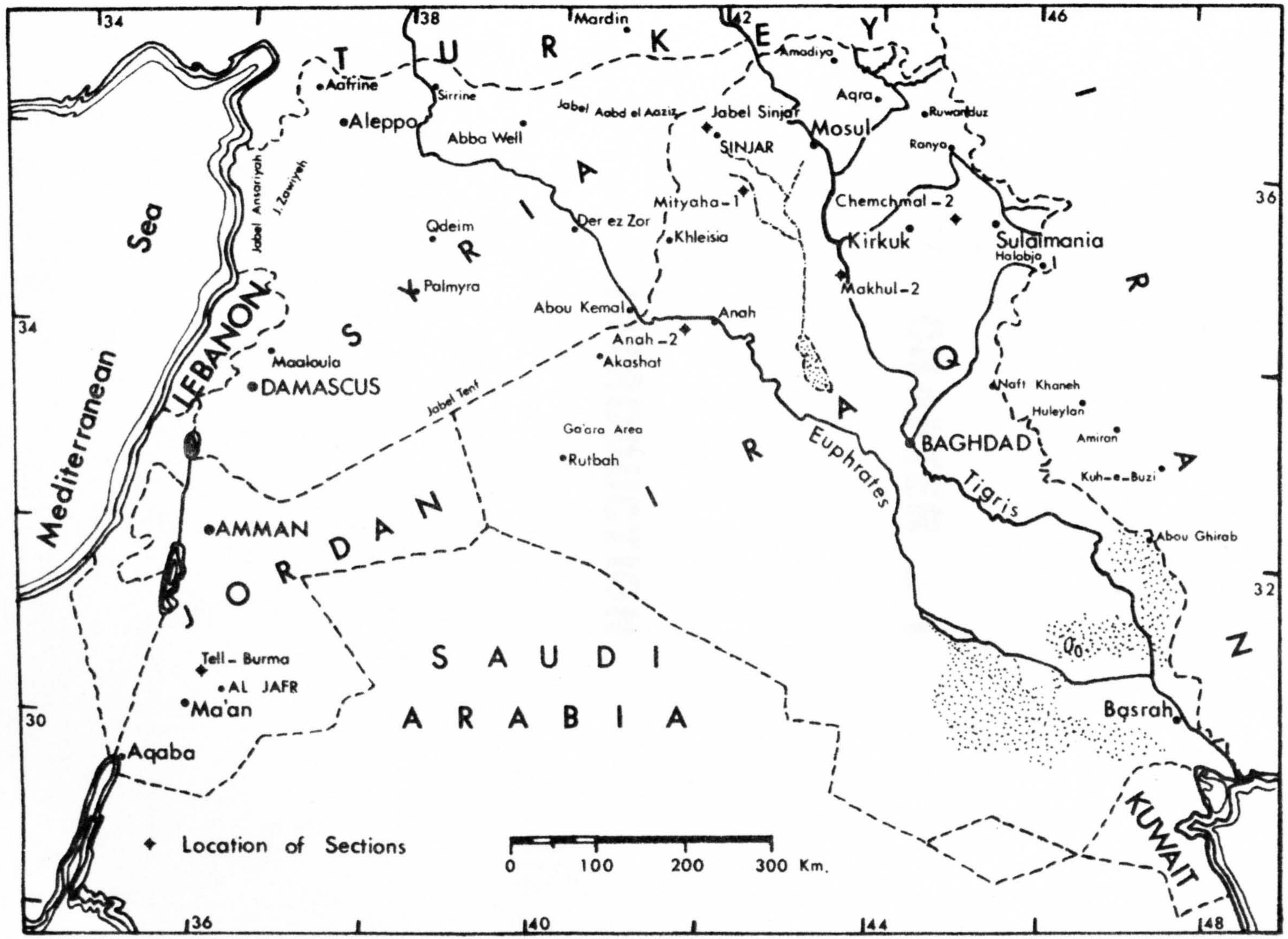


Figure 1 : Locality map.

CHAPTER _ 1

INTRODUCTION

INTRODUCTION

The area of Jordan, Syria, and Iraq occupied a crucial position during the Maastrichtian and Palaeogene if the relationship between North Africa, and Asian ostracod faunas are to be understood. This area on the southern shelf of Tethys lay across the prevailing west to east migratory route of most of the marine benthos. There have been five studies of the ostracods of the region; Upper Cretaceous and Palaeogene studies of Bassiouni (1969 - 1971) dealt with Egypt and Jordan, Siddiqui (1971) studied the Palaeogene of Pakistan, Al-Furaih (1975 - 1977) the Upper Cretaceous and Palaeogene of Saudi Arabia, while Sayyab (M.S. 1956) and Al-Abdul-Razzaq (M.S. 1977, 1979) studied the Middle and Upper Cretaceous faunas of the Arabian Gulf region. Thus no previous work has been carried out on the ostracods of Northern Iraq and Syria.

The material used in this study was obtained from the Iraq National Oil Company (Anah Well-2, Mityaha Well-1, Makhul Well-2, and Chemchemal Well-2), surface collecting in Iraq (Jabel Sinjar Section) by the author, and from the British Museum (Natural History) are the Jordanian material (Tell-Burma Section) and the Syrian material (8 selected samples, collected by the former Iraq Petroleum Company (I.P.C.) from the Dolaa camp of Bir Qdeim Section (Upper Cretaceous - Lower Eocene) and from Maaloula Section (Palaeocene and Middle Eocene). The Syrian material is of great importance in filling in the gap present between Jordan and Iraq. Further specimens were borrowed for examination from the British Museum (Nat. Hist.) (Sayyab material); from the Geological Survey Institute, Hannover (Bassiouni material); and from Professor R.A. Reyment; other specimens from Pakistan and Turkish Thrace were given by Dr.Q. Siddiqui and Dr. N. Gokcen, respectively.

The four subsurface sections studied from Western and

Northern Iraq were mostly from drillings, with a high probability of contamination. This problem was minimized by studying some core samples from the same sections, by careful picking of the sample and by precise comparison of any odd specimens with the general state of preservation of the faunal assemblages in each sample.

The state of preservation of the material is not very good, and the carapaces greatly outnumber single valves, so the internal features are not always clear. Sayyab, Siddiqui, Al-Furaih and Al-Abdul-Razzaq also encountered this problem. This type of preservation could be attributed mainly to the type of sediment and the very high rate of sedimentation within the Middle east basins, as seen in the thick Maastrichtian - Palaeogene deposits. Oertli (1971) has described a similar situation in the thick Cretaceous deposits of the Central Aquitaine Basin. In Egypt and Jordan the ostracods are much better preserved and the ratio of the single valves to carapaces is higher, probably because of the type of sediments, i.e. chalks and shales.

It had originally been intended to study the whole ostracod fauna, but as it became essential to compare the Jordan - Iraq material with that of other regions the number of species that could be examined was greatly reduced. In the end the study has been restricted to the subfamily Trachyleberidinae as defined by Hazel in 1967. This classification places importance in the pattern of the central muscle scars as well as other internal and external features.

The ornamentation technique of Liebau (1969, 1971) and Benson (1972) has been adopted in this study for some genera as it appears useful to some extent in differentiating between genera and also between their species.

All specimens with prefix (OS) are in the Department of Palaeontology, British Museum (Nat. Hist.); and those with the prefix (TKH) are in the Department of Micropalaeontology, Geological Survey Institute, Hannover, West Germany.

CHAPTER – 2

PALAEOGEOGRAPHY

PALAEOGEOGRAPHY

Throughout the late Palaeozoic, Mesozoic, and Palaeogene, the Middle East and North Africa lay on the southern shelf of the Tethys Ocean. The Middle East was bounded in the south and southwest by the Arabo-Nubian Shield. Henson (1951) divided the Middle East into four structural-palaeogeographical zones: The Arabian Shield, the stable shelf, the mobile shelf, and the Orthogeosyncline. Buday in 1973 utilising the work of Bolton (1955-1958), divided the Orthogeosyncline into Eu- and Miogeosynclinal realms, and further subdivided the Palaeogene Eugeosynclinal realm into three: Qandil and associated groups as an inner belt, the Walash facies in the centre and the Naopurdan group as an outer belt. The Eugeosynclinal realm is mainly found in Iran and Turkey. Buday redescribed the Eugeosynclinal realm of Iraq in 1975 in an attempt to unify his previous work (1973) and other studies carried out in neighbouring Iran and Turkey. As a result he divided the Eugeosynclinal realm into an outer sedimentary-volcanogenic belt consisting of the Naopurdan and Walash units of Tertiary age, and an inner, mostly metamorphosed zone (Qandil) of pre-Tertiary and Tertiary age. Baker (1953) believed that the rapid lateral facies changes seen in Mesozoic and Tertiary rocks was due to isolated platform areas, i.e. remnant blocks or uplifted areas of the Arabian Shield, lying within the trough of deposition. Examples of such areas are the Ga'ara - Rutbah Uplift, the Khlesia - Der ez Zor Uplift, and the Aleppo Uplift. Henson (1950), Dunnington (1955-1960), Buday (1973) and Al-Rawi (1975, 1978) ascribed the thickness and facies changes to deep seated faults in the Arabo-Nubian basement. Lateral and vertical movement occurred, limited both in time and areal extent. Although the overlying sediments are not faulted, the presence of faults in the basement is reflected in the thickness and facies changes in the overlying sediments. Stocklin (1968) on the other hand

believed the changes in facies and thickness to be an indication of gentle epeirogenic movements in pre-orogenic times. These resulted in very gentle and large-scale undulations of the sea floor, aligned with the N - S trend of the Arabian Shield rather than the NW - SE Zagros trend. He considered the folded belt to be a marginal, mobile sedimentary trough superimposed on the Arabian Shield.

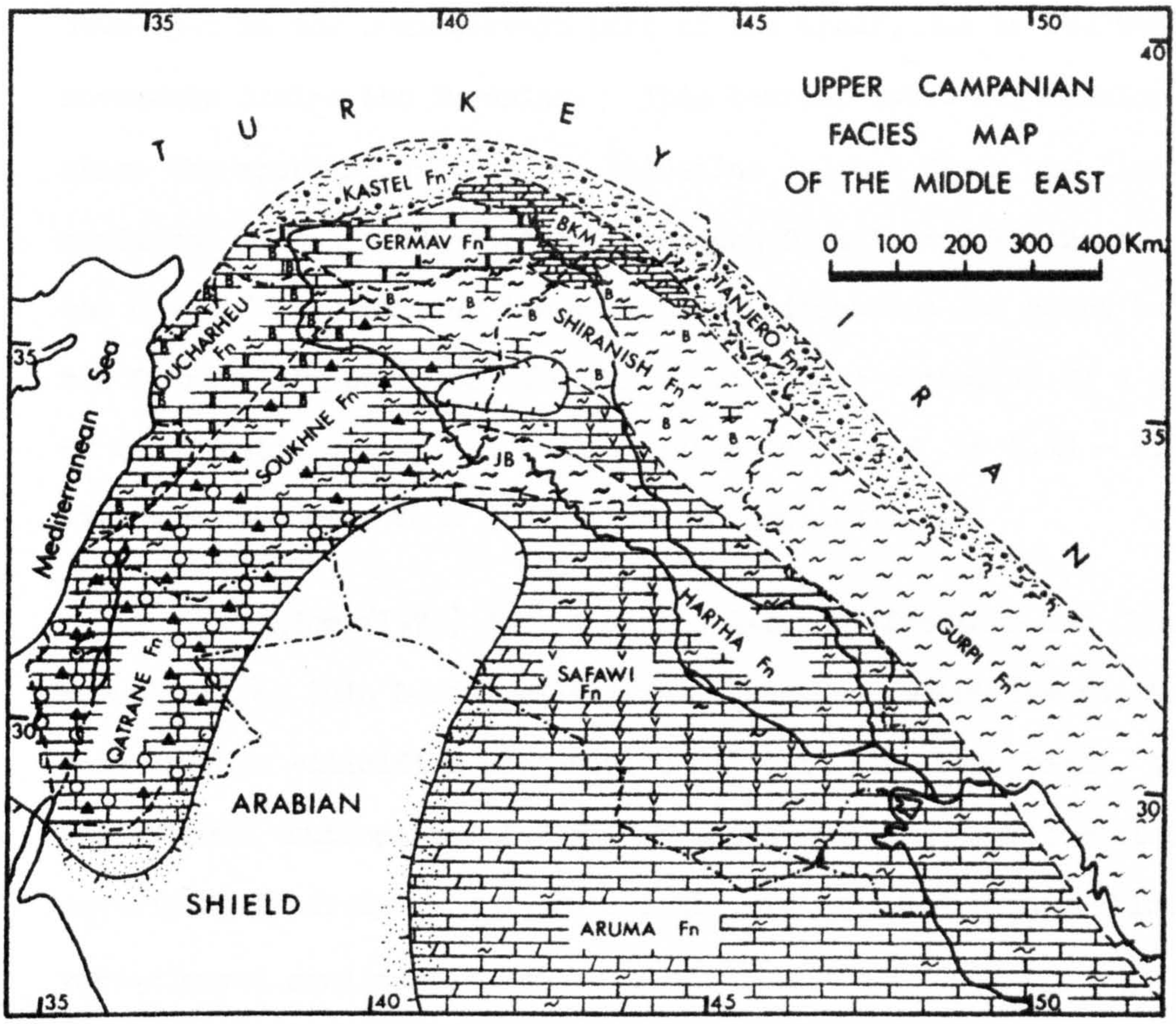
Kukal and Saadallah (1970) studied the palaeocurrents in Iraq, and concluded that only transversal filling of the basin occurred between the Triassic and Pliocene. The palaeocurrents flowed northeastward in the southwestern flank of the geosyncline (West and Southwestern Iraq) and southwestward in the northeastern flank of the geocyncline (Northeast and Eastern Iraq). The persistence of the current pattern from the Triassic to the Pliocene was thought to be due to the persistence of the same trends of tectonic movement, i.e. the gradual tectonic development of the Zagros range in the northeast and the rising of the Arabian Shield in the southwest.

1. Late Campanian - Maastrichtian (figs. 2 & 3)

This interval of time was considered by many authors to be of great importance for the palaeogeographic development of the Middle East, with special interest in Iraq. Buday (1973) assigned the beginning of this widespread transgressive cycle to the termination of the Subhercynian movements (late Cretaceous) in the inner parts of the Eugeosyncline, and with the general shifting of the sedimentary basins towards the craton.

A - Stable Shelf

I. During the Upper Campanian, the shelf was dominated by the deposition of neritic and/or littoral sediments. Daniel (in: Dubertret et al., 1963) mentioned that there was a barrier swell



REEFAL & LAGOONAL LIMESTONE

NERITIC LIMESTONE

PELAGIC CHALK

NERITIC – SHOAL DOLOMITIC LIMESTONE

NERITIC MARLY LIMESTONE

OPEN SEA MARL

NERITIC DOLOMITIC EVAPORITES

FLYSCH – CLASTICS

CONTINENTAL SANDSTONE

BITUMEN

CHERT BEDS OR NODULES

PHOSPHATES

AREA OF EROSION OR NO DEPOSITION

BKM BEKHME FORMATION

JB JIB'AB FORMATION

COMPILED WITH MODIFICATION FROM WOLFART, 1967; AND BUDAY, 1973.

Figure 2 : Upper Campanian facies map of the Middle East.

developed in the southwestern part of the shelf, due to the tectonic movements during the Turonian. This barrier swell was developed where the southern half of the Palestine Coastal Plain now lies, and continued to the north-northeast through Samaria and Tiberias. To the east of this barrier the phosphatic limestones and chert beds of the Qatrane Limestone and Chert Formation were deposited in a number of wide gentle basins and swells, elongated N - S or N.NE - S.SW, with some tendency to E - W swells and depressions.

Bender (1975) described the Qatrane Limestone and Chert Formation, as thin bedded silicified limestone, chert layers, thin more or less silicified phosphorite and thin limestone beds; towards the extreme southeast of Jordan, it wedges out or, together with the underlying Upper Cretaceous rock units, is replaced by a continental varicoloured sandstone.

Northwards to eastern central Syria, Daniel (in: Dubertret et al., 1963) described a sequence equivalent to the Qatrane Limestone and Chert Formation, called the Soukhne Formation, composed of thick chert beds, bituminous limestones and phosphatic limestones, followed by gypsiferous marls; a very restricted and special microfauna is present throughout. The Soukhne Formation finishes in many sections with a glauconite lenticle.

Towards the end of the Campanian a transgression of the sea occurred, with the deposition of a foraminiferal chalk of the "Shiranish Formation", which replaced the chert-phosphate sedimentation of the Coniacian-Campanian "Soukhne Formation".

Dunnington (in: Bellen et al., 1959) & (1960) mentioned that during late Campanian times, an important tectonic movement commenced in northern Iraq, causing the development of two rapidly subsiding troughs with east-west alignments (Jabel Sinjar and Anah Troughs),

possibly as a consequence of deep-seated faulting.

Al-Naqib (1967) assigned the formation of the east-west trending Anah graben trough to the middle Turonian and lower Campanian cycle. However, Daniel (in: Dubertret et al., 1963, p.165) stated that "Towards the end of the Cenomanian and in the Turonian changes occurred which are not clearly understood. It seems they included the uplift to some extent of the twin coastal mountains and subsidence of the Doumar-Damascus depression. While there was considerable volcanism in North Palestine, none is known in Interior Syria". This volcanic activity seems to correspond with the great volume of silica deposited in the Qatrane and Soukhne Formations (Henson, 1950). Movements appear to have continued (during the Late Cretaceous), always of epeirogenic and taphrogenic nature. They included especially the sinking of two east-west striking troughs or elongated basins (Jabel Aabd el Aaziz - Jabel Sinjar and Abou Kemal - Anah Troughs). At the same time the Afrine basin trending NE - SW also sank considerably (Daniel, in: Dubertret et al., 1963).

Buday (1973) in his discussion of the Jabel Sinjar and Anah troughs in Iraq concluded that the Anah trough was extremely mobile and was probably dissected by faults of ENE - WSW direction. The Anah trough also crossed the stable shelf and separated two uplifted areas (Khleisia and Rutbah Uplifts).

During the Upper Campanian, the neritic or littoral limestone of the Hartha (Pilsener) Formation was developed east of the area of deposition of the Soukhne Formation, separating the Arabian Shield uplift in the south and southwest from the open sea marls of the mobile shelf. The Jib'ab Marl Formation was the main lithological unit developed in the mobile Anah trough, deposited in

a basin lying between Abou Kemal and Anah and probably crossing the Euphrates river.

Dunnington (in: Bellen et al., 1959) and Buday (1973) agreed that the Jib'ab Marl Formation was deposited in a partly isolated, strongly subsiding trough; but Buday (1973) in accordance with a proposal made by Chatton and Hart (1961), and accepted by Ditmar et al. (1971), considered the Jib'ab marl as an aberrant facies of the Shiranish Formation, in spite of the faunal, genetic and geographical differences between those two formations (Dunnington, in : Bellen et al., 1959). The Hartha (Pilsener) Formation was deposited on the sides of the Anah trough, separating the Jib'ab marls and marly limestones from the Der ez Zor - Khleisia Uplift in the north and the Arabian Shield (Rutbah Uplift) in the south.

In the western and southwestern parts of Iraq, the lithology of the Hartha Formation changes laterally according to the palaeogeographic position of the formation; to the west, near the presumed shore line, the content of dolomite increases; to the east, away from the shore line, there is interfingering of the Safawi anhydrite; further east towards the open sea, the marl content increases (Al-Naqib, 1967). Southwards in Saudi Arabia, the equivalent of the Hartha Formation is the upper part of the Aruma Formation. This consists of widespread shallow-water carbonates, which give way to deep-water shales and limestones as distance from the basin margin increases. The marginal areas of the basin are defined by sandstones similar to those of southern Jordan (Powers et al., 1966 and Powers (1968).

II. During the Maastrichtian, the maximum transgression of this cycle was reached. In Jordan, Daniel's (in: Dubertret et al., 1963) basins and swells began to receive phosphatic and bituminous chalks

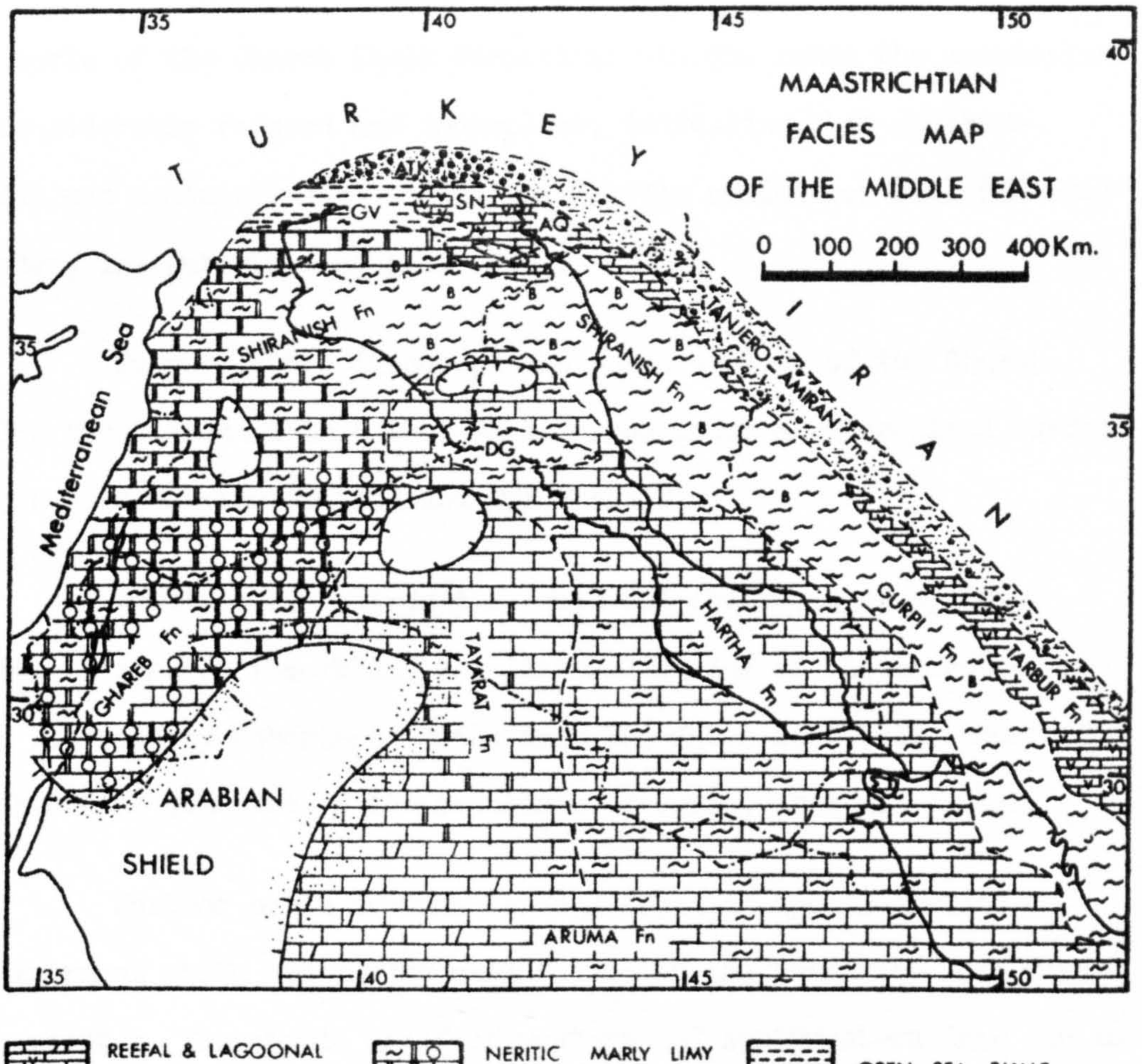


Figure 3 : Maastrichtian facies map of the Middle East .

and marls of the Gharab Chalk Formation; to the south the succession is considerably reduced and incomplete, indicating that southern Jordan was again situated in the oscillating neritic or littoral area (Bender, in: Dubertret et al., 1963).

Futyan (1968) discussed the palaeoecology of the Gharab Chalks and concluded that they were formed under a subtropical surface temperature, in the Central and Outer shelf.

Northwards, towards the south and southeast of Syria, sediments closely resembling the littoral facies of the Gharab Chalk were recorded by Dubertret (1958) from the Jabal Tanf Well, about 6Km. north of the junction of the frontiers of Syria, Iraq and Jordan.

Further north towards Central Syria an open sea white globigerinal chalk and chalky marl facies of the Shiranish Formation is present. The stable shelf of western and southwestern Iraq can be divided into two main lithofacies: a neritic-littoral facies, dominated by the deposition of the Tayarat Limestone Formation, and a neritic facies, the Hartha Formation. The Tayarat Limestone Formation at its type locality (Jabel Tayarat) south of the Rutbah Uplift, is composed of rubbly, porous white, buff and pink, rather chalky, fossiliferous, recrystallized, dolomitized, locally sandy limestone, conspicuously more massive at the base. The fauna is characterized by the presence of Loftusia morgani (Douville) and Omphalocyclus macropora (Lamarck). According to Dunnington et al., (in: Bellen et al., 1959), it is closely comparable with the Aruma Formation in Saudi Arabia; although, Powers (1963) mentioned that the Aruma Formation at its type section is composed of dolomite, limestones, sometimes with calcareous shale. In the Al-Widyan area (just north of the Iraqi-Saudi frontier), Al-Naqib (1967) has described the Tayarat Formation (in accordance to W.T. Foran's unpublished data, 1940) as fossiliferous limestone at

top, grading downwards to yellow marl, then shale, sandstones, and marl again; then changing to dolomite,limestone, with several marl intercalations; and finally into yellow marl with some limestone intercalations. The thickness of the Tayarat Formation increases towards the southeast (Basrah-Kuwait area), maintaining the same facies as in the type locality (Owen and Nasr, 1958)

Al-Mutter (1976) described the Tayarat Formation from the Akashat area, north of the Rutbah uplift, as mainly limestones, clayey marly limestone, rich in bones and phosphatic pellets, deposited in a sublittoral environment, and lacking the characteristic microfauna of the Tayarat Formation (i.e. Loftusia morgani Douville and Omphalocyclus macropora Lamarck).

The Tayarat Formation of the Akashat area is therefore different from the typical formation to the south, and could be regarded as a sub-littoral facies of the Ghareb Chalk Formation of Jordan and southern Syria. The noritic facies of the stable shelf in western andsouthwestern Iraq was dominated by the deposition of the globigerinal and argillaceous limestone of the Hartha (Pilsener) Formation, which becomes glauconitic to the south. The northern part of this formation, formerly called the Pilsener Limestone Formation by Dunnington et al. (in: Bellen et al., 1959), was mainly deposited between the Der ez Zor - Khleisia uplift in the north and the Rutbah - Ga'ara uplift in the south, and on the margins of the Abou Komal - Anah trough. The latter was active for the Mid and Upper Maastrichtian (Dunnington et al., in: Bellen et al., 1959). In this trough the phosphatic-glauconitic and locally silicified marls of the Digma Formation were deposited. Buday (1973) considered that the sediments of this formation were deposited in the latest phases of the progressive transgression of the Maastrichtian sea. However, Dunnington et al.,

(in: Bellen et al., 1959) separated the Digma Formation from the Jib'ab Marl Formation because of the presence of the normal neritic Hartha (Pilsener) Formation in between them, and the abundant, highly specialized fauna of the Digma Formation. Southwards, the Hartha Formation intercalates with the open sea marls of the Shiranish Formation to the east and with the littoral limestone of the Tayarat Formation to the west, and with both open sea and littoral sediments toward the Basrah area (Owen and Nasr, 1958; Dunnington et al. (in: Bellen et al., 1959); Al-Naqib, 1967; &Buday, 1973).

B - Mobile Shelf

Dunnington (1958), Dunnington et al. (in: Bellen et al., 1959), Daniel (in: Dubertret et al., 1963), Buday (1973) are all agreed that in the Upper Campanian, an important tectonic movement occurred in the Middle East, with some areas being uplifted or even exposed, and with the consequent development of three basins of subsidence. As previously discussed, the Abou Kemal - Anah Trough is one of these, the other two being the Jabel Aabd el Aaziz - Jabel Sinjar and Aafrine Basins. (Fig. 2).

The Aafrine Basin was located in the northwest part of Syria, trending NE - SW, and was filled during the Late Cretaceous by the bituminous marly limestone of the Oucharhou Formation, discussed by Daniel (in: Dubertret et al., 1963) and considered as a lateral equivalent to the Soukhne Formation. It differs in the considerably larger $CaCo_3$ content, with the development of limestone instead of marl etc., and the lack of any salt, gypsum, anhydrite or sand. There is a much reduced silica and phosphate content, particularly their absence in thick beds, There is also a lack of shelly beds and of concretionary limestones. Daniel concluded that the Oucharhou Formation was possibly deposited in some sort of euxinic environment

of "barred basin" type, yet the water was surchargod with minerals as in the Palmyra region, but under more marine conditions. To the east the northern part of Soukhne Formation was deposited within the mobile shelf, and changed laterally into the open sea marls of the Shiranish Formation in the northeast of Syria.

The Shiranish Formation represents the major part of the Upper Campanian - Maastrichtian mobile shelf, and was deposited in a deep open sea environment, in an E - W striking basin known as the Jabel Aabd el Aaziz - Jabel Sinjar Trough. This trough has been discussed by several authors since 1958, when Dunnington first suggested its presence; however, Buday (1973) in his detailed discussion of this trough suggested that the E - W directed Jabel Sinjar Trough has a southeastern extension, trending NW - SE towards Naft Khaneh on the Iraqi - Iranian frontier, and then continuing toward the Abou Ghirab area on the southern Iraqi - Iranian frontier. The northwestern part of the trough (Jabel Aabd el Aaziz - Jabel Sinjar areas) had been very mobile and filled with an exceptionally thick development of the Shiranish Formation; the trough became progressively deeper towards the southeast, and filled with open sea Shiranish sediments. The Der ez Zor - Khleisia Uplift, with a continuation to the east known as the Mosul Uplift separated the two parts of this trough.

Dunnington et al. (in: Bellen et al., 1959) described the lithology of the Shiranish Formation in its northern area as open sea, globigerinal marls and marly limestones. Al-Naqib (1967) mentioned that southwards the Shiranish Formation comes to consist mainly of globigerinal marl, dolomitic in some places, and glauconitic toward the base. After Owen and Masr (1953), the Shiranish Marls of the Basrah area pass into white to grey marly microcrystalline limestone in southern Kuwait, containing in many places grey chert nodules. In southwestern Iraq the Shiranish Marls pass into a chalky and marly

limestone facies within the Tayarat Formation. The Shiranish Formation in Syria was deposited during the maximum transgression of the sea during latest Campanian to Maastrichtian times. Thus it is present in almost the whole of Syria, except for the southern and southeastern parts where the neritic and littoral sediments of the Hartha and Ghareb Formations were deposited. According to Daniel (in: Dubertret et al., 1963) and Wolfart (1967), the Syrian Shiranish Formation can be divided into two lithofacies (fig. 3): to the east and northeast is the typical facies of the Shiranish marl and marly limestones, deposited in the western part of the Jabel Aabd ol Aaziz - Jabel Sinjar Trough; the second lithofacies is the marls, chalky marls and chalky limestones which are present in the central and western parts of Syria, including the Aafrine Basin in the northwest. The emplacement of the ophiolite complex took place in the Aafrine Basin during the deposition of the chalky marls and limestones, so there is a considerable thickness of sedimentary breccia. The breccias are composed of several different older Mesozoic limestones and radiolarian cherts set in a matrix of Shiranish, the latter containing fossil debris including Loftusia morgani (Douville) and Omphalocyclus macropora (Lamarck). In the extreme northwest, coarse agglomerates are present which pass into coarse conglomerates with ophiolitic constituents intertounging with the chalky limestones of the Shiranish Formation.

In addition, the northern part of Syria seems to have suffered from considerable differential movements during the Upper Cretaceous. These movements are indicated by the presence of large quantities of clean quartz sand, of unknown origin, in the Shiranish Formation in the Abba Well, the presence of conglomerates and exotic slumped blocks of Carboniferous and younger rocks embedded in the chalky

Shiranish at Jabel Aabd el Aaziz; pyroclastics at Jebissa; and the presence of steep dips in the basal Maastrichtian (Daniel, in: Dubertret et al., 1963).

Fairbridge and Badoux (1960), considered the palaeoecology of the Upper Cretaceous of northern Syria to suggest great variation in water depth and general bottom conditions.

C - Geosynclinal Trough

The Late Campanian - Maastrichtian geosynclinal trough is present in the extreme northern and northeastern parts of Iraq, but the major part of the trough lies within Turkey and Iran. It has a N.NW - S.SE alignment. (fig. 2 & 3).

According to the suppositions of Dunnington (1953-1959) and Buday (1973), this geosynclinal trough was separated from the mobile shelf by a ridge running roughly on the high folded zone, with an axis connecting Aqra and Nador. The Bekhme Limestone Formation and Hadiena Formation were deposited on the northern part of this ridge during the Late Campanian. The Aqra Limestone Formation followed in the Maastrichtian. To the southeast occasional tongues or lenses of the latter formation are found within the Tanjero Clastics. The Shiranish Formation replaces the above mentioned formations on the southern part of the ridge.

The Bekhme Limestone and Aqra Limestone Formations are both composed of reefal neritic limestones, and are considered to be two different units because of the presence of an intervening tongue of the Shiranish Formation or/and Tanjero Clastics. There is also a suggested depositional break at the top of the Bekhme Limestone in other sections. The two units can be readily distinguished by their different and characteristic faunal assemblages, based on the presence

of the Cosinella - Pseudosiderolites cf. heracleae in the Bekhme Limestone, and the presence of Loftusia spp. in the Aqra Limestone Formation. The latter is closely comparable with the Tayarat Formation in age, fauna and facies, but they are recognised as separate units because they are palaeogeographically and genetically distinct (Dunnington et al, in: Bellen et al., 1959).

Buday (1973) testified to the permanent shallow neritic character of the Aqra - Bekhme Limestone Formations, as their main development coincides with the Mosul Uplift, which was already submerged. He concluded that the ridge separating the mobile shelf from the geosyncline continued towards the west into the Mardin Ridge in Turkey, but towards the southeast the ridge did not continue into Iran. Another extension of this ridge seems to be present towards Diyarbaker in the northwest, where reefal sediments were developed during the Campanian to the end of the Palaeocene, represented by the Raman Reef, Garzan Reef and the Sinan Formation (Rigo de Righi and Cortesini, 1964).

Setudehnia (in: Stocklin and Setudehnia, 1972), (1978) described a very rapidly developed reef called the Tarbur Formation, lying along the Zagros Crush Zone, mainly in the Arabstan (Khuzestan) and interior Fars Provinces of Iran. This formation is of late Campanian - Maastrichtian age, rich in shallow water, reefal faunas similar to those of the Aqra and Tayarat Limestones Formations. Setudehnia suggested the correlation of the Tarbur Formation with the Tayarat Limestone Formation of Kuwait. However the Tarbur Formation is more likely to be correlated with the Aqra Limestone Formation; both formations are similar in lithology and faunal assemblages, and both lie parallel to the Zagros Crush Zone and acted as a barrier separating the open sea sediments of the Shiranish and Gurpi Formations from the fore-deep clastics or radiolarites (Tanjero,

Amiran Formations and Coloured Melange). All these factors suggest that the Mardin - Aqra - Nador Ridge continued towards the southeast into the interior Fars Province of southwestern Iran, through NE Lurestan and Arabstan (Khuzestan).

Another tectonic-depositional regime was developed in Turkey, the extreme northeast of Iraq and western Iran at the time of the formation of the Jabel Aabd el Aaziz - Jabel Sinjar - Abou Ghirab, Abou Kemal - Anah, and Aafrine Troughs. In this area a broad and rapidly subsiding trough developed parallel to the Zagros Crush Zone, receiving a great accumulation of flysch-like clastics. These were derived from a considerable uplift which occurred outside Iraq, referred to as the Sub-Hercynian stage by Buday (1975). As a result of this uplift, a great thickness of Triassic - Turonian sediments were eroded, amongst which were finer grade detritus of different limestones, and a volcanic calcareous type of sediments with radiolarian cherts. These were deposited as the flysch-like clastics of the Tanjero Formation in Iraq (Gormav Flysch Beds, Gaziantep-Kurd Dagh Flysch and part of Hakkari Complex, in southern Turkey; and the Maastrichtian flysch part of the Amiran Formation in Iran) (Dunnington et al. (in: Bellen et al., 1959), Buday (1973), and Setudehnia (1978).

Buday (1975) divided the Sub-Hercynian stage of the geosyncline into Mio- and Eugeosynclinal realms. The ridge of the Aqra/Bekhme and Hadiena Limestone Formations and the trough of the Tanjero Formation, represent the Miogeosynclinal realm. The Eugeosynclinal realm lying outside Iraq in Turkey and Iran is represented by a trough with coarse clastics known as the Qulqula Formation, this contains conglomerates composed of calcareous radiolarian sediments. The Qulqula trough represented the outer zone of the Eugeosyncline, while the inner zone was uplifted during that time.

There was a general uplift and regression of the sea throughout the Middle East towards the end of Maastrichtian. In northeast Syria, Iraq, Iran, and Saudi Arabia, the upper beds of the Maastrichtian were eroded (Dunnington, 1955 - 1959; Daniel, in: Dubertret et al., 1963; Powers et al., 1966; Powers, 1968; Stocklin and Setudehnia, 1972; Buday, 1973; and Setudehnia, 1978). In the west, i.e. Syria, Lebanon, Jordan, and Palestine, some authors (Dubertret, Daniel and Bender, 1963; Wolfart, 1967; and Bender, 1968 and 1975) believe that sedimentation was continuous from the Late Cretaceous into the Tertiary despite the gentle uplift. Recent micropalaeontological wprk indicates both a lithological and faunal break between the Maastrichtian and Palaeocene and between the Palaeocene and Eocene (Futyan, 1968 and 1976; Hamam and Haynes, 1977; and Yassini, 1979).

Buday (1973) regarded this uplift to be part of the Laramide orogenic event, connected with folding, thrusting, and finally orogenic uplift of the whole Middle East area.

2. Palaeocene - Early Eocene (fig. 4)

Mesozoic tectonic movements, ending with the Laramide orogenic movements at the Maastrichtian - Palaeocene boundary, gave rise to a new palaeogeographic picture for the Tertiary (Buday, 1973). The general uplift of the whole area was followed by a new cycle of transgression over newly developed basins separated from one another by uplifted islands or ridges. Such a geography had a great influence on facies changes as in the previous cycle of deposition. The most effective Tertiary ridge was the successor to the Mardin - Aqra - Nador Ridge, separating the Miogeosyncline from the former mobile shelf. This had an axis running from Diyarbaker, Mardin in Turkey, through Amadiya, Rowanduz, Ranya, towards Halabja in Iraq and further southeast to western Iran through Huleylan, Amiran and Kuh-e-Buzi. The Tertiary

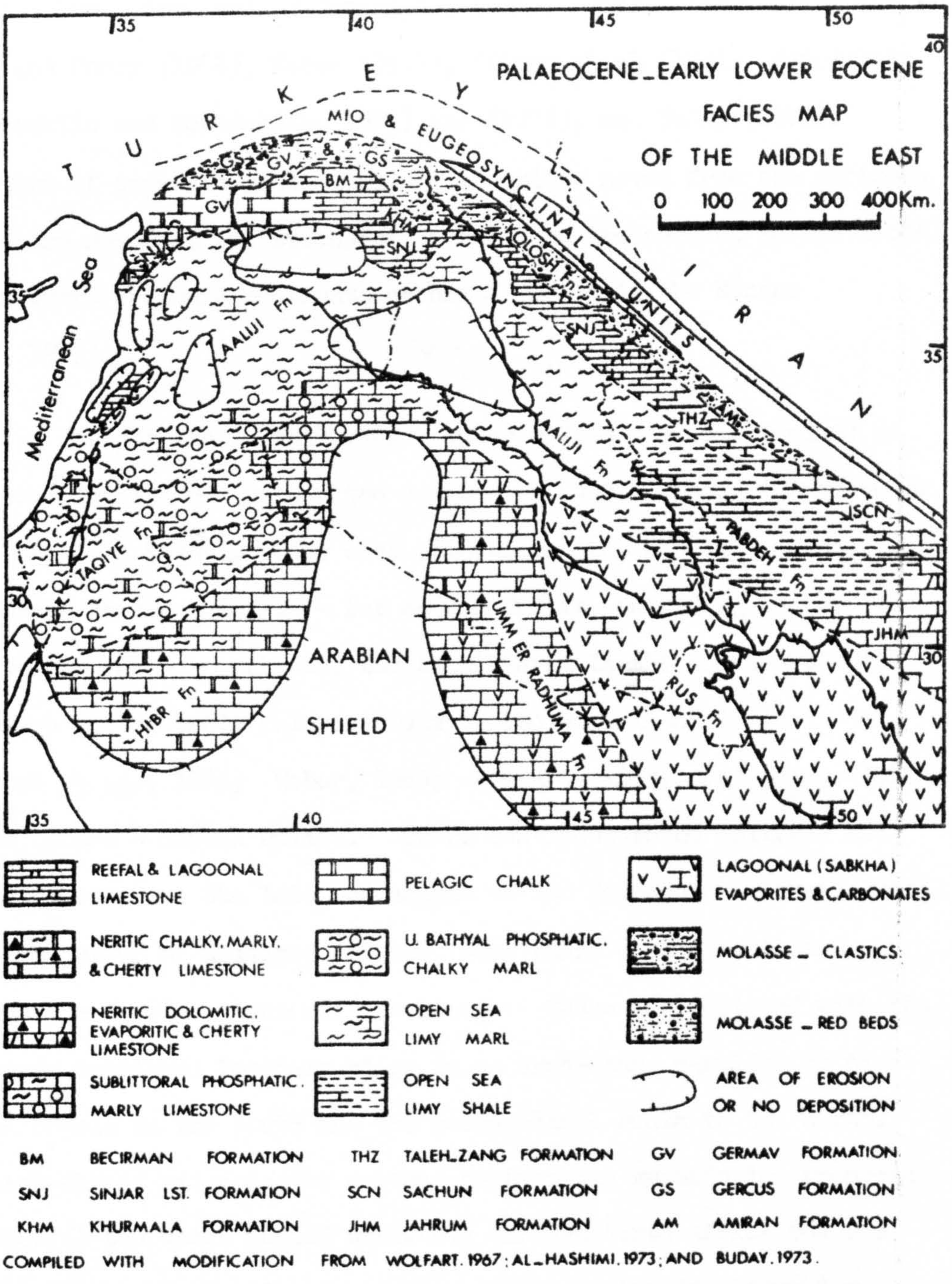


Figure 4 : Palaeocene - early Lower Eocene facies map of the Middle East .

ridge has been discussed by Dunnington (1953, 1958), Bolton (1958), Temple and Perry (1962), Weber (1963), Ditmar et al. (1971), Setudehnia (in: Stocklin and Setudehnia, 1972) and (1978), and Buday (1973). The centre of orogenic activity along the ridge moved from the northern area, where movement was strongest in the Late Cretaceous, to the south in Iran where orogenic movements occurred mostly in the Eocene (Buday, 1973).

In addition to this ridge, other uplifted areas remained as non-deposition islands within the sea to its west. These islands were of two types. Firstly there were remnants of the Arabian Shield, represented by the Khleisia - Der ez Zor Uplift, extending to the Mosul Uplift in the northeast, the Awasil area in the southeast and the Jezira and probably Palmyra areas to the west (Daniel, in: Dubertret et al., 1963; Weber, 1963; Wolfart, 1967; and Buday, 1973); and the Ga'ara - Rutbah Uplift. These continued to be uplifted and emergent throughout the Late Cretaceous to the Palaeocene (Baker, 1953). The second group of uplifted islands, were those caused by latest Cretaceous - Tertiary tectonic movements. These were aligned with the previously mentioned Tertiary ridge in an arch-shape parallel to the Arabian Shield in the south and the geosynclinal realm to the north. This arch-shaped ridge is the eastern part of the geanticline proposed by Klemme (1958) which passed westwards through North Africa towards the Atlantic. Klemme also proposed a minor geanticline occupying southern Turkey, the Balkan, the Southern Alps and north-central Italy, where the deposition of some reefal carbonates occurred. The islands remained as emergent areas of non-deposition throughout the Palaeocene and Early Eocene, with the exception of some reefal developments in the Lebanon - Anti Lebanon Mountains. They are represented by the Jabel Aabd el Aaziz Uplift of Northern Syria, Jabel Ansariyeh and Jabel Zawiyeh Uplifts of western Syria, and the Lebanon - Anti Lebanon Mountains Uplifts.

A - Stable Shelf

Due to continuous uplift in northern and western Syria during the Palaeocene - Early Eocene, the transgression of the sea extended further to the south, where it overstepped the Upper Cretaceous shore line of the southwestern part of the shelf, i.e. Jordan and extreme northwestern Saudi Arabia. In this region the light-coloured, thin-bedded, chalky and cherty limestone and marl deposits of the Hibr Formation conformably overlie the Aruma Formation in the eastern area of the outcrop, but overlie unconformably both the Aruma Formation and Lower Devonian strata to the south and west as far as the Jordan border with Saudi Arabia.

Powers et al. (1966) and Powers (1968) considered the undivided Palaeocene and Eocene rocks of the Hibr Formation to be at least partially equivalent to the Umm er Radhuma, Rus and Dammam Formations of the Palaeocene - Eocene of the eastern and southeastern parts of the stable shelf. He presumed that the Hibr Formation was a Mediterranean facies deposited in a seaway not directly connected with the Arabian Gulf Basin.

Northward, within Jordan, Daniel (in: Dubertret et al., 1963), and Bender (1968, 1975) argued that Upper Cretaceous sedimentations apparently continued into the Palaeocene and Eocene without any significant major lithological break. The sediments of the Taqiye Marl Formation were confined to the basinal and synclinal depressions during the Palaeocene. The overlying Sara Chalk and Flint Formation of Early and Middle Eocene age, was deposited after a general subsidence of the sea at the beginning of the Early Eocene, with the progressive submergence of the still developing basins and swells.

The Taqiye Marl Formation is composed of grey-blue and olive-green, gypsiferous, sometimes slightly salty, marls and shales

with abundant nodules of marcasite but without any chert. The contact with the underlying Gharab Chalk Formation is marked by the total extinction of typical Cretaceous pelagic and benthonic Foraminifera. Just above the base of the Taqiye Marl characteristic Tertiary pelagic and benthonic Foraminifera appear. There is a transitional zone between the two faunas which could correspond to the Danian, containing only small Globigerinidae and Gumbelinidae (Daniel, in: Dubertret et al., 1963).

Futyan (1968) concluded that the great abundance and diversity of planktonic species relative to the few arenaceous forms in the Taqiye Marl Formation is an indication of tropical surface waters with an unrestricted connection with the open sea. The presence of benthonic forms with a deep to moderately deep water optimum habitat point to a marine environment of deposition on the outer shelf or upper bathyal zone.

At the end of the Palaeocene a marine transgression began which continued until the end of the Middle Eocene, During this transgression were deposited the alternating beds of chalk, phosphatic chalk and flint (described as chert by Bender, 1968 & 1975) and the locally nummulitic facies of the Sara Chalk and Flint Formation. This could be regarded as a continuation of the early Palaeocene transgression because there is no evidence of any considerable regression after the deposition of the Taqiye Marl Formation (Daniel, in: Dubertret et al., 1963). In this context, Futyan (1968) concluded that the Sara Chalk and Flint Formation was deposited in deep water, in the upper or middle bathyal zone, under relatively cooler temperatures than in the Palaeocene.

To the northwest, in the Beka'a area between the Lebanon and anti Lebanon Mountains, sediments of Palaeocene age occur which

are similar lithologically to the Taqiye Marl Formation (Dubertret, 1951, 1954); there are also sediments of Early Eocene age, equivalent to the Sara Chalk and Flint Formation (Dubertret, 1955).

To the southwest, the Taqiye Marl Formation was deposited in the Negev and South Palestine as transgressive deposits overlying the Gharab Chalk Formation. The "Esna Shales" of Egypt can almost certainly be correlated with the Taqiye Marl Formation (Daniel, in: Dubertret et al., 1963).

The phosphate bearing sediments of the Palaeocene - Lower Eocene stable shelf extended into southern and southeastern Syria and western Iraq. In southern Syria, the Taqiye Marls and the lower part of the Sara Chalks pass northwards into the open sea sediments of the Aaliji Formation. The latter was considered by Daniel (in: Dubertret et al., 1963) to be similar in lithology to the sediments of the Taqiye and Sara Formations of Jordan and of the Beka'a region in Lebanon (information on Beka'a region from Dubertret, 1951, 1954). In SE Syria (Jabel Tenf Well) and Western Iraq (west and north of the Ga'ara Area), phosphate bearing sediments were deposited, differing lithologically from the Taqiye Marls and Sara Chalks of Jordan. The Palaeocene sediments at both localities are quite unlike the Taqiye Marl Formation. They are known as the Aaliji Formation in the Jabel Tenf borehole, and the Umm er Radhuma Formation in the Ga'ara Area. The Lower Eocene deposits were considered to be a shallower water facies of the Sara Chalk and Flint Formation, being composed of limestone rather than chalk or marl, with much flint, and occasional phosphate horizons and yielding Nummulites spp. These deposits are referred to as the Jaddala Formation in SE Syria and the Umm er Radhuma Formation in Western Iraq (Dubertret, 1958; Bellen, in: Bellen et al., 1959; and Daniel, in: Dubertret et al., 1963). The lower Eocene part of the Umm er Radhuma Formation around the Ga'ara Area is considered to be equivalent to the lower part of the Dammam Formation due

th its distinctive facies characterized by Nummulitic Limestone (Ctyroky and Karim, 1971; Al-Hashimi, 1973; Al-Mutter, 1976; and Karim, 1977).

The Umm er Radhuma Formation in the north of the Ga'ara area is composed of white shelly dolomitic limestone, grey fossiliferous marly limestone, chalky limestone with marl, grey fine to medium grained oolitic sandstone, grey pseudoolitic marly limestone, and white pinkish limestone rich in phosphatic pellets and with some iron oxide, chert and bones fragment. It is of Middle to Late Palaeocene age (Al-Mutter, 1976).

These Palaeocene sediments are quite similar in lithology and microfauna to the equivalent Palaeocene sediments of the Jabel Tenf borehole (Dubertret and Vautrin, 1937; Tromp, 1949; Lys, 1951; Atfeh and Faradjev, 1963; and Daniel, in: Dubertret et al., 1963), but unlike the typical Umm er Radhuma sediments, which are mainly anhydritic and dolomitic limestones (Bellen, in: Bellen et al.,'1959).

The faunal assemblages of the Umm er Radhuma Formation were studied by Ctyroky and Karim (1971), Al-Mutter (1976) and Karim (1977) from the Akashat area which lies north to the Ga'ara. They are much like the faunal assemblages of the Taqiye Marl Formation of Jordan (Daniel, in: Dibertret et al., 1963; and Bender, 1968), presumably with some intermixing with the planktonic Foraminifera of the Aaliji Formation (Al-Mutter, 1976). They are however most unlike the typical Umm er Radhuma faunal assemblages listed by Bellen (in: Bellen et al., 1959), which consists mainly of larger Foraminifera (i.e. Alveolina spp. and Operculina sp.).

The Umm er Radhuma Formation was deposited under marine sublittoral conditions, with some communication with the Palaeocene World Ocean. Lagoonal influences are also apparent and the phosphatic

facies was deposited in a warm tropical unsettled sea bottom in shallow near-shore waters (Ctyroky and Karim, 1971; Buday, 1973; Al-Mutter, 1976; and Karim, 1977). The Lower Eocene sediments of this area (Jabel Tenf and Ga'ara) were deposited, in a forereef sublittoral neritic environment (Henson, 1950; Bellen, in: Bellen et al., 1959; Al-Hashimi, 1972 & 1973; Al-Mutter, 1976; and Karim, 1977).

Following from this discussion it is likely that the Palaeocene Umm or Radhuma and Aaliji sediments are sublittoral and open lagoonal facies of the Taqiye Marl Formation; and the Lower Eocene sediments a sublittoral limestone facies of the Sara Chalk and Flint Formation.

The eastern part of the stable shelf (i.e. Southern and Southwestern Iraq, Kuwait, and Eastern Saudi Arabia) was dominated by sedimentation of anhydritic, dolomitic limestones deposited under neritic/littoral conditions during the Palaeocene - Early Eocene (Umm er Radhuma Formation). This was followed during the earliest Early Eocene by the development of a local off-shore basin, where lagoonal evaporitic sediments of the Rus Formation were deposited. These lagoonal sediments change in facies towards the shore line and pass into nummulitic sublittoral limestone of the Dammam Formation (Bellen, in: Bellen et al., 1959; Powers et al., 1966; Al-Naqib, 1967; Powers, 1968; Al-Hashimi, 1973; and Buday, 1973).

Al- Hashimi (1973) considered the rather distinctive facies zone of the lower part of the Lower Eocene sediments indicated that a regressive phase prevailed during the Early Eocene. He concluded that the sea became progressively shallower during the earliest Early Eocene in southern and southwestern Iraq. The Umm or Radhuma Formation in the north (i.e. southern and southwestern Iraq and Kuwait) is composed of anhydritic and dolomitic limestone, mostly dull white or buff, microcrystalline and porous. Chert occurs in the higher parts.

The formation increases greatly in thickness eastwards, where it passes laterally into the Aaliji (Pabdeh) Formation (Owen and Nasr, 1958; and Bellen, in: Bellen et al., 1959). To the west, in the Al-Widyan country (north of the Iraq - Saudi Frontier) the Umm er Radhuma Formation consists mostly of alternating soft friable chalks, sporadic dolomitic chalks, bedded chalky limestones, and thin porcelaneous silicified limestones, with subordinate marl, shale, and chert horizons. Chert, flint, quartz vugs, and geodes are distributed throughout the sequence, but are better developed in the south (Al-Naqib, 1967).

To the south in Saudi Arabia, the Umm er Radhuma Formation becomes aphanitic limestone, partially dolomitized, commonly fossiliferous, chalky, in the upper part thinly interbedded with calcarenitic limestone and dolomite (Powers, 1968).

The Lower Eocene lagoonal sediments of the Rus Formation in southern Iraq and Kuwait, are composed predominantly of massively bedded white and blue tinted crystalline anhydrite with alternations of thin unfossiliferous limestones, blue shale, and marl. This formation passes westward into the Lower Eocene units of the Dammam Formation. The Lower Wagsa Unit is a chalky, moderately fossiliferous limestone, while the Upper Huweimi (Chalk), Shabicha, and Sharaf Units have chalks alternating with chalky limestones containing badly preserved lamellibranchs. The chalks are white or pink and were probably deposited in fresh water (Al-Naqib, 1967). The Wagsa Unit (Lower Ypresian) is a sublittoral nummulitic facies, replaced by a littoral, miliolid-molluscan facies in some places (Sharaf and Shabicha Beds) and by an anhydrite facies (Rus Formation) in others towards the close of the Palaeocene - Lower Eocene (Upper Ypresian) cycle (Al-Hashimi, 1973).

Towards the south in Saudi Arabia, Powers et al. (1966) and Powers (1968) divided the Rus Formation at the type locality into three lithologic units of Early Eocene ago. The basal unit is composed of limestone, grey to buff, compact, commonly partially dolomitized, with minor beds of soft limestone made porous by the leaching of small organic remains. Quartz geodes are rare in the lower part, but are typical of the upper part. The middle unit is of light-coloured marl with local irregular masses of crystalline gypsum and occasional thin, harder limestone beds; geodal quartz is present at several levels. The upper unit consists of white, soft, chalky, porous limestone, with several thin beds of calcarenite at the top. The overlying Lower Eocene part of the Dammam Formation is composed of a few metres of yellow-brown shale with light-grey marl and soft impure limestone at the bottom (Midra Shale member), followed by a blue to blue-grey, subfissile shale, with a thin basal unit of light-grey limestone (Saila Shale member); both members contain Nummulites globulus Leymerie, which gives the Early Eocene age.

B - Mobile Shelf

The mobile shelf of the Palaeocene - Early Eocene differed from that of the Late Cretaceous, consisting of two basins separated by an arch-shaped ridge as previously discussed. The northern basin was narrower, deeper, and more mobile; the southern basin was an open sea offshore basin passing latterally into the stable shelf. The offshore basin was dominated by the deposition of marls, shales, and marly limestones of the Aaliji (Pabdeh in Iran) Formation. The Aaliji Formation was also affected by the uplifted islands lying within the basin of deposition. It was deposited in two subsiding basins separated by the Khleisia - Der ez Zor Uplift and its extensions (Buday, 1973) (see fig. 4). In the western basin, which covered almost the whole

of Syria, the Aaliji Formation is composed of olive green, dark grey and dark blue marls and shales with thin bands of limestone in the east, northeast, and northwest, in the Palmyra mountain range (Central Syria), it consists of white to greyish-yellow chalky marls at the top, and highly glauconitic marls with some small pebbles at the base (Daniel, in: Dubertret et al., 1963).

The southeastern basin in Iraq and Western Iran was more mobile than the western basin, and the Aaliji Formation here is composed of grey and light brown argillaceous marls, marly limestones and shales with occasional microscopic fragments of chert and rare scattered glauconite (Bellen, in: Bellen et al., 1959). Further to the southeast, in Iran, the sediments consist of pelagic marls and shales intercalated with subordinate argillaceous limestones, known as the Pabdeh Formation (Setudehnia, in: Stocklin & Setudehnia, 1972). According to Ponikarov et al. (1967) and Powers et al. (1966), Buday (1973) considered the presence of the Khleisia - Der ez Zor Uplift and its extensions as an important bioprovincial boundary of the Palaeocene - Eocene open sea sediments, separating the western basin which was a part of the Mediterranean bioprovince from the southeastern basin which was of eastern, Indopacific character.

The Aaliji offshore open sea basin was separated by an arch-shaped uplifted ridge from a relatively narrow and strongly mobile trough or basin, referred to as the foredeep area of the mobile shelf by Buday (1973). He considered the foredeep area to be a Lower Palaeocene near-geosynclinal foredeep trough which developed as a result of the Laramide Orogeny. It was filled by the Palaeocene - Lower Eocene mollase sediments of the Kolosh Formation (this is known as the Upper Germav Formation (Palaeocene) and the Gercus Formation (Lower Eocene) in Turkey; and the Amiran Formation (Palaeocene) and

Kashkan Formation (Lower Eocene) in Iran). The lithology of the Kolosh Formation was first described by Bellen (in: Bellen et al., 1959) according to the unpublished report of Dunnington (1952), who suggested an interfingering of the Kolosh Clastics with the Sinjar Limestone in the higher parts of the formation. Ditmar et al (1971) considered the uppermost unit of the Kolosh type section as the Sinjar Limestone Formation; Buday (1973) agreed with Ditmar et al., and considered again that another upper portion of the remaining Kolosh Formation was an intertongue between the Sinjar Limestone and Kolosh Formations.

Finally Kassab (1976a) divided the residual part of the Kolosh Formation into two units: an upper unit of sandstones, red shales, marls, limestone and a few conglomerates, and a lower unit composed of blue shales, red shales (rare), green sandstones, and grey limestones (rare).

In Turkey and the extreme northeast of Syria the equivalent of the Kolosh Formation is known as the Upper Germav Formation. This is composed mainly of grey silty shale and marl, with thin beds of argillaceous limestone and sandstone. The Gercus Formation (Lower Eocene) consists mainly of red siltstones, sandstones and conglomerates (Dam, 1955; Bellen, in: Bellen et al., 1959; and Daniel, in: Dubertret et al., 1963). In Iran the equivalent of the Kolosh and Tanjero Formations is the Amiran Formation. It is of Maastrichtian age and equivalent to the Tanjero Formation in northeastern Lurestan, becoming younger towards Central Lurestan where it is of Palaeocene age and equivalent to the Kolosh Formation. It consists of dark olive-brown siltstone and sandstone with local development of chert conglomerates and shelly limestones. The clasts are mainly chert fragments. The Lower Eocene equivalent of the Kolosh Formation is the Kashkan Formation

which is restricted to Central Lurestan, and is composed of red conglomerate, sandstone, and siltstone. Chert forms the main constituent of the rocks (Setudehnia, in: Stocklin and Setudehnia, 1972).

Kassab (1976a) considered the Kôlosh Clastics to be representative of the near-shore facies of the Palaeocene - Lower Eocene transgressive cycle, and the clastics to be erosional products from rising areas (Cretaceous - Jurassic Rocks). These rising areas were toward the east in the case of the Iraqi - Iranian clastics and toward the north in the case of the Turkish clastics, according to Klemme (1958). The latter attributed the rapid vertical variation in lithology (shales to sandstones) and fauna, to the rapid oscillation in sea level during the late Middle Palaeocene to Late Palaeocene. In the Upper Palaeocene the presence of miliolid and larger foraminiferal limestones indicates shallowing. This shallowing in the foredeep trough has been discussed by Henson (1950), Dunnington (1958), Bellen (in: Bellen et al., 1959) and Buday (1973), who mentioned that during the Late Palaeocene - Early Eocene the foredeep trough subsided less, with lagoonal environments prevailing, in which the Khurmala Formation was deposited. "The Khurmala lagoon was, however, mobile mainly to the SE of the Mosul Uplift (NE part of the Khleisia - Der ez Zor Uplift), whereas to the NW the lagoon did not occur and that area was either above the sea level, or was covered with a thin veneer of neritic limestones or open sea marls" (Buday, 1973, p.327). However, Temple and Perry (1962) followed by Rigo de Righi and Cortesini (1964) have recorded the prevalence of lagoonal conditions during the Palaeocene in the area near Diyarbakir. In this area the reefal limestone of the Sinan Formation changed into a carbonate-evaporite assemblage, thought to have developed because of restricted circulation due to the presence of local residual highs inherited from the Upper Cretaceous.

The Khurmala Formation consists of dolomite which is suboolitic in part, and finely recrystallized limestone. They are probably chemical limestones, interfingering strongly with material from the Kolosh Formation, containing detrital chert, flint, radiolarite, and green rocks, of silt and sand size. Anhydrite, which is probably secondary, occurs occasionally (Bellen, in: Bellen et al., 1959). Buday (1973, based on Ditmar et al., 1971) remarks on the occurrence of the Khurmala Formation in the Chemchemal and Kirkuk areas where it is underlain by the Kolosh clastics, or in its lower part is interfingering with them. He supposed that the Khurmala Formation is of Late Palaeocene - Early Eocene age and as a whole is younger than the Kolosh Formation.

The foredeep trough of the Kolosh Formation was separated from the offshore basin of the Aaliji Formation by an arch-shaped uplifted ridge or zone, where reef and offshore shoal sedimentation occurred during the Late Palaeocene and Early Eocene. Those reefal and shoal deposits are known as the Sinan Formation (Palaeocene) and the Becirman Formation (Lower Eocene) in Turkey; Sinjar Limestone Formation (Upper Palaeocene - Lower Eocene) in Iraq; and the Taleh Zang Formation (Upper Palaeocene - Middle Eocene) in Iran (Bellen, in: Bellen et al., 1959; Rigo de Righi and Cortesini, 1964; and Setudehnia, in: Stocklin and Setudhnia, 1972). The Sinjar Limestone Formation in its type section in Jabel Sinjar is composed of limestone, showing elements of algal reef facies, a lagoonal miliolid facies and shoal nummulitic facies. It is usually recrystallized and yellowish in colour, and is of Palaeocene - Early Eocene age (Bellen, in: Bellen et al., 1959). Towards the southeast (i.e. the Kirkuk and Chemchemal areas) the lithological picture becomes more complicated, with frequent interfingering and intermixing of the Kolosh clastics, Aaliji marly

limestones, Khurmala lagoonal carbonates and the Sinjar shoal limestone. These complicated relationships are difficult to explain if the Sinjar reefal limestone is regarded as a reef wall separating the open sea in the west from lagoonal areas in the east. This is because the barrier between the two areas was incomplete. Bellen (in: Bellen et al., 1959), Buday (1973) and many other authors surmounted this problem by regarding the Sinjar reefal limestone as a row of islands and shoals, or as a bank reef according to Henson (1950). These islands, shoals, and reef knolls continually changed position. As a result, Buday (1973) proposed a transitional zone lying roughly in the Chemchemal area, where a mixed Aaliji - Kolosh facies dominates, which he called the Aaliji - Kolosh Formation.

Farther to the SE in Iran, the Taleh Zang Formation was considered by Allison and Slinger (1948, IOOC report) to be a reefal development. It is composed mainly of medium-bedded to massive, resistant, grey and brown, fossiliferous limestone, changing in thickness very rapidly over a short distance. It interfingers with and passes into the shales and limestones of the Pabdeh Formation from Central Lurestan towards the southwest and southeast (Setudehnia, in: Stocklin and Setudehnia, 1972).

North of the Jabel Sinjar area (i.e. Qaratchok Darh Oilfield in northeast Syria), the Sinjar Limestone Formation seems to be similar to its development in the Chemchemal area, interdigitating at the base with the Germav Formation, passing up into a largely dolomitic sequence (Khurmala Formation) with interfingering clastics of the Gercus Formation from SE Turkey (Daniel, in: Dubertret et al., 1963). In western and northwestern Syria, similar Bank-reefs developed during the Early - Middle Eocene, recorded by Henson (1950). These Lower Eocene deposits in northwest Syria (Baflioun and Aafrine Areas)

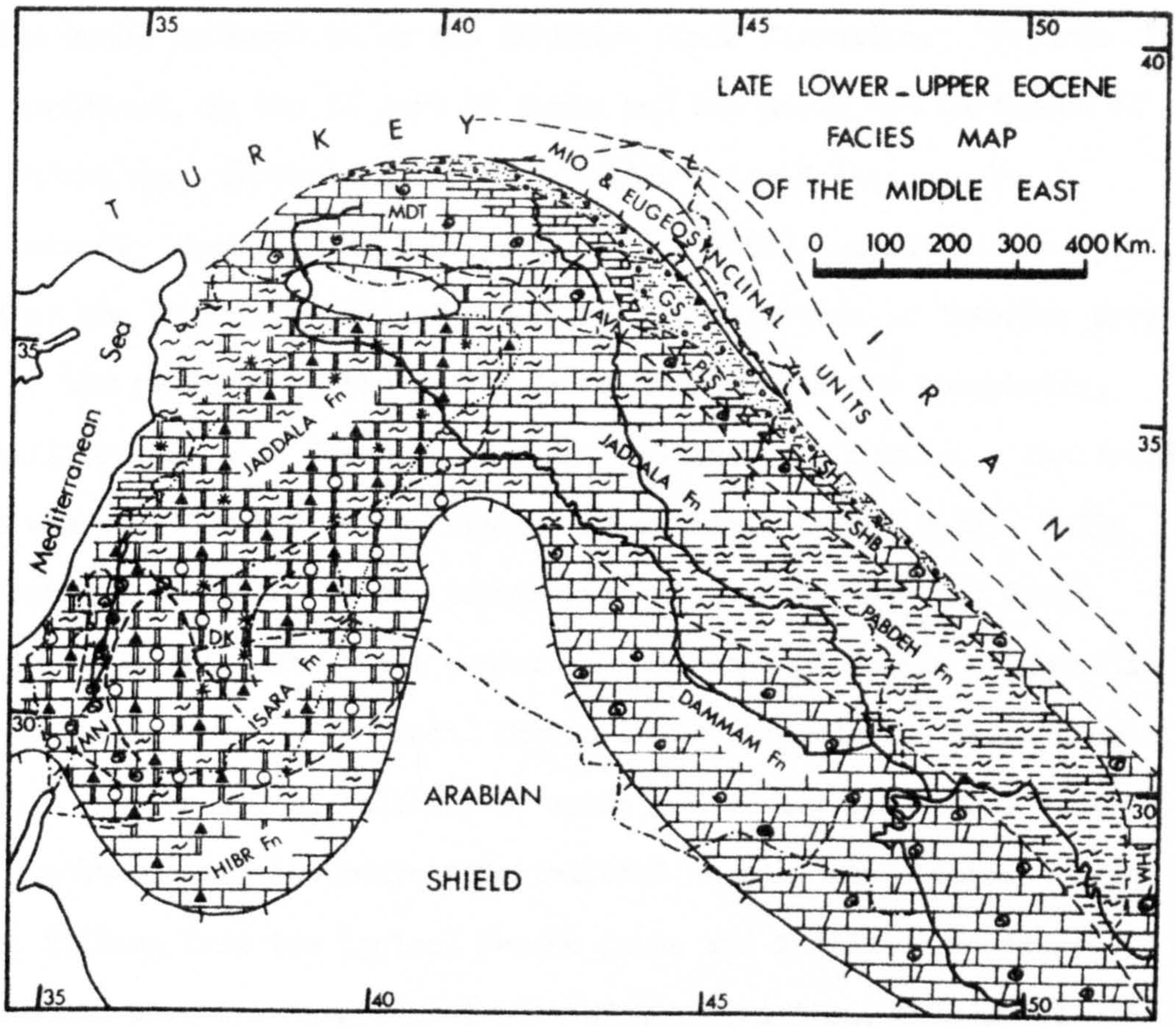
were also named the Sinjar Limestone Formation, being composed of "limestone, often chalky, with scattered nodules of flint and occasional glauconite: the rock is frequently bituminous. Where chalky it is often full of semi-losse Nummulites spp. showing some degree of wear" (Daniel, in: Dubertret et al., 1963, p.261).

3. Latest Early Eocene - Late Eocene (fig. 5)

A general uplift of the area during the easrliest Early Eocene resulted in a regression of the sea, notably in Syria, Turkey and Iraq. In these countries an unconformity separates the lower part of the Lower Eocene from the upper part of the Lower Eocene deposits. No unconformity has been recorded in Jordan and southeastern Iran, although a lithological and faunal break is present at the Palaeocene/ Eocene boundary in Jordan (Futyan, 1968 & 1976; Hamam and Haynes, 1977; and Yassini, 1979). A marine transgression took place in the later Early Eocene, submerging most of the islands present in previous periods, although the extent of the transgression was less than that of the Palaeocene - earliest Early Eocene (see figs. 4 & 5). The overall palaeogeography was similar to that of the Late Cretaceous and Palaeocene.

A - Stable Shelf

The Hibr Formation of northwestern Saudi Arabia continued to be deposited from the previous cycle, possibly until the Upper Eocene, while the Sara Chalk and Flint Formation of Jordan showed continuous deposition from the lower part of the Lower Eocene through to the Middle Eocene. At the end of the Lower Eocene a local regression of the Sara and Hibr Sea began, with local deposition of nummulitic limestone in many places and at different horizons, ranging from the uppermost part of the Lower Eocene to the Middle Eocene. This is called the Ma'an Nummulitic Limestone Formation. Earlier in the Late Eocene a general



REEFAL LIMESTONE

LAGOONAL DOLOMITIC LIMESTONE

SHOAL & NERITIC NUMMULITIC LIMESTONE

NERITIC CHALKY, MARLY, & CHERTY LIMESTONE

SUBLITTORAL PHOSPHATIC. MARLY LIMESTONE

BATHYAL PHOSPHATIC. MARLY CHALK & FLINT

U. BATHYAL PHOSPHATIC. GLAUCONITIC CHALK

OPEN SEA GLAUCONITIC. MARLS, CHALKS, & FLINTS

OPEN SEA MARLY LIMESTONE

OPEN SEA CHALKY MARL

OPEN SEA LIMY MARLS & SHALES

MOLASSE _ RED BEDS

AREA OF EROSION OR NO DEPOSITION

FLINT BEDS LIMIT

MDT MIDYAT FORMATION
AVN AVANAH LST. FORMATION
PLS PILA SPI LST. FORMATION
DK DHAHKIYE CHALK FORMATION
MN MA'AN NUMM. LST. FORMATION
SHB SHAHBAZAN FORMATION
GS GERCUS FORMATION
KSH KASHKAN FORMATION
JHM JAHRUM FORMATION

COMPILED WITH MODIFICATION FROM WOLFART. 1967; AL_HASHIMI. 1973; BUDAY. 1973; AND BENDER. 1975.

Figure 5 : Late Lower - Upper Eocene facies map of the Middle East .

regression of the Sara and Hibr Sea occurred, with only local deposition in the depression of the Dhahkiye taking place. These deposits are mainly chalks, glauconitic and phosphatic chalks, with bituminous marl at the base, referred to as the Dhahkiye Chalk Formation. Towards the northeast, in the SE part of Syria and the north and northeast of the Ga'ara area in Western Iraq, a shallow water facies can be recognized. Daniel (in: Dubertret et al., 1963) considered the Syrian part of the facies to belong to the Jaddala Formation of Interior Syria, due to the presence of the Arak Flint member within the phosphatic, nummulitic limestone deposits of this shallow water facies. The Iraqi part was considered by many authors (Al-Hashimi, 1973; Buday, 1973; and others) to belong to the Dammam Formation of SW Iraq and Saudi Arabia. It lacks the flint member and is composed mainly of nummulitic limestones, with a sudden local facies change towards the Akashat area, where a phosphatic bed followed by marls and chalky limestones containing new planktonic and benthonic foraminiferal assemblages occurs. This fauna differs from the typical Dammam fauna and indicates a direct connection with the open sea of the Jaddala Formation. Buday (1973) states that the facies of the sediments is somewhat different to the east and west of both the Rutbah Uplift and the Central Arabian arch. The eastern sector is covered by typical Dammam sediments. In the west, clastic admixture, flint and chert layers and nodules, some phosphatic admixture, and some frequent marly beds also occur. The western facies belongs to the Mediterranean, the eastern to the Indo-pacific bioprovince.

It is in fact more plausible to consider the shallow water facies of the Jabel Tenf - Ga'ara Area as a transitional facies separating both Mediterranean and Indopacific bioprovinces. This transitional facies is composed of a mixture of the nummulitic limestone of the Dammam Formation, some of the open sea Jaddala Formation faunal assemblages, as well as some of the flint and phosphatic lithofacies of

the Sara Chalk and Flint Formation. Southward in the eastern part of the stable shelf, the Dammam Formation was deposited under neritic/ littoral conditions, being composed mainly of dolomitized limestone. The limestones are sometimes chalky; blue silty waxy shale streaks or partings occur toward the base (Owen and Nasr, 1953).

The sea began to regress by the close of the Middle Eocene, as in the western side of the stable shelf (Al-Hashimi, 1973). Shallow, littoral and lagoonal conditions prevailed over most of the eastern side of the stable shelf, including the eastern part of the transitional facies, where it is dominated by open, littoral deposits, yielding Miliolid Foraminifera. The southern facies was dominated by very shallow, marine water, with lagoonal conditions characterized by the development of dolomites and dolomitic limestones yielding Mollusca, bryozoan skeletones, as well as miliolids. Towards the latest Eocene the sea had completely withdrawn from the south, whereas the shallow sea of the transitional facies in the north became progressively deeper, where open sea sublittoral, nummulitic and planktonic marly limestones were deposited.

B - <u>Mobile Shelf</u>

The end of the Van phase movements during the Early Eocene, saw a similar palaeogeographic picture to that of the Palaeocene. The mobile shelf consisted of two main basins of deposition, both trending E - W in their western parts and NW - SE in their eastern parts. The southern basin was large and open sea, separated from the northern basin by a shallow marine shoal zone. The northern basin was a strongly subsiding Foredeep Trough. The latter was separated from the Miogeosynclinal area by a pronounced uplifted ridge running from Amadiya - Ranya to Sulaimaniya in a NW - SE direction. (fig. 5).

The large open sea basin was infilled by the Jaddala Formation in Syria and Iraq and by its equivalent, the Pabdeh Formation, in Iran. To the west in Syria, the Jaddala Formation covers almost the entire country, apart from the northeast of the Euphrates river where part of the former Jabel Aabd el Aaziz Uplift still existed. No deposits of the Jaddala Formation have been recorded from the Sirrine area, and only a few metres at the flank of the uplift in the Abba and Jabel Aabd el Aaziz areas. The Jaddala Formation of Syria is composed of chalks, chalky and marly limestones, chalky marls, glauconitic beds, with numerous flint beds (Arak Flint member) and nodules towards base (Daniel, in: Dubertret et al., 1963). The lower flinty part of the Jaddala Formation is an offshore facies of the Sara Chalk and Flint Formation, deposited under cooler open sea conditions where no phosphatic deposits accumulated.

Beydoun (1977) in accordance with Dubertret (in: Dubertret et al., 1963) indicated that the Middle Eocene chalky marls of the Jaddala Formation changes into limestones and chalky limestones of subreefal origin towards the southern and Beka'a regions of Lebanon.

Eastwards in eastern Syria and Iraq the Jaddala Formation was deposited under deeper open sea conditions, with globigerinal marly and chalky limestones and marls prevailing. The former stable Khleisia - Der ez Zor Uplift was no longer in existence, being buried beneath the basinal sediments of the post-Palaeocene Tertiary. The Jaddala basin was the first Tertiary basin to become incorporated in the later uplift (Weber, 1963; and Buday, 1973), although, the basin was not uniform because the Jaddala Formation is of reduced thickness over parts of the former Khleisia - Der ez Zor and Mosul Uplifts.

According to Dunnington (1958), Weber (1963) and Buday (1973) an increase in the thickness of the Jaddala Formation can be observed

to the south of the Jabel Sinjar area, along the Makhul area and over the former Anah Trough. Farther southeastwards in Iran, the open sea basin became more mobile, with the marls and shales intercalated with subordinate argillaceous limestones of the Pabdeh Formation being deposited (Setudehnia, in: Stocklin and Setudehnia, 1972). The Pabdeh Formation was developed in southern Lurestan, Khuzestan, Coastal and subcoastal Fars Province. Farther southeastwards it passes into the carbonates of the Jahrum Formation, through a mixed facies of the Pabdeh and Jahrum Formations. North and northeastwards, the Jaddala and Pabdeh Formations interfinger with their inshore equivalent, known as the Avanah Limestone Formation and its equivalents in Turkey and Iran.

According to Bellen (in: Bellen et al., 1959) the Avanah Formation is composed of nummulitic limestone, generally dolomitized and recrystallized, of shoal facies, and with occasional intercalation of lagoonal dolomitized limestone which are regarded as tongues of the Pilaspi Limestone Formation. The sedimentation of this formation was controlled by a belt of shoals and islands, forming an effective barrier separating the foredeep trough of the Gercus Formation from the offshore open sea basin of the Jaddala Formation. In northeast Syria and southeast Turkey, the Midyat Limestone Formation is the equivalent to both the Avanah Limestone Formation and the lagoonal Pilaspi Formation. The Midyat Limestone Formation is composed of nummulitic limestone, dolomitic limestone, calcarenites, and evaporites (Rigo de Righi and Cortesini, 1964).

Southwards in northeast Syria the Midyat Limestone Formation becomes more dolomitic than in southeast Turkey, and fossils have been mostly destroyed by recrystallization (Daniel, in: Dubertret et al.,1963).

In Iran, the equivalent of the Avanah Limestone Formation are the upper part of the Taleh Zang Formation and the Shahbazan Formation, both in central and northeastern Lurestan. The Shahbazan Formation consists of white and brown weathering, thick bedded, porous, sugary dolomite and dolomitic limestone, yielding few fossils amongst which are Nummulites (Setudehnia, in: Stocklin and Setudehnia, 1972). Farther south towards Khuzestan, interior Fars, and the coastal Fars Provinces, the massive dolomites and dolomitic limestones of the Jahrum Formation are the equivalent to both the Taleh Zang and the Shahbazan Formations.

In general, according to Bellen (in: Bellen et al., 1959), the controlling belt of shoals and islands, and the foredeep trough behind it, moved slightly eastwards relative to the former belt and foredeep of the Palaeocene - Early Eocene. Evidence for this shorewards shifting of facies belts is the further northeastwards extension of the Pilaspi Limestone Formation relative to the former (Palaeocene - Lower Eocene) Khurmala Formation, and the presence of the offshore Jaddala Formation in the position of the former (Palaeocene - Lower Eocene) shoal facies of the Sinjar Limestone Formation around the Jabel Sinjar area. (see figs. 4 & 5).

The Foredeep basin progressively developed during the late Early Eocene, with subsidence becoming greater and the basin more mobile in the northwest. This area was most affected by the Van phase folding. Towards the southeast the basin was less mobile, with thinner sediments (Buday, 1973).

The deposits which filled the foredeep trough are known as the Gercus Formation, and consist of red and purple shales, mudstones, sandy and gritty marls with or without pebbles, some soft pebbly sandstones and conglomerates; lenticles of gypsum are present

especially towards the top, rare lignite occurs in a sandstone near the base, and rock salt occurs sporadically throughout (Bellen, in: Bellen et al., 1959). The Gercus Formation, according to Buday (1973), is apparently diachronous throughout its area of distribution. The age changes along the axis of the forodeep trough from the northwest to the southeast, being late Palaeocene - Early Eocene in southeast Turkey and Early Eocene - early Late Eocene in northeast Iraq. The equivalent to the Gercus Formation in Iran, known as the Kashkan Formation, is of Palaeocene? - Middle Eocene age.

The Kashkan Formation is composed of red conglomerate, sandstone, and siltstone; chert forms the main constituent of the rocks, the main identified fauna is Radiolaria spp., as in the Gercus Formation (Setudehnia, in: Stocklin and Setudehnia, 1972).

The foredeep trough showed less subsidence by the end of Middle Eocene, due to the stillstand situation of the Van phase movements. Partly lagoonal conditions prevailed over the basin, where the Pilaspi Limestone Formation was deposited. This formation in its upper part is composed of well-bedded bituminous limestone, chalky and crystalline limestone, with bands of pale green marl or white chalky marl, and with bands of buff chert nodules towards the top; the lower part shows well-bedded limestones, porous or vitreous, bituminous or white, and poorly fossiliferous limestones with algal and shell sections (Bellen, in: Bellen et al., 1959).

The Pilaspi Limestone Formation is of Middle and Upper Eocene age, it passes laterally southwestwards into the Avanah Limestone Formation, interfingering with it in the transitional zone. In some places the Pilaspi Limestone Formation interfingers with the Gercus Formation, otherwise the Pilaspi Limestone Formation is younger than the Gercus Formation, and the boundary is often marked by conglomerates.

The equivalent to the Pilaspi Limestone Formation in southeast Turkey is the northern part of the Midyat Limestone Formation, covering the Cizre and Hazro areas (Buday, 1973). The southeastern equivalent of this formation in Iran is the Shahbazan Formation, distributed over central and northeastern Lurestan (Setudehnia, in: Stocklin and Setudehnia, 1972). Signs of the Pyrenean Orogeny appeared during the late Eocene, associated with slowing down or ceasing of the subsidence of the geocynclinal and foredeep areas.

An increase in uplift and folding followed during the Oligocene, associated with an almost general regression of the sea in the Middle East, apart from some restricted basins in the northwestern to southeastern parts of Iraq, central and extreme nothwestern Syria, northern Jordan and southeast Turkey (Dunnington, 1958; Bellon, in: Bellon et al., 1959; Daniel, in: Dubertret et al., 1963; Rigo de Righi and Cortesini, 1964, and Buday, 1973).

During the Oligocene, the sedimentation in the southeastern part of the open sea basin continued and the upper part of the Pabdeh Formation was deposited in southwest Lurestan, Khuzestan and Coastal Fars trough in southwestern Iran (Setudehnia, in: Stocklin and Setudehnia, 1972).

CHAPTER _ 3

STRATIGRAPHY

STRATIGRAPHY

1. Jabal Sinjar Section (Table 1).

Location : Between lat. 36°24' N., long. 41°59' E and lat. 36°21'45" N., long. 41°58'30" E. at the southern flank of the eastern part of the Jabal Sinjar anticline.

Lithological Units:

1 - Shiranish Formation

Age : Maastrichtian

Thickness : 290.2 metres

Lithology : At the base of the exposure, the formation consists of grayish blue shaley marl and marl interbedded with thin beds of sandy limestone. Towards the middle, the formation consists of interbedded blue marl and marly limestone with beds of sandy limestones or calcareous sandstone, with some bitumen.

At the top the formation consists mainly of dark grey marly limestones, highly bituminous in some places, with some interbedded marl, sandy limestone and limestone.

The Shiranish Formation is overlain unconformably by the Sinjar Limestone Formation.

ii - Sinjar Limestone Formation

Age : Palaeocene

Thickness : 2.00 metres

Lithology : Conglomeratic limestone, overlain unconformably by the Aaliji Formation.

iii - Aaliji Formation

Age : Palaeocene? - Lower Eocene

Thickness : 44 metres

Lithology : Shaley marl at the base with a ripple marked

sandy limestone in the lowest metre above the Sinjar Limestone Formation. The shaley marl grades into marly beds interbedded with a few thin marly limestones containing some chert nodules or fragments. At the top, the marls become shaley, highly fractures and of a grayish blue colour.

This formation is unconformably overlain by the Middle Eocene Jaddala Formation.

iv - Jaddala Formation

Age : Middle - Upper Eocene.

Thickness : Lower part : 130.4 metres

Upper part : 110.8 metres

Lithology : Lower part - marl and marly limestone with abundant chert nodules.

Upper part - sandy, clayey marl at the base, followed by interbedded marl and marly limestones, the latter containing chert nodules. Towards the top the marly limestones become hard and are sometimes dolomitic and the marly beds become shaley and calcareous and contain siliceous limestone and limonitic pebbles. These increase in size toward the top becoming large spherical cobbles. At the extreme top, just below the unconformable contact with the early Miocene Serikagni Formation, the shaley marl becomes conglomeratic with some glauconitization.

v - Avanah Limestone Formation

Age : Middle / Upper Eocene

Thickness : 60.2 metres

Lithology : This formation exists as a tongue within the Jaddala Formation. At the base, there is a 50cm thinly bedded clayey marl and claystone, followed by interbedded hard marly

limestone, massive limestone (sometimes recrystallized), and some beds of marly or calcareous marl. This tongue of the Avanah Limestone Formation can be easily distinguished from the Jaddala Formation by the lack of chert nodules and the presence of the massive recrystallized limestones.

Remarks

Bellon (in: Bellon et al., 1959), Al-Saddiki (M.S. 1969), Kureshy (1970) and Youash and Naoum (1970) have studied sections from the Jabel Sinjar anticline, mostly from the northern flank near Mamissa Village. While those sections show the Shiranish, Sinjar Limestone, Jaddala, Serikagni Limestone, Jeribe Limestone and Lower Fars Formations, the Aaliji and Avanah Formations have not been recorded in this northern area.

Al-Rawi (1973) divided the Shiranish Formation of the section studied here into 3 units : thin platy blue shales at the bottom; a middle unit of alternating marls and sandy limestones with the upper portion characterized by chert nodules; and an upper unit of marls. He also noticed that the Sinjar limestone passes laterally from a reef facies in the west to marls in the east near Zerwan, where these marls contain chert nodules and two thick beds of sandy limestone. Amer (1977) considered the marls facies of the Sinjar limestone to be the Aaliji Formation, due to its characteristic assemblages, which are similar to those of the upper part of the Aaliji Formation of Well Injana-5 of Lower Eocene age described by Kassab (1975c). He also noticed that the Jaddala Formation of this area (East Jabel Sinjar) includes a lense of the Avanah Formation, a "shorewards facies of the Jaddala Formation".

2. Anah Well-2 Section: (Table 2)

Location : Iraq Grid E. 1,174,880; N. 1,373,890.

Lithological Units:

i - Jib'ab Marl Formation

Age : Upper Campanian - Maastrichtian

Thickness : 1229.2 metres

Lithology : Marly limestones and marl, locally glauconitic and bituminous. This formation is overlain conformably by the Hartha Limestone Formation.

ii - Hartha Limestone (Pilsener Limestone) Formation

Age : Maastrichtian

Thickness : a - Lower part 95.8 metres

b - Upper part 346.2 metres

Lithology : a - Lower part (mixture of Jib'ab-Hartha Formations):consists mainly of marly limestone beds interbedded with limestones, locally bituminous, with some glauconite and sands at the top.

b - Upper part (Hartha Limestone) : At the base, it consists of beds of marly limestone and sandy limestone with recrystallized pellets, followed by globigerinal and argillaceous limestones, limey marls, and marls, locally glauconitic,grading into sandy limestones at the top. The overlying Jaddala Formation is unconformable with the Hartha Limestone Formation.

iii - Jaddala Formation

Age : Middle - Upper Eocene

Thickness : 210.3 metres

Lithology : The formation consists mainly of glauconitic marls and marly limestones with abundant chert nodules.

The Sheikh Alas Limestone Formation of Oligocene age, rests unconformably above the Jaddala Formation.

Remarks

Buday (1973) considered the Jib'ab marl to be a somewhat aberrant facies of the Shiranish Formation; however, Dunnington et al. (in: Bellon et al., 1959) mentioned that "the Jib'ab marl is not strictly equatable with the Shiranish Formation, because of its character of faunal restriction and impoverishment which sets it apart from the open water/bathyal, richly microfossiliferous Shiranish Formation".

The upper part of the Hartha Limestone Formation consists mainly of glauconitic limey marls and marls, is possibly the equivalent of the Digma Formation which is found in Anah Well-1; however the contact between the real Hartha Limestone Formation and the overlying suggested equivalent of the Digma Formation is gradational.

3. Mityaha Well-1 Section: (Table 3).

Location : lat. 35°37'20.28" N., long. 42°13'54.52".

Lithological Units:

i - Shiranish - Hartha Formation

Age : Maastrichtian

Thickness : 127.7 metres

Lithology : At the base the formation consists of bituminous limey marls, marly limestones and evaporites, grading into evaporitic and locally dolomitized sandy marly limestones, enriched with bitumens at the top.

This formation is underlain unconformably by the Upper Campanian Sa'di Formation, and overlying unconformably by the Upper Eocene Jaddala Formation.

ii - Jaddala Formation

Age : Upper Eocene

Thickness : 197.3 metres

Lithology : The formation consists of intercalation of limey marls, marly limestones with chert nodules, shaley marls and evaporitic limestone; towards the top the formation becomes dolomitic with anhydrite nodules.

Towards the base, the marly limestones become sandy with some bitumens. This formation is overlain by the lower Miocene Euphrates Limestone Formation with an unconformable contact.

4. Makhul Well-2 Section (Table 4)

Location : Iraq Grid E. 1,361,600; N. 1,453,330.

Lithological Units:

i - Hartha Limestone (Pilsener Limestone) Formation

Age : Upper Campanian - Maastrichtian

Thickness : 417.3 metres

Lithology : The upper 284 metres were studied, which consist mainly of globigerinal and argillaceous limestones, largely recrystallized and dolomitized, sometimes becoming marly, sandy marly or evaporitic with some sulfur fragments. This formation grades upwards conformably into the Shiranish Formation.

ii - Shiranish Formation

Age : Maastrichtian

Thickness : 123.4 metres

Lithology : Intercalation of marls and marly limestones; highly bituminous and sometimes sandy. This formation is overlain unconformably by the Jaddala Formation.

iii - Jaddala Formation

Age : Middle - Upper Eocene

Thickness : 47.6 metres

Lithology : Marly limestone. The overlying formation, the Oligocene Palani Formation is unconformable due to a depositional break.

5. Chemchemal Well-2 Section (Table 5).

Location : lat. 35°33'27.65" N., long. 44°51'14.86" E.

Lithological Units

1 - Shiranish Formation

Age : Maastrichtian

Thickness : 366.4 metres

Lithology : Intercalations of marls, marly limestones and limestones at the base, grading into marls, sandy mudstones and marly limestones in the upper part.

It rests unconformably upon the Kometan Formation of Turonian age, and is overlain unconformably by the Aaliji-Kolosh Formation.

ii - Aaliji-Kolosh Formation

Age : Palaeocene - Lower Eocene

Thickness : 713.6 metres

Lithology : This lithological unit consists of intermixed Aaliji open sea sediments and the Kolosh near-shore clastics.

The main lithology is limestone, marl, sandstone, siltstone, shale and mudstone. It is overlain conformably by the Sinjar Limestone Formation.

iii - Sinjar Limestone Formation

Age : Lower Eocene

Thickness : 93.6 metres

Lithology : At the base interbedded reefal limestones, shales and marls, grading upwards into nummulitic limestone.

The contact with the overlying Khurmala Formation is conformable.

iv - Khurmala Formation

Age : Lower Eocene

Thickness : 77.7 metres

Lithology : Recrystallized Limestone, with some chert and marly intercalations at the top

The contact with the overlying Gercus Formation is unconformable.

v - Gercus Formation

Age : Middle Eocene

Thickness : 15.2 metres

Lithology : Red and purple shales, mudstones, sandy and gritty marls, grading up to marly limestones at the top. The Pilaspi Limestone Formation overlies the formation conformably.

vi - Pilaspi Limestone Formation

Age : Middle - Upper Formation

Thickness : 232.2 metres

Lithology : The lower part is composed of anhydrite, dolomitic limestones which are sometimes shaly, marly and highly bituminous.

The upper part is composed of well bedded bituminous,

chalky and crystalline limestones, shaley in some parts and highly porous in other parts.

This formation is overlain unconformably by the Lower Fars Formation of Middle Miocene age.

Remarks:

The upper part of the Shiranish Formation shows intercalations of mudstones, sands and marls, which suggest the upper part is transitional towards the Tanjero Clastic Formation. However, Dunnington (in: Bellen et al., 1959) mentioned the probability of finding Tanjero Clastics in this section. Buday (1973) proposed a transitional Zone lying in the area of this section, where a mixed Aaliji-Kolosh facies dominates, as it was described by Jameson (1961) as Aaliji-Kolosh Formation. This intermixing between the Aaliji open sea sediments and the Kolosh Clastics was explained by Bellen (in: Bellen et al., 1959), as being due to the ineffectiveness of the Sinjar Limestone and Khurmala Formations as barriers between the landwards lagoonal area and the open sea.

6. Tell-Burma Section: (Table 6)

Location : This section was measured and sampled by Futyan (1968) at Tell-Burma, South Jordan, 7.5 Km. south of the Jurf ed Darawish Railway Station, and 50 Km north of Ma'an town.

Lithological Units

i - Gharob Chalk Formation

Age : Middle - Upper Maastrichtian

Thickness : 10 metres

Lithology : Mainly chalk and chalky limestone, sometimes with light brown soft marl. It is overlain unconformably by the Taqiye Marl Formation.

ii - <u>Taqiye Marl Formation</u>

Age : Palaeocene

Thickness : 35 metres

Lithology : Clayey marl, gypsiferous mudstone on siltstone, brownish to olive green and grayish in colour, intercalated with a 1m.thick bed of hard splintery grey limestone near the base, and 50cm. of discontinuous nodular marly limestones below the top. This formation is overlain conformably by the Sara Chalk & Flint Formation.

iii - <u>Sara Chalk & Flint Formation</u>

Age : Lower Eocene

Thickness : The lower 9 metres only were studied.

Lithology : Limestone with a 1m. sandy limestone bed at the base, and chalky limestone with chert bands and nodules on the top (the first chert bed appears 10-15m. above the base).

CHAPTER _ 4

BIOSTRATIGRAPHY

BIOSTRATIGRAPHY

The biostratigraphy of the area stretching from Egypt to Iraq has been studied by El-Naggar (1966; Egypt); Futyan (M.S. , 1968; Jordan); Al-Hashimi (M.S., 1972; western Iraq); Kassab (1973; 1974; 1975a, b, c; 1976a, b; 1978; northern Iraq); Hamam and Haynes (1977; Jordan) and Yassini (1979; Jordan). These authors were able to recognize three faunal breaks in the Middle East using planktonic foraminiferal zones (Table 7). The first of these breaks occurs at the Cretaceous - Palaeocene boundary; in Egypt the upper part of the Globotruncana esnehensis and the whole Globigerina eugubina and Globorotalia pseudobulloides zones are absent; in Jordan the break was slightly shorter because the upper part of the Grt. pseudobulloides zone is present; eastwards in Iraq the break started slightly later with only the topmost part of the Glt. esnehensis zone missing, but its duration was longer, with the absence of the entire Lower Palaeocene and the lowest part of the Middle Palaeocene Grt. uncinata zone; in some parts of western and mid-northern Iraq the break is even greater, extending to the Truncorotaloides rohri zone of the uppermost Middle Eocene. The second faunal break is well recognized in the Middle-Upper Palaeocene of southern Jordan where it is identified by the disappearance of the upper part of the Grt. uncinata zone, the whole of the Grt. angulata and Grt. pusilla pusilla zones and the lower part of the Grt. acuta /Grt. velascoensis zone of Futyan (M.S., 1968). The third faunal break has been identified by Al-Hashimi (M.S., 1972) in western Iraq and by Kassab (1975c, 1976a, 1978) in northern Iraq; it lies at the Lower-Middle Eocene boundary and is generally defined by the last appearance of the Grt. aragonensis zone and the first appearance of the Globigerapsis kugleri zone in northern Iraq, or the Grt. lehneri zone in western Iraq.

SERIES	STAGE	GENERAL & TRINIDAD BOLLI. 1966	EGYPT EL-NAGGAR 1966	TELL-BURMA JORDAN PUTYAN IMS 1968)	SYRIA EAEL 1969	N IRAQ KASSAB 1973-1978	W IRAQ AL-HASHIMI (MS 1972)
MAASTRICHTIAN	UPPER	Globorotalia cerroazulensis			Glt. cerroazulensis		Glt. cerroazulensis
		Globigerapsis semiinvoluta			Gs. semiinvoluta		
	MIDDLE	Truncorotaloides rohri			T. rohri		T. rohri
		Particulasphaera mexicana			Part. mexicana		Glt. lehneri
		Globorotalia lehneri			Glt. lehneri		
		Globigerapsis kugleri			Gs. kugleri		
		Hanthkenina aragonensis			Glt. hullbrooki		
	LOWER	Globorotalia palmerae			Glt. pentacamerata		
		Globorotalia aragonensis		Globorotalia rex	Glt. aragonensis	Glt. aragonensis	
		Globorotalia formosa formosa	Globorotalia wilcoxensis		Glt. formosa formosa	Glt. formosa formosa	
		Globorotalia rex			Glt. subbotinae	Glt. subbotinae	
PALEOCENE	UPPER	Globorotalia velascoensis	Glt. velascoensis	Glt. acuta/ Glt. velascoensis	Glt. velascoensis	Glt. velascoensis	Glt. acuta Glt. conomiozea
		Globorotalia pseudomenardii					Glt. pseudomenardii
	MIDDLE	Globorotalia pusilla pusilla	Glt. angulata	Glt. pusilla pusilla	Glt. angulata	Glt. pusilla pusilla	
		Globorotalia angulata				Glt. angulata	
		Globorotalia uncinata		Glt. uncinata		Glt. uncinata	
	LOWER	Globorotalia trinidadensis	Glt. compressa/ G. dumbjergensis	Glt. compressa/ G. dumbjergensis			
		Globorotalia pseudobulloides		Glt. pseudobulloides			
		Globigerina eugubina					
MAASTRICHTIAN	UPPER	Abathomphalus mayaroensis	Glt. conomiozea	Glt. conomiozea		Glt. falsocalcarata	Glt. falsocalcarata Ab. mayaroensis
	MIDDLE	Globotruncana gansseri	Glt. gansseri	Glt. gansseri		Glt. gansseri	Glt. gansseri
	LOWER	Globotruncana lapparenti tricarinata	Glt. formicata			Glt. ara	Glt. ara

Table 7 : Planktonic Foraminiferal Zonation of the Middle East .(Crossed areas mean non- studied, and the striate areas are unconformities)

Forty six species of Trachyleboridinae have been found in the sections studied in Jordan and Iraq. In addition, nine species were found in the material from Syria, which help to fill in the gap between Jordan and Iraq. The ostracods occur at different horizons, often separated by faunal breaks which may represent long periods of time. Characteristic faunas will be discussed for each section studied.

1. - Tell-Burma Section:

Two biostratigraphic horizons can be recognized within this section (Table 8):

a - A Maastrichtian horizon correlated with the foraminiferal zones Glt. ganssori - Glt. esnehensis; the only species of Trachyloberidinae is Cristacleberis fornicata Bassiouni (1970), associated with the non-trachlyberidine Mauritsina supracretacea Bassiouni (1970), Orthonotacythere? sp., and Protobuntonia sp.

b - A Lower - Middle Palaeocene horizon correlated with the Grt. pseudobulloids - Grt. compressa / G. daubjergensis - Grt. uncinata zones; this horizon contains 13 trachyleberidine species belonging to the genera Acanthocythereis, Allocosta, Cristacleberis, Oertliella, Ordoniya, and Paracosta. Other ostracods present include Bairdia, Cytherella, Cytherelloidea, Cytheropteron, Eucytherura?, Mauritsina, Pontocypris, Protobuntonia and Xestoleberis.

2. - Anah Well-2 Section:

Two biostratigraphic horizons can be recognized in this section (Table 8):

a - A horizon correlated with the upper part of the Maastrichtian horizon of the Tell-Burma Section and defined by the upper

part of the Glt. contusa - osnehensis - duwi zone of Kassab of northern Iraq.

The most abundant ostracode genus at this horizon is Occultocytherois, associated with Acanthocytherois and Dumontina; besides there are many other non-trachyleberidine genera such as Bairdia, Cytherella, Cytherelloidea, Cytheridea (Haplocytheridea), Cytheropteron, Echinocytherois, Eucytherura, Hemicytherura, Hermanites, Orthonotacythere, Paracypris, Paracytheridea, Pontocyprella, Schulerioidea?, Semicytherura?, and Xestoleberis.

b - A Middle - Upper Eocene horizon, defined by the uppermost Middle Eocene foraminiferal zone Truncorotaloides rohri at the base and the Upper Eocene zone Grt. cerroazulensis at the top. Paracosta (Paracosta) hammurabii sp. nov. is the most abundant trachyleberidinae species, associated with some other species belonging to the genera Ordoniya and Paracosta. The association of Paracosta (Paleocosta) crassireticulata with Paracosta (Paleocosta) aliena appears to be of some importance concerning correlation with the lowermost part of the Upper Eocene of Egypt.

Other non-trachyleberidine genera are Bairdia, Buntonia, Cytherella, Cytheropteron, Eucytherura, Leguminocytherois?, and Protobuntonia?.

3. Mityaha Well-1 Section:

In this section the only trachyleleridine species found is Paracosta (Paracosta) praecrassireticulata from a horizon correlated with the lowermost Upper Eocene of Anah Well-2. The associated non-trachyleberidine genera are Argilloecia, Cytherella, Krithe, Leptocythere, Loxoconcha, Paracypris, Paradoxostoma?, Pokornyella, and Xestoleberis, which suggest a brackish to littoral environment,

Table 8 : Distribution of the Ostracod species (Subfamily Trachyleberidinae) in the studied sections. (Crossed areas mean non- studied, and the striate areas are unconformities)

probably reflecting the Khleisia - Der ez Zor Uplift which separated the Mediterranean Bioprovince from the Indopacific Bioprovince (See figs. 4 & 5).

4. Jabel Sinjar Section:

Three biostratigraphic horizons can be recognized.

a - A Maastrichtian horizon correlated with the Glt. arca - tricarinata - subcircumnodifer subzone and Glt. gansseri - bohijae - Gubl. cuvillieri subzone, and defined by the presence of Paragrenocythere monilis sp. nov. associated with the genera Argilloecia, Bairdia, Cytherella, Eucytherura, Krithe, Paracypris, Pterygocythere, and Xestoleberis.

b - A Palaeocene? - Lower Eocene horizon correlated with the Grt. subbotinae and Grt. formosa formosa zones of northern Iraq; it contains 5 species belonging to the genera Occultocythereis, Ordoniya, and Paracosta (see Table 8).

Paracosta (Paracosta) arabica occurs in the Lower-Middle Palaeocene horizon of the Tell-Burma Section; in the Jabel Sinjar Section it extends to a Middle - Upper Eocene; the distribution of Ordoniya (Ordoniya) sinjariya also extends to the Middle - Upper Eocene of the Anah Well-2 Section. The associated non-trachyleberidine genera are Argilloecia, Bairdia, Buntonia?, Cytherella, Cytheropteron, Echinocythereis, Hermanites, Kingmaina?, Monoceratina, Orthonotacythere, Paracypris, Paracytheridea, Phalcocythere, Quadracythere, Schizocythere, Semicytherura?, and Xestobeleris.

c - A Middle - Upper Eocene horizon bounded by the foraminiferal zones Globigerapsis kugleri at the base and Grt. cerroazulensis at the top, and containing a variety of species belonging to the

trachyleberidine genera Allocosta, Occultocythereis, Ordoniya and Paracosta, of which Allocosta ninurta sp. nov. and Ordoniya (Pharkidata) bilobatus sp. nov. are the most characteristic species. Paracosta (Paracosta) praecrassireticulata occurs at this horizon in the Mityaha Well-1 and Makhul Well-2 Sections, but it occurs at older horizons in Jordan, i.e. Lower? - Middle Eocene (Bassiouni, 1969a, b, 1970).

The associated non-trachyleberidine genera are Argilloecia, Bairdia, Brachycythere?, Buntonia, Cytherella, Cytherelloidea, Cytheridea, Cytheropteron, Cytherura, Echinocythereis?, Eucytherura, Hermanites, Kingmaina?, Krithe, Loxoconcha?, Mauritsina, Monoceratina?, Orthonotacythere, Paracytheridea, Paracypris, Phalcocythere, Polycope, Pantocypris, Protobuntonia, Quadracythere, Schizocythere, Uroloberis, and Xestoloberis.

5. Makhul Well-2 Section:

This section has some similarity to the Mityaha Well-1 Section with respect to a very long faunal break affected by the Khleisia - Der ez Zor Uplift. The two biostratigraphic horizons of this section indicate deeper water conditions than those of the Mityaha Well-1.

a - A Maastrichtian horizon correlated with the foraminiferal subzones Glt. gansseri - bohijae - Gubl. cuvillieri and Glt. arca - tricarinata - subcircumnodifer (Kassab, 1973, 1974, 1975a, b, c, 1976b) (Table 7). This horizon contains most of the trachyleberidine species of the section, belonging to the genera Cythereis (most common), Occultocythereis and Polorions. Cythereis? ashurbanipali sp. nov. is the most characteristic species of this horizon. The associated non-trachyleberidine genera are Bairdia, Brachycythere, Cytherella, Eucytherura,

Krithe, Paracypris, Polycope, Pontocyprella, Pterygocythere, Schizocythere, Uroleberis, and Xestoleberis.

b - An uppermost Middle - Upper Eocene horizon correlated with those of the Mityaha Well-1 and Anah Well-2 Sections, and the upper part of the Jabel Sinjar Section. It contains the species Paracosta (Paracosta) praecrassireticulata, associated with a few specimens belonging to the genera Bairdia and Paracyprideis?.

6. Chemchemal Well-2 Section:

a - A Maastrichtian horizon correlated with that of the Tell-Burma Section and Anah Well-2, with two species of the genus Acanthocythereis, of which Acanthocythereis (Acanthocythereis) cornioculus sp. nov. is the most important, appearing in an older horizon than its occurrence in the Palaeocene of the Tell-Burma Section of Jordan. The associated non-trachyleberidine genera are Bairdia, Cytherella, Echinocythereis, Hermanites?, Mauritsina?, Paracypris, Pontocyprella, Quadracythere, and Schizocythere.

b - A Middle? Palaeocene - Lower Eocene horizon probably bounded by the Grt. pusilla pusilla zone at the base and the Grt. formosa formosa zone at the top; the horizon has the same two species that appeared in the underlying horizon, i.e. this extends the range of Acanthocythereis (Canthylocythereis) alacer (M.S.) Al-Furaih, 1976 into younger strata than in Saudi Arabia, while A. (A.) cornioculus is also present here at a younger horizon than in Jordan. The associated non-trachyleberidine genera are Alocopocythere, Argilloecia, Bairdia, Brachycythere?, Buntonia, Cytherella, Cytheropteron, Eucytherura, Hermanites, Kingmaina, Krithe, Loguminocythereis, Paracyprideis, Polycope, Pontocypris, Propontocypris, Quadracythere, Schizocythere, and Xestoleberis.

OSTRACOD BIOZONES

The presence of stratigraphical breaks in the successions at the various localities examined make it difficult to establish a zonation for any individual section. The palaeogeography of the time, together with evidence of west to east ostracod migration pose extra difficulties. The Syrian material has proven useful for completing the gap in data between Jordan and Iraq, and as a result a preliminary biozonation of the area is attempted. Five biozones are recognized, but further study will be required to see whether this scheme can be further refined (Table 9).

Siddiqui (1971) and Al-Furaih (M.S., 1976) have attempted zonal schemes based on ostracods for the Palaeogene of Pakistan and the Maastrichtian - Palaeocene of Northeastern Saudi Arabia respectively. It has not been possible to recognize their zones in the Jordan - Iraq area because the species they used are absent. A general correlation between the three ostracode biozonations can be attempted however.

Ostracod Biozone I:

This Biozone is of Maastrichtian age, with 18 trachyleberidine species. Its base is defined by the first appearance of Cristaeleberis formicata Bassiouni (1970) and Cythereis? ashurbanipali sp. nov., its top by the first appearance of the genera Allocosta nov. and Ordoniya nov. of Ostracod Biozone II.

Two species of this Biozone have a long range extending to the lower part of Ostracod Biozone III, (Acanthocythereis (C.) alacer (M.S.) Al-Furaih, 1976 and Acanthocythereis (A.) cornioculus sp. nov.). This Biozone is probably correlatable with the Ostracod Biozone II

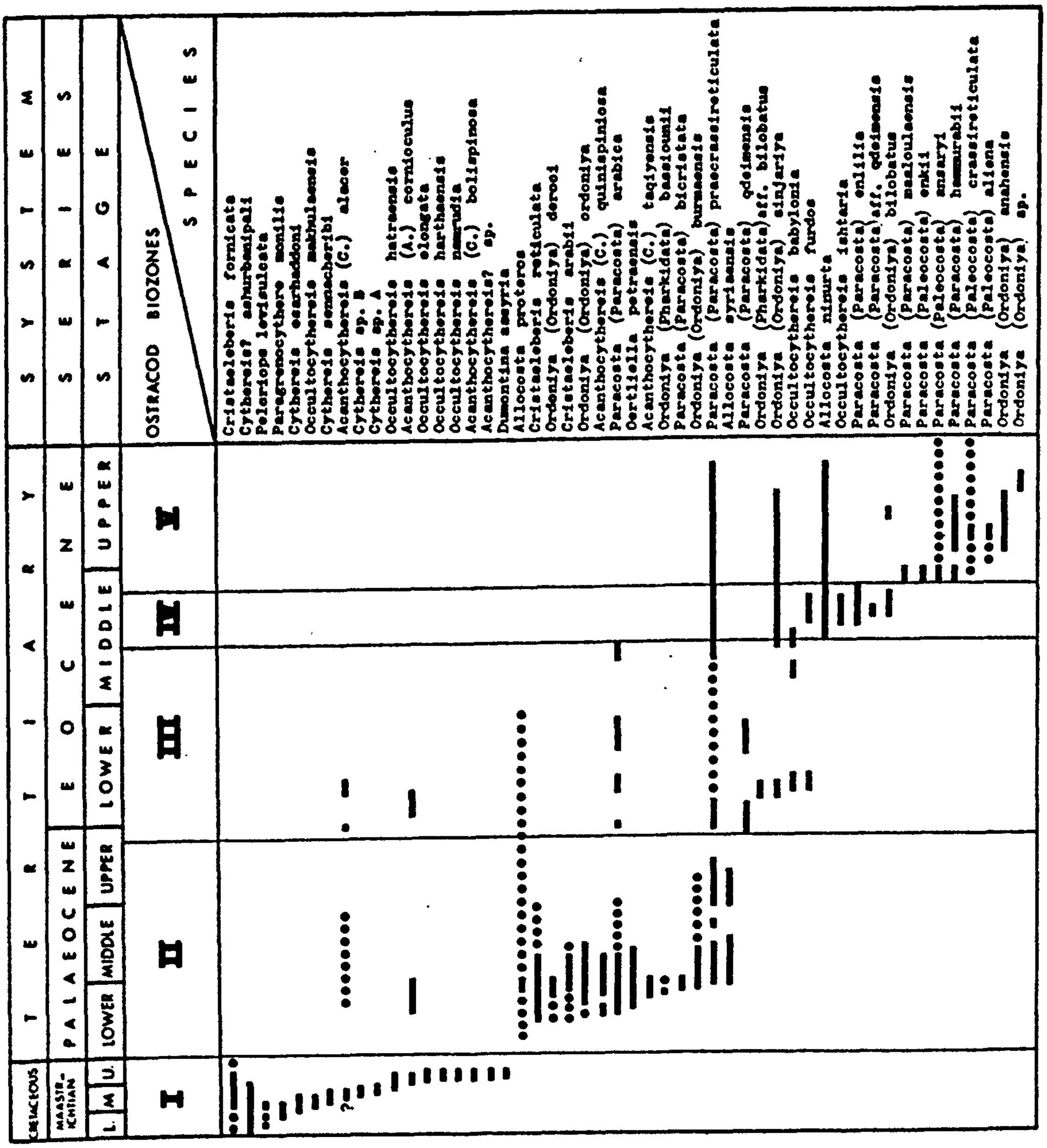


Table 9 : Preliminary Ostracod (Subfamily Trachyleberidinae) Biozonation of the Middle East .(Dotted ranges are after Bassiouni(1969a,b&1970) and Al- Furaih (M.S. 1976) .

described by Al-Furaih (M.S., 1976) from Saudi Arabia, but they have no species in common.

Ostracod Biozone II:

This Biozone is of Palaeocene age, with 16 trachyleberidine species. The base is defined by the first appearance of the genera Allocosta nov. and Ordoniya nov. and the top by the disappearance of Allocosta syriaensis sp. nov. and the first appearance of Paracosta (Paracosta) qdeimensis sp. nov.. Apart from the underlying Biozone, three species of this Biozone, Allocosta proteros (Bassiouni), Paracosta (Paracosta) arabica (Bassiouni) and Paracosta (Paracosta) praecrassireticulata (Bassiouni) have long ranges, extending in the case of the latter species into Ostracod Biozone V. This Biozone is approximately correlated with Ostracod Biozone III - V of Saudi Arabia and Ostracod Biostratigraphic Units I & II of West Pakistan. In both cases there are only related species present, except Acanthocythereis (C.) alacer (M.S.) Al-Furaih, 1976 which is present in Saudi Arabia as well as Iraq.

Ostracod Biozone III:

This Biozone is of latest Late Palaeocene - earliest Middle Eocene age, with 10 trachyleberidine species of which 3 are characteristic for the biozone, and usually appear in combination with the others. The most characteristic species are Paracosta (Paracosta) qdeimensis sp. nov. or Ordoniya (Pharkidata) aff. bilobatus sp. nov. and Occultocythereis babylonia sp. nov.; others are Paracosta (Paracosta) arabica (Bassiouni) and/or Paracosta (Paracosta) praecrassireticulata (Bassiouni).

There is no equivalent Ostracod Biozone in Saudi Arabia but in West Pakistan, Siddiqui's Ostracod Biostratigraphic Units

III, IV and the lower part of V contain some related species of Occultocythereis and Acanthocythereis.

Ostracod Biozone IV.

This belongs to the middle part of the Middle Eocene, with 5 characteristic trachyleberidine species together with other 3 species present in the underlying biozones. This Biozone can be easily distinguished in Iraq by the first appearance of Allocosta ninurta sp. nov., Occultocythereis ishtaria sp. nov., Ordoniya (Pharkidata) bilobatus sp. nov., and Paracosta (Paracosta) enlilia sp. nov., in association with Ordoniya (Ordoniya) sinjariya sp. nov. and Paracosta (Paracosta) praecrassireticulata (Bassiouni).

Paracosta (Paracosta) praecrassireticulata (Bassiouni) also appears in the lower part of the Upper Chocolate Clays of the Ostracod Biostratigraphic Unit V of Pakistan; it is synonymous with Costa (Paracosta) compitalis Siddiqui, 1971 (See taxonomical comments for more details).

Ostracod Biozone V.

This Biozone is of latest Middle Eocene - Late Eocene age, defined by the first appearance of six species of the genus Paracosta of which Paracosta (Paracosta) hammurabii sp. nov., Paracosta (Paleocosta) crassireticulata (Bassiouni), Paracosta (Paleocosta) ansaryi (Bassiouni) and Paracosta (Paleocosta) aliena (Bassiouni) are of great importance throughout the Upper Eocene of the Middle East. This Biozone includes 12 trachyleberidine species, 4 of which are present in older biozones. Allocosta scitula (Bassiouni) from Egypt and Jordan, and Paracosta (Paracosta) capsella (M.S., Al-Furaih,

1976) from Saudi Arabia are other species included in this Biozone.

The Upper Eocene part of the Ostracod Biostratigraphic Unit V of West Pakistan is correlated with this Biozone.

CHAPTER _ 5

SYSTEMATIC DESCRIPTIONS _ A

Subclass	OSTRACODA Latreille, 1806
Order	PODOCOPIDA Muller, 1896
Suborder	PODOCOPINA Sars, 1866
Superfamily	CYTHERACEA Baird, 1850
Family	TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily	TRACHYLEBERIDINAE Sylvester-Bradley, 1948

Genus Acanthocytherois R.C. Howe, 1963

Type Species: Acanthocytherois araneosa R.C. Howe, 1963.

Diagnosis: Trachyleberidinae in which the surface is reticulate with superimposed spines, distinct or indistinct sub-central tubercle, marginal area variable, and with a crenulate or non-crenulate posterior tooth.

Discussion:

According to Hazel (1967) Trachyleberis Brady (1898) is a non-reticulate genus with spines as the only ornamentation; Actinocytherois Puri (1953) is also non-reticulate but with spines arranged in three rows; and the reticulate and spinose species which are often placed in Actinocytherois or Trachyleberis, are classified in the genus Acanthocytherois R.C. Howe (1963). Acanthocytherois as usually diagnosed also differs from the other two genera in having an indistinct sub-central tubercle, narrow marginal areas, and has some crenulations on the knoblike posterior tooth of the hinge. Thus it is not just a matter of presence or absence of reticulation.

In 1971 Siddiqui described 5 species which he assigned to the genus Trachyleberis (Acanthocytherois), from West Pakistan. This was followed by Al-Furaih (M.S. 1976) who described a further group of 8 species assigned to Acanthocytherois, from Saudi Arabia. Both groups of species have a distinct sub-central tubercle and have a moderately broad marginal zone, quite unlike the type species of the genus Acanthocytherois R.C. Howe (1963). Together with further species

from Iraq, Syria, and Jordan, it is possible to recognize a quite distinct taxon, recognised here as a new subgenus of Acanthocythereis. This subgenus includes all those species with a distinct sub-central tubercle and wide marginal area. Thus the genus Acanthocythereis R.C. Howe (1963) may or may not have a sub-central tubercle.

Subgenus Acanthocythereis (Acanthocythereis) sensu stricto

Diagnosis: A subgenus of Acanthocythereis with indistinct sub-central tubercle .

Acanthocythereis (Acanthocythereis) cornioculus sp. nov.

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

Name: Latin corni -, horn + oculus, eye; with reference to the horn-like eye tubercle.

Diagnosis: A species of the subgenus A.(Acanthocythereis) with a horn-like eye tubercle and a distinct ventromarginal rim.

Holotype: Female carapace, OS 11194, pl . 1 , figs. 1 & 4

Paratype: OS 11195 - OS 11203

Material : 15 specimens : including 11 specimens from the Lower Palaeocene of Jordan, 2 specimens from the (Maastrichtian?) Palaeocene - Lower Eocene of the Chemchemal Well-2, NE Iraq, and 2 specimens from the Palaeocene - Lower Eocene of the Bir Qdeim section, Syria.

Type Locality: Toll-Burma section, Jordan

Type Horizon: Lower Palaeocene (Upper Danian) Sample no. BMJ 850

Description: Eye tubercle is surprisingly well developed and protruding over the dorsal margin diagonally towards the anterior like a horn. Marginal rim present, extending from the eye tubercle around the anterior, ventral, and posterior margins and ending at the posterior cardinal angle; the ventro-marginal rim is distinctly developed.

Surface ornamentation consists mainly of reticulations and superimposed spines; the reticulation varies, the larger and quadratic

reticules are arranged in the outer rows, whereas the smaller and triangular to rounded reticules are present towards the centre of the valve. The main featured spines are pore cones in the position of "Pisces, Alpha, Capricornus, Beta, and Scorpio" in the case of the anterior spines; "Aquarius, Sagittarius, and Virgo" in the case of the dorsal spines; and "Charon, Omega, and Leo" for the middle spines. (For definition of pore cones, see fig. 10, and Benson, 1972); the ventral part is ornamented by a row of six spines, the posterior one being the strongest. There are also two rows of spines around the anterior margin; the outer row consists of 19-20 small spines; 9-10 small spines or nodes lying on the anteromarginal rim form the inner row of spines. At the postero-marginal rim there are 7 spines or pore cones; five of them on the ventral part of the rim, the other two are on the dorsal part; the dorsal-most spine is missing in the right valve.

Dorsally, the carapace is wedge-shaped, both sides converging to the anterior, with laterally compressed ends, maximum width is level with the posterior-most posteroventral spine. In ventral view, the ventro-marginal rim can be clearly distinguished.

Internally, marginal area is narrow, inner margin and line of concrescence coincide; selvage submarginal and prominent; radial pore canals are straight and simple, with about 21 anterior pore canals, and 12 posterior pore canals. Hinge is Amphidont/Heterodont; the left valve hinge elements consisting of an anterior deep tooth socket, a postjacent conical tooth, followed by finely crenulated median bar, ending with a posterior socket. Muscle scars lie in a shallow depression and consist of 4 elongated adductor muscle scars, the second one from the top being the longest, and a V-shaped frontal scar which lies in front of the dorsalmost two adductor muscle scars.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11194	female (Holotype)	0.937	0.555	0.460?	1.689
OS 11195	male	0.960	0.525?	0.500?	≈1.823
OS 11197	juvenile	0.750	0.430	0.450	1.744

Discussion :

This species can be easily distinguished from other species of Acanthocythereis found in the Middle East by its large size and protruding well developed eye tubercle. There is some resemblance between this species and some species of the genera Mauritsina Deroo (1962) and Spinoleberis Deroo (1966); but the lack of the sub-central tubercle, and differences in the diagnostic internal features such as muscle scar pattern and hinge elements assign this species to Acanthocythereis.

Acanthocythereis projecta Bassiouni (1969b) from the mid Upper Eocene of Egypt, shows some resemblance in shape and presence of protruding eye tubercle, but differs in its smaller size, better developed marginal spines, and spines on the lateral surface, and by having a moderately wide marginal area. Acanthocythereis salahii Bassiouni (1969b) from the Upper Eocene of Egypt and Oligocene of Libya, differs in general outline, lacking the protruding eye tubercle, and also in the details of ornamentation. Acanthocythereis sp. Salahi (1966) from the Lower Eocene of Libya, resembles this species in outline, shape, protruding eye tubercle, and ornamentation; but the extremely large size of Acanthocythereis sp. Salahi (1966) (i.e. 1.50 cm.) precludes the possibility of considering them conspecific; it is possible however, that there is a phylogenetic relationship between these two species, with the Libyan species a descendant of Acanthocythereis (Acanthocythereis) cornioculus sp. nov.

Occurrence: Known so far from the Upper Cretaceous - Palaeocene of the Chemchemal Well-2, Iraq, at drilling depths 3124' - 3142' and 5555' - 5560'; and from the Lower Palaeocene and Lower Eocene of the Bir Qdeim section, Syria, I.P.C. Samples no. Jd 680 and Jd 743 respectively, and from Lower Palaeocene (Upper Danian) of the Tell-Burma section, Jordan.

Acanthocytherois (Canthylocytherois) subgen. nov.

Name: kanthyle (G.) = swelling, with reference to the distinct sub-central tubercle

Diagnosis: Acanthocytherois with a distinct sub-central tubercle, moderately broad marginal area and with a non-crenulate posterior tooth.

Type Species: Acanthocytherois (Canthylocytherois) quinquespinosa sp. nov.

Occurrence: This subgenus is distributed over the area stretching from the Middle East, through Saudi Arabia to Pakistan, ranging from the Upper Cretaceous to the Upper Eocene.

Acanthocytherois (Canthylocytherois) quinquespinosa sp. nov.

pl. 1, figs. 6, 9-11; pl. 2, figs. 1-5

Name: Latin *quinque*, five + spinosus, thorny; with reference to the five spines present on the sub-central tubercle.

Diagnosis: A species of Acanthocytherois (Canthylocytherois) with a distinct sub-central tubercle bearing five spines; eye tubercle distinct with 2-3 small spines lying on its dorsal side. Surface reticulate with numerous normal pore canals; spines are of varying strength and usually bear a normal pore canal.

Holotype: Female carapace, OS 11208, pl. 1, figs. 6 & 10

Paratype: OS 11209 - OS 11220

Material: 110 specimens from the Lower Palaeocene (M.-U. Danian) of the Tell-Burma section, Jordan.

Type Locality: Tell-Burma section, Jordan .

Type Horizon: Lower Palaeocene (Upper Danian) sample no. BMJ 848 .

Description: Subrectangular carapace in lateral outline; anterior margin is moderately and obliquely rounded; posterior end pointed at the middle. Eye tubercle distinct with 2-3 small spines or nodes lying on its dorsal side, the longest spine being at the posterior. Subcentral tubercle is distinct and bears 5 spines, two of them lying anteriorly in a vertical row, while the other three lie around the posterior part of the sub-central tubercle; the middle spine is usually the longest.

Antero and postero-marginal rims are distinct; anteriorly there are 3 rows of spines, the outer row consisting of 14-16 strong spines, the middle row of 7-8 spines, while the inner row which lies at the antero-marginal rim, has 11-13 small spines. The postero-marginal rim has 6 large spines; 4 on the ventral part, one on the dorsal and one at the pointed posterior end which is divided into four small spines, one of those small spines points laterally, while the other three point to the posterior. The entire surface is covered by small rounded reticulation apart from the first and second anterior rows (A & B) which have large fossae with narrow muri, and the surface just beyond the postero-marginal rim which is smooth. There are many normal pore canal openings amongst the reticulation, some of which have developed to pore cones or spines of varying strength. Anteriorly there are five prominent small spines (pore cones of Pisces, Capricornus, Alpha, Beta, and Scorpio); dorsally there are four prominent spines (pore cones of Aquarius, Sagittarius, Taurus and Virgo), Sagittarius is a large pore comulus while Virgo is the largest and has a small branch at its base; there is another strong spine at

the posterior cardinal angle, present in the left valve only; the posterior surface has 2 pore cones, the largest is the Charon pore conulus while the other is the Psi pore conulus. Ventrally there are 7 pore cones; 5 of them arranged as a ventral row, increasing in strength towards the posterior, the other 2 pore cones are Leo and Phi.

In dorsal view, the carapace has almost parallel sides, with laterally compressed ends, maximum width at the subcentral tubercle or at the posterior spine of the ventral row. In ventral view, the anterior surface has 4 rows of nodes, the outer three rows ending at the mid-length while the inner row divides towards the posterior.

Internally, the marginal area is moderately wide; inner margin and line of concrescence coincide; selvage submarginal and prominent; radial pore canals are straight and simple, with some 32 at the anterior and 13-14 at the posterior. Hinge is Amphidont/ Heterodont, right valve hinge elements consisting of a high subangular anterior tooth with a posterior extension separating the postjacent socket from the inside of the valve, a narrow crenulate median groove, with an elongated moderately developed posterior tooth. Muscle scars lie in a deep depression and consist of a row of 4 adductor muscle scars, the uppermost two being the longest, the lowermost two lying on the posteroventral side of the depression, with a U-shaped frontal scar, the U opening towards the anterior tooth of the hinge elements. The entire inner surface of the valve is perforated by the numerous normal pore canals openings.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11208	female (Holotype)	0.713	0.395	0.360	1.805
OS 11209	male	0.725	0.345	0.315?	2.101
OS 11211	female	0.700	0.375	0.325?	1.866
OS 11214	male	0.707	0.350	0.280?	2.020
OS 11218	juvenile	0.575	0.305	-	1.885
OS 11219	juvenile	0.555	0.283	-	1.961
OS 11220	juvenile	0.445	0.260	-	1.712

Discussion :

Acanthocytherois (Canthylocytherois) quinquespinosa sp. nov. differs from Acanthocytherois (Canthylocytherois) taqiyeansis sp. nov. in being smaller, in the details of reticulation and spine arrangement, and in some minor internal details.

This species can be easily distinguished from A.araneosa Howe (1963), which has an indistinct subcentral tubercle, different details of reticulation and spines, rather narrow marginal area, and a crenulate posterior tooth.

Al-Furaih's (1976) species Acanthocytherois alacer (M.S.), A.conjuncta (M.S.), A.fungosa (M.S.), A.spongiosa (M.S.), A.multibulbosa (M.S.), A.oxydorca (M.S.), A.posterotuber (M.S.), A.prora (M.S.), and A.stymatoura (M.S.) from the uppermost Cretaceous to the Palaeocene of Saudi Arabia, can be easily distinguishedfrom this species by differences in the details of reticulation and in having less developed or differently shaped spines.

Acanthocytherois projecta Bassiouni (1969b) from the mid-Upper Eocene of Egypt, differs from this species in having an indistinct subcentral tubercle, highly protruding eye tubercle, differences in details of reticulation and in the presence of a

crenulate posterior tooth. Acanthocytherois salahii Bassiouni (1969b) differs in the general outline, details of ornamentation, and the absence of a subcentral tubercle.

Occurrence: Known so far from the Danian of the Tell-Burma section, Jordan.

Acanthocytherois (Canthylocythereis) alacer (M.S.) Al-Furaih, 1976

pl. 3, figs. 2, 4, 5, 8 & 11

1976, Acanthocytherois alacer (M.S.) Al-Furaih.

Diagnosis: A species of Acanthocytherois (Canthylocythereis) with distinct posterodorsal process. Surface reticulate with a few small spines at the intersection of some of the muri. The fossae of the first and second anterior rows (A & B) and the posterior row (H) have narrow muri. Anterior, dorsal and posterior margins bear a double row of denticles.

Figured Specimens: OS 11234 - OS 11237

Material: 28 specimens from the (Maastrichtian?) Palaeocene/L.Eocene, of Chemchemal Well-2, NE Iraq, between drilling depths of 3124' - 5320'?.

Type Locality: El-Alat W-1, Saudi Arabia.

Type Horizon: Middle Palaeocene, sample 1455' - 1461' below surface.

Dimensions : (In mm.)

		L.	H.	W.	I/H
OS 11234	female	0.525	0.285	0.225	1.842
OS 11235	male	0.575	0.280	0.200	2.053

Discussion :

The specimens described here from northeastern Iraq are not well preserved, but from the general resemblance in outline,

shape, and ornamentations, they are closely related to Acanthocythereis alacer (M.S.) Al-Furaih (1976) from the Lower-Middle Palaeocene of Saudi Arabia. The Iraqi specimens are slightly smaller.

Al-Furaih has discussed the possible affinities of his species with Trachyloberis (Acanthocythereis) decoris Siddiqui (1971) from the M.-U. Eocene of West Pakistan. The presence of Acanthocythereis (Canthylocythereis) alacer in NE Iraq and Saudi Arabia during the Palaeocene suggests that A.(C.) alacer (M.S.) Al-Furaih (1976) is ancestral to T.(A.) decoris Siddiqui (1971).

This is further evidence of west to east migration within the Indopacific bioprovince of the southern shelf of Tethys, as seen in the genus Paracosta.

Occurrence: Known from the (Maastrichtian??) Palaeocene-Lower Eocene of Chemchemal Well-2 of NE Iraq, and from the L.-M. Palaeocene of El-Alat W-1 of eastern Saudi Arabia.

Only one specimen has been found in the Maastrichtian sediments of the Chemchemal Well-2, and it is highly likely that this odd specimen is due to well-drilling contamination.

Acanthocythereis (Canthylocythereis) bolispinosa sp. nov.

pl. 3, figs. 7 & 10; pl. 4, figs. 1, 2 & 4

Name: Latin boli-, lumpy + spinosus, thorny; with reference to the two lumpy spines of the species.

Diagnosis: A species of Acanthocythereis (Canthylocythereis) with a hinge ear at the anterodorsal corner of the left valve, and with two lumpy spines or pore cones in the position of "Taurus and Virgo".

Holotype: Carapace probably female, OS 11231, pl. 3, fig. 7 & 10

Paratype: OS 11232 - OS 11233

Material: 6 specimens from Sample no. 15, Anah Well-2 .

Type Locality: Anah Well-2, Western Iraq .

Type Horizon: Limey marl and marl beds of the Hartha Limestone (Pilsener) Formation, of Maastrichtian age, Sample no. 15, at drilling depths 2000' - 2016' .

Description: The anterior margin is rounded, posterior margin pointed below the middle of the margin; eye tubercle distinct, with a well developed hinge ear lying above it in the left valve; sub-central tubercle present but not well developed. The entire surface is ornamented by a small rounded reticulation with thick walls (muri), with small spines or postules developed principally in the positions of the normal pore canals; the posterodorsal spines, lying in the position of the "Taurus and Virgo" pore cones are each developed in the form of 2 masses of 3-4 postules or pore cones. The other postules are of varying size, some of the small ones arranged in a ventral row of 8-10 postules ending at 2 large vertically arranged postules, the lower of which is at the position of the "Phi" pore conulus. Antero- and posteromarginal rims are present; antero-marginal area ornamented by 2 rows of small spines, inner row lying on the anteromarginal rim and consisting of 12 small spines, the outer row consisting of some 20 spines. Posterior margin ornamented by 8-9 small spines arranged at different levels along the posteromarginal rim, especially along its ventral half.

In dorsal view the carapace has subparallel sides, with laterally compressed ends, maximum width at the position of the sub-central tubercle. Internally the marginal area is wide, inner margin and line of concrescence coincide. Selvage is present and submarginal. Hinge is Amphidont/Heterodont, the left valve hinge consisting of a deep anterior socket, a postjacent conical tooth, crenulated median bar, with a posterior tooth socket.

Muscle scars and radial pore canals could not be seen.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11231	female? (Holotype)	0.505	0.295	0.240	1.712
OS 11232	female?	0.500	0.287	0.230	1.742
OS 11233	male?	0.515	0.277	-	1.859

Discussion :

This species can be easily distinguished from Acanthocytherels sp. by its small size, general outline, ornamentation and internal details. Acanthocytherels (Canthylocytherels) quinquespinosa sp. nov. and A.(C.) taqiyeansis sp. nov. from Jordan differ from this species in having better developed subcentral tubercles and spines, lack the 2 lumpy postules or pore cones of the posterodorsal area, and differ in the details of reticulation.

Acanthocytherels fungosa (M.S.), Al-Furaih (1976), from Saudi Arabia, differs in the details of ornamentation, notably in its mushroom-shaped tubercles and the conjunctive spines. The lumpy postules of this species are quite different from the mushroom-shaped tubercles defined by Al-Furaih (M.S. 1976).

Occurrence: Known so far from the Maastrichtian of Anah Well-2, Western Iraq.

Acanthocytherels (Canthylocytherels) taqiyeansis sp. nov.

pl . 2 , figs. 6-11; pl . 3, figs. 1, 3, 6 & 9

Name: After the type horizon of the Taqiye Marl Formation

Diagnosis: A large species of Acanthocytherels (Canthylocytherels) in which the entire surface is reticulate, and with a spine lying just below the "Charon" pore conulus in the females or at two mesh distance beyond it in the males.

Holotype: Female carapace, OS 11221, pl . 2 , fig. 7 & 10

Paratype: OS 11222 - OS 11230

Material: 25 specimens from the Lower Palaeocene (Upper Danian) of the Tell-Burma section, Jordan; and the Lower Palaeocene of the Bir Qdeim section, Syria.

Type Locality: Tell-Burma section, Jordan .

Type Horizon: Lower Palaeocene (Upper Danian), Sample no. BMJ 350 of the Taqiye Marl Formation .

Description: Large carapace; eye tubercle spherical and very distinct, with a node or some thickening lying behind it; subcentral tubercle distinct and divided into 5 spines, two of them lying anteriorly in a vertical row of which the dorsal spine is the strongest, the other three spines lying at the posterior part of the sub-central tubercle, the dorsalmost spine being the largest, the middle spine lying just below the centre of the tubercle touching the ventral spine which is the smallest.

Antero- and postero-marginal rims are distinct; anteriorly there are 2 rows of spines, the outer row has 18-19 spines, the inner row has 10-11 nodes and small spines. The posteromarginal rim has 6 spines as in A.(Canthylocythereis)quinquespinosa sp. nov. .

The entire surface is reticulate; the reticulation varies from 4 sided fossae in the first and second anterior rows (A & B) and the last posterior row, to 3-5 sided moderately large fossae covering the rest of the surface. The reticulation is intercalated by numerous normal pore openings, and pore cones or spines, all having the same positions and arrangements as in A.(Canthylocythereis) quinquespinosa sp. nov. except for the presence of the "Chi" pore conulus, which lies just above the "Charon" pore conulus in the females, and at a two mesh distance behind it in the males; in the males this is because of the elongation of the carapace.

Internally, the marginal area is moderately wide, inner margin and line of concrescence coincide, selvage submarginal and prominent; radial pore canals are straight and simple, with 38-40 at the anterior, and about 16 at the posterior. The hinge is Amphidont/Heterodont, right valve hinge element consisting of a conical anterior tooth with low distal part, with a posterior extension separating the postjacent deep socket from the inside of the carapace, crenulate median groove; and large posterior tooth. Muscle scars are as for the genus.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11221	female (Holotype)	0.875	0.460	0.445	1.902
OS 11222	male	0.975	0.478	0.385	2.039
OS 11223	female	0.825	0.425	0.362	1.941
OS 11224	male	1.025	0.450	-	2.277
OS 11228	juvenile	0.700	0.400	-	1.750

Discussion:

See Acanthocythereis (Canthylocythereis) quinispinosa sp. nov. .

Occurrence: Known so far from the Middle and Upper Danian of the Tell-Burma section, Jordan; and the Lower Palaeocene of the Bir Qdeim section, Syria.

Acanthocythereis ? sp.

plt. 4 , figs. 3, 5 & 11

Figured Specimens: OS 11204 - OS 11206

Material: 11 juvenile specimens from the Maastrichtian of the Anah Well-2 section, Western Iraq. From a limey marl and marl beds of the Hartha Limestone (Pilsener) Formation, Sample no. 15, at drilling depths 2000' - 2016'.

Description: Eye tubercle rounded and glassy, lying below the dorsal margin; sub-central tubercle present, but not well developed. Antero- and posteromarginal rim are indistinctly present due to the type of ornamentation covering the entire surface; both antero- and postero-marginal rims are broken into small spines.

The ornamentation covering the entire surface of the carapace consists mainly of small, equal-sized spines or postules superimposed around the side walls (muri) of the small rounded reticulation. The anteromarginal area is ornamented by two rows of spines, the inner row lies upon the indistinct marginal rim and is comprised of 16-18 small spines or postules, this row is not well distinguished from the overall surface ornamentation; the outer row of anteromarginal spines is comprised of 19-21 spines, those in the ventral half being the strongest developed. Posteriorly, there are another 2 rows of marginal spines, the inner row being well defined, lying upon the posteromarginal rim and consisting of 10-12 spines; the outer row consists of 8-9 spines, of which the spine at the pointed end, if preserved, is trifurcate.

Internally, marginal area narrow; inner margin and line of concrescence do not quite coincide, with very narrow vestibules at the anteroventral and posteroventral corners; selvage submarginal and prominent. Radial pore canals are straight, simple and numerous, but because of the type of ornamentation, it is difficult to count them. Hinge is Merodont/Entomodont, the right valve hinge elements consisting of a probably smooth weakly developed tooth, followed by finely crenulated median groove, ending by a crenulated posterior tooth. Muscle scar pattern unknown.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11204	juvenile	0.615	0.320	-	1.922
OS 11205	juvenile	0.575	0.305	-	1.885
OS 11206	juvenile	0.555	0.287	-	1.934
OS 11207	juvenile	0.470	0.245	-	1.918

Discussion :

This species is doubtfully assigned to the genus Acanthocytherois R.G. Howe (1963), because of the presence of reticulation with superimposed spines covering the entire surface of the carapace. The hinge and weakly developed marginal zone suggest that all the specimens are juveniles.

Acanthocytherois ? sp. shows some affinity to the genus Echinocytherois Puri (1954), but the latter differs in details of ornamentation, with the spines arranged concentrically in rows, and the internal details.

Acanthocytherois (Canthylotherois) multibulbosa (M.S.) Al-Furaih, 1976 from the Upper Cretaceous - Lower Palaeocene of Saudi Arabia, has a similar type of ornamentation, but differs in having a well-developed eye tubercle lying in different position, a less distinct sub-central tubercle, and in the internal features, Acanthocytherois (Canthylotherois) conjuncta (M.S.) Al-Furaih, 1976 from the uppermost Cretaceous - Lower Palaeocene of Saudi Arabia, differs in having a better developed eye tubercle and sub-central tubercle and a different type of ornamentation which consists of reticulations with conjunctive spines, the spines being stronger than those of Acanthocytherois ? sp.; it also differs in the internal details.

Occurrence: Known so far from the Maastrichtian of the Anah Well-2 section, Western Iraq.

Genus Cristacleberis Bassiouni, 1970

Type Species: Cristacleberis reticulata Bassiouni, 1970

Description: A genus of the sub-family Trachyleberidinae; with moderately large carapace, rectangular in outline. The ornamentation consists of an eye rib below the well developed eye tubercle, which thickens into a comb-like node at about mid height; the lateral surface is either reticulate with or without spines, or smooth.

Internally, the comb-like node and some of the spines have corresponding depressions; a strikingly broad eye socket is present. The marginal zone is relatively narrow; inner margin and line of concrescence are coincide. The marginal pore canals are simple, straight, numerous and sometimes present in pairs; there are about 25-30 anteriorly, and up to 20 posteriorly. Muscle scars lie in a shallow depression and consist of 4 adductor muscle scars, the second from dorsal being the longest, the lower two scars are oval and are sometimes joined together; the frontal scar is V-shaped with a longer posterior branch. The hinge is very weak Amphidont/Heterodont. The hinge of the right valve has a small, weakly bilobate or smooth, arch-shaped anterior tooth; shallow and smooth postjacent socket; smooth median groove, and bilobate posterior tooth which is stronger than the anterior tooth. In the left valve the corresponding elements are present, consisting of shallow anterior socket, a postjacent very weak tooth, smooth median bar, and a posterior socket which is open to the valve.

Occurrence: Known from Upper Cretaceous and Palaeocene of Jordan.

Cristaeloberis arabii Bassiouni, 1970

pl. 4, figs. 6-10; pl. 5, figs. 1, 3, 6 & 9

1970, Cristaeloberis arabii arabii, Bassiouni, p. 27,

pl. 3, figs. 1 - 4

Diagnosis: A species of Cristaeloberis with weak punctation and large nodal spines on the lateral surface; strong longitudinal nodo in the anterior part of the carapace; 3-4 posterior spines.

Figured Specimens: Males and females, OS 11456 - OS 11459 from samplo no. BMJ 849 and OS 11460 - OS 11462 from sample no. BMJ 850.

Material: 133 specimens, including adults and juvenilos from tho Lower Palaeocene (U. Danian) of tho Toll-Burma section, Jordan; samples no. BMJ 849, BMJ 850, BMJ 851 & BMJ 853.

Type Locality: El-Hasa, Jordan .

Type Horizon: Lowermost Middlo Palaeocene.

Dimensions: (In mm.)

		L.	H.	W.	I/H
OS 11456	femalo	0.610	0.350	-	1.743
OS 11459	femalo	0.645	0.355	0.337	1.817
OS 11560	malo	0.660	0.354	0.332	1.864

Discussion:

Bassiouni (1970) describod two subspecios of Cristaeloberis arabii, C. arabii arabii from the L. Palaeocene and C. arabii rotundonodosa from tho uppermost Middlo Palaeocene. Although no specimens of tho lattor subspecios wero found in the present study, it has been possiblo to examino topotypo material (TKH 11763 - TKH 11771, pl. 5, figs. 2, 4, 5, 8 & 11). It is suggosted that the two taxa should be regarded as distinct specios. Cristaeloberis arabii differs from Cristaeloberis rotundonodosa Bassiouni (1970) in having a larger carapace, and :ettor dovoloped marginal spines; tho posterior nodal spines aro loss dovoloped, and aro joined togothor in

Cristaeloberis rotundonodosa, and finally, the comb-like anterior node of the latter species is much thicker.

Occurrence: Known so far from Jordan, where it is abundant in the Lower Palaeocene and rare on the Middle Palaeocene.

Cristaeloberis formicata Bassiouni, 1970

pl. 5, figs. 7 & 10; pl. 6, figs. 1, 3 & 4

Diagnosis: A species of Cristaeloberis with evenly developed reticulation and showing distinct sexual dimorphism. The eye rib is weakly developed, uniform in its entire course up to the anterior comb-like node. Small nodes can be seen at the intersections of the muri when examined carefully.

Figured Specimens: Males and females, OS 11465 - OS 11468 from sample no. BMJ 66 of Middle Maastrichtian age; and OS 11469 from sample no. BMJ 73 of Late Maastrichtian age.

Material: 231 specimens, including adults and juveniles from the Middle and Upper Maastrichtian of the Tell-Burma section of Jordan; samples no. BMJ 62, BMJ 65, BMJ 66, BMJ 68, BMJ 70 and BMJ 73.

Type Locality: Ma'an borehole, Jordan.

Type Horizon: Maastrichtian.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11465	female	0.650	0.370	0.300	1.756
OS 11466	male	0.682	0.350	0.310	1.948
OS 11469	male	0.685	0.370	0.312	1.851

Occurrence: This species is limited to the Upper Cretaceous of Jordan.

Cristaeleberis roticulata Bassiouni, 1970

pl . 6 , figs. 2 & 5-11; pl . 7, figs. 1 & 3

Diagnosis: A species of Cristaeleberis with close and equal reticulation, and with a spine or node at the posterior cardinal angle and the ventral angle. The carapace curvature is somewhat sunken in behind the anterior comb-like node, and shows a very clear arching towards the ventral side.

Figured Specimens: Males and females, OS 11470 - OS 11474 from sample no. BMJ 842 of M. Danian age, and OS 11475 -OS 11477 from sample no. BMJ 848 of U. Danian age.

Material: 273 specimens, including adults and juveniles from the Lower Palaeocene (M. - U. Danian) of the Tell-Burma section of Jordan; samples no. BMJ 842, BMJ 845, BMJ 847, BMJ 848, BMJ 849, BMJ 850, BMJ 851 and BMJ 853.

Type Locality: Southern Yarmuk - bank, Jordan.

Type Horizon: Middle Palaeocene .

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11470	female	0.575	0.335	0.310	1.716
OS 11472	male	0.603	0.325	0.294	1.855

Occurrence: This species was recorded from the Middle Palaeocene of Jordan, by Bassiouni (1970); in this study it has been found in the Lower Palaeocene (M. - U. Danian) of the Tell-Burma section of Jordan.

Genus Cytherois Jones, 1849

Type Species: Cytherina ciliata Reuss, 1846

Cytherois ? ashurbanipali sp. nov.

pl . 7 , figs. 2 & 4-11

Name: With reference to the Assyrian king "Ashurbanipal", 668 B.C. - 627 B.C.

Diagnosis: A small species of Cytherois with a short distinct dorsal ridge, indistinct median ridge, and marked ventral ridge. Subcentral tubercle distinct; the entire surface reticulate, the reticules with small spines projecting into the alveoles.

Holotype: Female carapace, OS 11435, pl . 7, fig. 2 .

Paratype: OS 11436 - OS 11442

Material: 40 specimens : 21 specimens from the Shiranish Formation of Maastrichtian age; and 19 specimens from the Hartha Limestone Formation of Upper Campanian?-Maastrichtian age. All specimens from the Makhul Well-2, samples no. 25, 31, 32, 35, 36, 38, 39, 41-45, 47, 49, 50, 53, 54, 60, 65, 66, 70, 71, 80 & 82 at drilling depths of 1375' - 2125'.

Type Locality: Makhul Well-2, northern Iraq.

Type Horizon: Limey marl beds of the Shiranish Formation, of Maastrichtian age, sample no. 31, drilling depth 1475' - 1480'.

Description: Carapace small and subrectangular, anterior margin broadly rounded, posterior margin pointed or narrowly rounded; dorsal and ventral margins straight, and converging to the posterior; eye tubercle rounded and small; sub-central tubercle more or less distinct.

Lateral surface reticulate; the reticulation is 3-5 sided with secondary ornamentation of small spines projecting into

the alveoles. Dorsal ridge short, undulate and distinct, commencing from the mid-dorsal area and ending by a prominent posterodorsal process; the median ridge is indistinct; the ventral ridge is marked by a node lying at the posterior part of a ventrolateral swelling. Marginal rim extends along the anterior, ventral and posterior margins; it is better developed at the anterior and posterior where it is denticulate; there are some 12-13 denticles anteriorly, and 4-5 denticles at the posterior.

In dorsal view the carapace has subparallel sides slightly converging to the anterior, with laterally compressed ends; the subcentral tubercle appears in a shallow depression, and posterodorsal process is well developed; maximum width lies at the posterior third of the carapace. No internal features were observed.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11435	female (Holotype)	0.635	0.375	0.252	1.693
OS 11436	male	0.650	0.373	0.295	1.742
OS 11439	male	0.720	0.390	0.275	1.846
OS 11440	female	0.712	0.420	0.280	1.695

Discussion:

Cythereis? ashurbanipali sp. nov. differs from other species of Cythereis by lacking a prominent sub-central tubercle, and having an indistinct median ridge.

Ordoniya (Ordoniya) sinjariya sp. nov. differs in having three distinct longitudinal ridges, better developed sub-central tubercle and larger reticulation.

Occurrence: Known so far from the Upper Campanian? - Maastrichtian of the Makhul Well-2 section, northern Iraq.

Cytherois esarhaddoni sp. nov.

pl . 8 , figs. 1, 3, 4, 6 & 8-10

Name: With reference to the Assyrian king "Esarhaddon", 681 B.C. - 668 B.C.

Diagnosis: A species of Cytherois with a smooth surface, apart from some reticulation between the ventral ridge and the ventro-marginal rim.

Holotype: Female carapace, OS 11449, pl . 8 , figs. 1, 4 & 8.

Paratype: OS 11450 - OS 11452

Material: 7 specimens from the type locality, samples no. 40, 42, 43, 44 & 45, at drilling depths of 1605' - 1665'.

Type Locality: Makhul Well-2, northern Iraq.

Type Horizon: Marly limestone beds of the Shiranish Formation of Maastrichtian age; sample no. 43, at drilling depths of 1645' - 1650'.

Description: Carapace with obliquely rounded anterior margin, and pointed posterior margin; dorsal and ventral margins straight and converging to the posterior; eye tubercle small; sub-central tubercle distinct and formed as part of an anteromedian swelling.

The lateral surface between the longitudinal ridges is smooth, apart from some reticulation between the ventral ridge and the ventro-marginal rim. There are three longitudinal ridges showing a tendency to break into nodes; the dorsal ridge is distinct, commences below the eye tubercle, curving upwards and slightly over-reaching the dorsal margin, and showing a tendency to break into 6 nodes; the median ridge short, distinct, curves upward, starting from a depression lying behind the sub-central tubercle, and it shows a tendency to divide into 4 nodes; the ventral ridge is the longest, lying in the dorsal edge of a small ventro-lateral swelling; the latter is covered by some reticulation and is bounded from below by the ventro-marginal rim. Marginal rims present at the anterior, ventral and posterior margins;

the ventral part of the antero-marginal rim broken into 6-7 nodes. Apart from those nodes, there are 17-19 small spines or nodes at the anterior margin and 8-9 small spines posteriorly.

In dorsal view, the carapace has parallel sides, with laterally compressed ends; the dorsal ridge and the depression which separates the sub-central tubercle from the median ridge can be seen clearly. In ventral view the reticulation of the ventral surface is clear.

Internally, the anterior marginal area is broad; inner margin and line of concrescence coincide; selvage prominent; hinge is Amphidont/Heterodont, the anterior hinge elements of the right valve consisting of a conical anterior tooth with low distal part and a posterior continuation separating the postjacent socket from the inside of the valve; the postjacent socket is followed by a median groove which is probably crenulate.

Dimensions: (In mm.)

	L.	H.	W.	L/H
OS 11449 female (Holotype)	0.717	0.450	0.355	1.593
OS 11450 male	0.762	0.445	0.342	1.712

Discussion:

Cytherois esarhaddoni sp. nov., Cytherois sennacheribi sp. nov. and Cytherois sp. B from the Maastrichtian of northern Iraq differ from Cytherois sensu stricto as discussed by Sylvester-Bradley (1948) and Van Morkhoven (1963) in having an Amphidont/Heterodont hinge. However, following Alexander (1933), many authors have placed species with this type of hingement into Cytherois. Therefore, following Sayyab (M.S., 1956), Bischoff (1963), Bassoullet and Damotte (1969), Grosdidier (1973) and Al-Abdul-Razzaq (M.S., 1977) these species are placed in Cytherois. The Iraqi species show similarities to species

of Veenia Butler and Jones (1957) in the hinge and ornamentation, but differ in lateral outline, notably in lacking the convex margin of Veenia. Cytherois jezzinoensis Bischoff (1963), Cytherois maghrebensis Bassoullet and Damotte (1969), Cytherois stroblolophata and Cytherois pericompsa described by Al-Abdul-Razzaq (M.S., 1977) from the Cenomanian-?Turonian of Kuwait, differ from the Maastrichtian species described in this study from northern Iraq, in having different outlines, better developed dorsal ridges and eye tubercles, and in the presence of other ornamental differences such as cross ribs, cross reticulation, or sub-concentric reticulation.

Cytherois sp. B (OS 11453, pl . 8, figs. 7& 11; pl .9, figs,.6 &7) is a single specimen found in a higher Maastrichtian horizon than that of Cytherois esarhaddoni sp. nov., at drilling depths of 1455' - 1460'. This species has the same shape and ornamentation of C.esarhaddoni, but differs in its larger size (L. = 0.937mm., H. = 0.580mm., W. = 0.457mm. and L/H. = 1.702), and weaker reticulation between the ventral ridge and the ventro-marginal rim.

Occurrence: Known so far from the Maastrichtian of Makhul Well-2, of northern Iraq, at horizon older than that of Cytherois sennacheribi sp. nov.

Cytherois sennacheribi sp. nov.

pl . 8 , figs. 2 & 5; pl . 9, figs. 1 & 2

Name: With reference to the Assyrian king "Sennacherib", 704 B.C. - 681 B.C.

Diagnosis: A species of Cytherois in which the median surface of the valves is randomly reticulate, with some cross ribs present between the dorsal and median ridges; the dorsal ridge bears, or breaks into, 6 nodes.

Holotype: Carapace, probably male, OS 11454, pl . 8, figs. 2 & 5; pl . 9, fig. 2

Paratype: OS 11455

Material: 2 specimens only from the type locality, samples no. 34, & 39, at drilling depths of 1505' - 1510' and 1570' - 1575' respectively.

Type Locality: Makhul Well-2, northern Iraq.

Type Horizon: Marly limestone beds of the Shiranish Formation of Maastrichtian age, sample no. 34, at drilling depths of 1505' - 1510'.

Description: Carapace with obliquely rounded anterior margin and backwards pointing posterior margin; dorsal and ventral margins straight and converging toward the posterior; eye tubercle small and distinct; sub-central tubercle prominent; hinge ear present in the left valve. The lateral surface is reticulate, the reticulation of the median surface arranged randomly, with some cross ribs between the dorsal and median ridges; the reticulation of the anterior surface is arranged parallel to the anterior margin, with some radial ribs spreading out from the sub-central tubercle towards the antero-marginal rim. There are three distinct longitudinal ridges; the dorsal one bears or breaks into 6 nodes; the median ridge is short, thick, and commences from a depression lying behind the sub-central tubercle; the ventral ridge is well developed, forming with the ventro-marginal rim a ventro-lateral slope ornamented by 2 rows of reticulation; the latter can be seen clearly in ventral view. Marginal rim is distinct, extending along the anterior, ventral, and posterior margins; there are some denticulations at the anterior margin, and 6-7 small nodes at the ventral part of the posterior margin.

In dorsal view, the carapace has subparallel sides, with laterally compressed ends; maximum width lies at the sub-central tubercle; the nodes of the dorsal ridge and the depression which separates the sub-central tubercle from the median ridge can be seen

clearly. No internal details were observed.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11454	male? (Holotype)	0.890	0.532	0.390	1.673
OS 11455	female?	0.875	0.527	0.405	1.660

Discussion:

This species is easily distinguished from Cytherois esarhaddoni sp. nov. and Cytherois sp. B, in having a reticulate surface, and a size intermediate between them. See also Cytherois esarhaddoni sp. nov.

Occurrence: Known so far from the Maastrichtian of Makhul Well-2, northern Iraq, at horizons younger than those of C.esarhaddoni sp. nov., and older than Cytherois sp. B.

Cytherois sp. A

pl. 9 , figs. 3-5 & 8

Figured Specimen: Carapace, OS 11434 .

Material: 1 specimen only from the Shiranish Formation of the Makhul Well-2 section, northern Iraq; Maastrichtian age; sample no. 28, at drilling depths of 1435' - 1440'.

Description: Carapace subrectangular and ventrally flattened, anterior margin broadly rounded, posterior margin pointed posteriorly; dorsal and ventral margins straight, and converging to the posterior; eye tubercle distinct; sub-central tubercle prominent; hinge ear is present in the left valve only.

Lateral surface is ornamented by a very fine reticulation covering the entire surface of the carapace including the longitudinal ridges and marginal rims; at the dorsomedian surface, the fine reticulation has superimposed upon it another type of very weak, large and polygonal reticulation. Dorsal ridge is indistinctly present, ending by a prominent posterodorsal process; the latter is subangular, elongate, lying vertical to the dorsal ridge. The median ridge is indistinct, but marked by a weak hump lying posterior to the prominent sub-central tubercle. The ventral ridge is thickly developed, lying on the ventrolateral swelling of the carapace, and sometimes broken into some nodes of which the posteriormost node is the biggest and most prominent. Marginal rim well developed along the anterior and posterior margins; there are some 10 nodes at the anteromarginal rim, which are less pronounced because of the fine reticulation covering the marginal rim.

In dorsal view, the carapace has sub-parallel sides, with well developed sub-central tubercle and posterodorsal process; both ends are laterally compressed; maximum width lies at the sub-central

tubercle on the posteriormost node of the ventral ridge. No internal features were observed.

Dimensions: (In mm.)

	L.	H.	W.	L/H
OS 11434	0.780	0.427	0.362	1.827

Discussion:

This species is assigned to the genus Cytherois Jones (1849) because of the presence of the prominent sub-central tubercle and three longitudinal ridges. The genus Paniloberis Deroo (1966) differs in having less prominent sub-central tubercle, two longitudinal ridges, and with some tuberculation in addition to the reticulation of the surface. The genus Peloriops Al-Abdul-Razzaq (1979) differs principally in having no sub-central tubercle, a prominent eye tubercle, and two longitudinal ridges.

The species described by Grosdidier (1973) as Cytherois IR E21 from the Campanian of Iran shows some similarity to this species, but differs in the less developed sub-central tubercle, and in details of ornamentation. Spinoloberis? IR K20 Grosdidier (1973) from the Albian of Iran has the same type of very fine reticulation, but it is quite different in shape and in having a less developed sub-central tubercle.

Occurrence: Known so far from the Maastrichtian of Makhul Well-2, northern Iraq.

Genus Dumontina Deroo, 1966

Type Species: Cythere punctturata Bosquet, 1854

Dumontina assyria sp. nov.

pl . 9 , figs. 9-14

Name: With reference to the ancient realm of Assyria, 2000 B.C. - 612 B.C.

Diagnosis: A species of Dumontina in which the surface reticulation is arranged in rows parallel to the longitudinal ridges; the anterior part of the median ridge splits into two branches at the distinct sub-central tubercle.

Holotype: Male carapace, OS 11430, pl . 9 , figs. 9 & 10

Paratype: OS 11431 - OS 11433

Material: 10 specimens, including adults and one juvenile, from the type locality and horizon only.

Type Locality: Anah Well-2 section, western Iraq.

Type Horizon: Limey marl beds of the Hartha Limestone Formation of Maastrichtian age, sample no. 15, at drilling depths of 2000' - 2016'.

Description: Carapace subrectangular; anterior margin obliquely rounded, posterior margin rounded or bluntly pointed; dorsal margin straight, ventral margin slightly concave; dorsal and ventral margins are subparallel, converging to the posterior; highest point at eye tubercle; eye tubercle small and rounded; sub-central tubercle distinct.

Lateral surface reticulate, the reticules of the median surface are oblong and arranged in rows parallel to the longitudinal ridges; the muri have secondary ornamentation formed as small spines projecting into the alveoles. There are three longitudinal ridges: the dorsal ridge is distinct, short, and slightly convex upwards; the median ridge is less developed than the dorsal ridge but distinct,

running diagonally from a small posterodorsal process through the sub-central tubercle where it splits into two branches, both ending just before reaching the anteromarginal rim; the ventral ridge commences from the anteroventral corner of the carapace, running parallel to the median ridge, and terminating abruptly at the edge of the posterior slope of the lateral surface. The marginal rim extends weakly along the anterior, ventral and posterior margins being better developed at the anterior and posterior.

In dorsal view, the sides of the carapace converge toward the anterior; both ends are laterally compressed; sub-central tubercle distinct; maximum width lies at the abrupt posterior end of the ventral ridge.

Internally, the marginal area is moderately wide; inner margin and line of concrescence coincide; selvage prominent. The hinge is Amphidont/Heterodont, left valve hinge elements consisting of deep anterior socket, postjacent tooth with higher and conical-shaped dorsal part, followed by finely crenulate median bar, ending with a posterior socket. The muscle scars were not observed.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11430	male (Holotype)	0.600	0.292	0.220	2.054
OS 11431	female	0.595	0.312	0.230	1.907
OS 11432	female	0.575	0.300	0.237	1.916

Discussion:

This species differs from Dumontina? IRE 18 of Grosdidier (1973) from the Santonian - Coniacian? of Iran, in its shape, details of ornamentation, and the better developed sub-central tubercle. Ordoniya (Ordoniya) burmaensis (Bassiouni) differs by its larger size, more pointed posterior end, prominent longitudinal ridges, and in the details of reticulation.

Occurrence: Known so far from the Maastrichtian of Anah Well-2, western Iraq.

Genus Occultocythereis H.V. Howe 1951

Type Species: Occultocythereis delumbata H.V. Howe, 1951

Occultocythereis babylonia sp. nov.

pl . 10 , figs. 1, 3, 4, 6 & 7

Name: With reference to the great city of Babylon .

Diagnosis: A species of Occultocythereis, with an elongate posterior end, and lateral surface smooth or faintly reticulate.

Holotype: Carapace, OS 11243, pl . 10 , fig. 1 .

Paratype: OS 11244 - OS 11246

Material: 4 specimens from the Palaeocene - Middle Eocene of the Jabel Sinjar section, samples no. S45, S62 and S71.

Type Locality: Jabel Sinjar section, Iraq.

Type Horizon: Marly beds from the Middle Eocene part of the Jaddala Formation, sample no. S62.

Description: Carapace elongate; length usually double the height; anterior margin narrowly and sometimes obliquely rounded; posterior margin is elongate and pointed below the middle; dorsal and ventral margins are straight and converge towards the posterior. Eye tubercle small; sub-central tubercle distinct and forming part of an antero-median swelling running obliquely toward the anteroventral corner of the carapace.

Lateral surface is smooth or weakly reticulate in the centre of the carapace. The dorsal ridge commences from a pore conulus or small node lying behind and below the eye tubercle, curving upwards and ending posteriorly with an angular posterodorsal process, which is confluent with a short vertical ridge. A median ridge runs obliquely from the end of the short vertical ridge through the sub-central tubercle and the anteromedian swelling of the carapace, towards the

anteroventral corner of the carapace. A short ventral ridge is present, lying along the ventrolateral swelling of the carapace. The latter lies parallel, below and posterior to the antero-median swelling. Marginal rim extends along the anterior, ventral and posterior margins, being weaker along the ventral margin. Anterior and posterior marginal rims have traces of small marginal spines.

In dorsal view, the carapace has almost parallel sides which may converge slightly to the anterior, with laterally compressed ends; maximum width lies at the abrupt end of the ventral ridge. In ventral view, the ventrolateral swelling can be clearly distinguished from the anteromedian swelling by the presence of a sinus between them. Internal details were not seen.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11243	(Holotype)	0.500	0.240	0.185	2.083
OS 11244		0.490	0.245	0.195	2.000
OS 11245		0.470	0.225	0.145	2.088
OS 11246		0.505	0.255	0.192	1.980

Discussion:

Occultocythereis ishtaria sp. nov. from the Middle/Upper Eocene of the Jabel Sinjar section differs from this species in having a more reticulated surface, which is sometimes striated in the centre of the carapace; the median ridge is indistinct; and the very short ventral ridge ends at the centre of the carapace.

Occultocythereis arabica (M.S.) Al-Furaih, 1976 from the Lower Palaeocene of Saudi Arabia has a reticulate surface but is less elongate and has better developed reticulation, as well as having four ridges confluent with the posterodorsal process.

Occultocytherois elongata sp. nov. from the Maastrichtian of the Anah Well-2 section shows some similarity to the Occultocytherois babylonia sp. nov. and Occultocythereis ishtaria sp. nov., but the latter two species are slightly smaller and differ in some details of ornamentation. The three species are probably related, forming a lineage with O. elongata (Maastrichtian) the oldest, O. babylonia (Palaeocene - Middle Eocene) next, and O. ishtaria (Middle - Upper Eocene) the youngest species.

Occurrence: Known so far from the Palaeocene to the Middle Eocene of the Jabel Sinjar section, northwestern Iraq.

Occultocytherois elongata sp. nov.

pl .10 , figs. 2, 5, 10 & 11

Name: (L.) olongatus = prolonged, with reference to the elongated posterior end.

Diagnosis: A large species of Occultocytherois with an elongate posterior end pointed below the middle; two rows of rounded reticulation lie between the sub-central tubercle and the ventral ridge, and continue as one row of quadratic shaped reticulation behind the antero-marginal rim.

Holotype: Carapace probably female, OS 11247, pl .10 , figs. 2 & 10.

Paratype: OS 11248 - OS 11251

Material: 10 specimens from the type locality only.

Type Locality: Limey marl beds of the Hartha Limestone Formation, of Maastrichtian age, sample no. 15, at drilling depths of 2000' - 2016'.

Description: Large carapace, normally the length is more than double the height; anterior margin is rounded; the posterior end is elongate and pointed below the middle; dorsal and ventral margins slightly converge backwards. The eye tubercle is distinct and a sub-

central tubercle or anteromedian swelling is present. A marginal rim extends around the anterior, ventral and posterior margins; the antero-marginal rim and the ventral part of the postero-marginal rim are well developed relative to the weak ventro-marginal rim.

There are three longitudinal ridges present : a well developed dorsal ridge, commencing just below the eye tubercle, curving upwards without any undulations and ending at the well developed subangular posterodorsal process; this is confluent with another ridge running obliquely towards the anteroventral corner through the antero-median swelling of the carapace; the third longitudinal ridge is a ventral ridge commencing just below the antero-median swelling, and running parallel to the oblique median ridge; finally a weak rib runs in the middle of the carapce parallel to and between the median and ventral ridges. The lateral surface of the carapace is generally smooth or sometimes slightly punctate, apart from the presence of one row of quadratic-shaped reticulation behind the anteromarginal rim; this row changes into two rows of rounded reticulations lying between the ventral ridge and the anteromedian swelling. There are 4-5 small marginal spines on the ventral part of the posterior margin, and several spines present at the anterior margin although it is difficult to count them with certainty because of their state of preservation.

In dorsal view, the carapace has two parallel sides, and laterally compressed ends, maximum width lies at the posterior end of the ventral ridge.

Internally, the marginal area is moderately wide, inner margin and line of concrescence coincide, hinge is Amphidont/Heterodont.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11247	female? (Holotype)	0.510	0.250	0.170	2.040
OS 11248	male?	0.537	0.255	0.160	2.106
OS 11249	female?	0.540	0.267	0.171	2.022
OS 11250	female?	0.515	0.268	-	1.922

Discussion:

Occultocytherois harthaensis sp. nov. from the Maastrichtian of the Anah Well-2 is similar in size to O. elongata sp. nov., but differs in the details of ornamentation, and in shape, notably the posterior end. For further discussion see O. babylonia sp. nov..

Occurrence: Known so far from the Maastrichtian of the Anah Well-2 section of Western Iraq.

Occultocytherois fordus sp. nov.

pl .10 , figs. 8, 9, 12 & 13; pl . 11, fig. 1

Name: (L.) fordus = pregnant, with reference to the ventrolateral swelling of the carapace.

Diagnosis: A species of Occultocytherois with reticulate surface, and with a ventrolateral swelling, lying below the ventral ridge.

Holotype: Male carapace OS 11252, pl . 10 , figs. 8, 9 & 12 .

Paratype: OS 11253 - OS 11256

Material: 9 specimens from the Palaeocene and Middle Eocene of the Jabel Sinjar section, Iraq; Samples no. S45, S83, S86 and S87.

Type Locality: Jabel Sinjar section, Iraq.

Type Horizon: Marly beds of the Avanah Limestone Formation of Middle Eocene age, sample no. S83.

Description: Carapace with a narrowly rounded anterior margin, posterior margin bluntly pointed, dorsal and ventral margins straight

and converging to the posterior. The eye tubercle is small and rounded, sub-central tubercle is present in connection with an anteromedian swelling running obliquely towards the anteroventral corner of the carapace.

A distinct marginal rim extends along the anterior, ventral and posterior margins, being more prominent at the anterior margin than at the ventral and posterior. There are many small spines or nodes ornamenting the anterior margin, and 5-6 small spines at the postero-marginal rim. The lateral surface of the carapace is reticulate; the dorsal ridge is short and distinct ending posteriorly by an angular posterodorsal process; it is confluent with two more small ridges : the first running obliquely downwards toward the end of the ventral ridge, the second running vertically downward to terminate at mid-height. The median ridge is indistinct; ventral ridge weakly developed because of a ventrolateral swelling lying below it.

In dorsal view, the carapace sides converge towards the anterior, with both ends laterally compressed; maximum width lies on the abrupt posterior end of the ventral ridge. No internal details were observed.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11252	male (Holotype)	0.455	0.220	0.175	2.068
OS 11253	female	0.432	0.235	0.163	1.838
OD 11254	male	0.450	0.220	-	2.045
OS 11256	female	0.480	0.265	0.180	1.811

Discussion:

Occultocytherois spilota Siddiqui (1971) from the Lower Eocene of West Pakistan resembles O.fordus sp. nov. in general outline but differs in having large puncta instead of reticulation, and an

oblique posteroventral process lying in a posteroventral swelling. Occultocythereis arabica (M.S.) Al-Furaih, 1976 from the Lower Palaeocene of Saudi Arabia differs from this species in having a more reticulated surface, better developed posterodorsal process, and smaller ventrolateral swelling.

Occurrence: Known so far from the Palaeocene and Middle Eocene of the Jabel Sinjar section, northwestern Iraq.

Occultocythereis harthaensis sp. nov.

pl. 11, figs. 3, 4, 6-8 & 10

Name: After the Hartha Limestone Formation from which this species is described.

Diagnosis: Large species of Occultocythereis, surface punctate, the puncta become larger along the ventrolateral swelling, and dorsal ridge well developed and undulating.

Holotype: Female carapace, OS 11257, pl. 11, figs. 4 & 6.

Paratype: OS 11258 - OS 11260 and OS 11275 - OS 11278

Material: 23 specimens from the type locality and horizon only.

Type Locality: Anah Well-2, western Iraq.

Type Horizon: Limey marl beds of the Hartha Limestone Formation of Maastrichtian age, sample no. 15, at drilling depths of 2000' - 2016'.

Description: Large carapace with rounded anterior margin and pointed posterior margin; dorsal and ventral margins straight and slightly converging to the posterior, eye tubercle rounded and distinct; subcentral tubercle present but not pronounced.

A distinct marginal rim extends along the anterior, ventral and posterior margins, being better developed along the anterior and posterior than the ventral margin, the anterior margin has approximately 10 spines, which are sometimes indistinct because of the thickening of

the anteromarginal rim; there are 5-6 large spines at the ventral part of the posterior margin. Lateral surface is punctate, the puncta along the ventrolateral swelling of the carapace are larger than in other places; posterodorsal process is well developed and confluent with three ridges: a well developed undulating dorsal ridge, slightly convex upwards; median ridge runs diagonally and faintly towards the anteroventral corner of the carapace and is very weak in the mid posterior area; the third ridge is very short, runs vertically downwards and terminates at the mid height. There are two swellings on the lateral surface: an anteromedian swelling lies at the area of the sub-central tubercle and is inclined towards the anteroventral corner of the carapace; a ventrolateral swelling lies posterior and parallel to the anteromedian swelling, commencing from mid-height.

In dorsal view, the carapace has two parallel sides, with laterally compressed ends; the undulating dorsal ridge and the posterodorsal process can be seen clearly. Internal details are unknown.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11257	female (Holotype)	0.535	0.280	0.187	1.911
OS 11258	male	0.550	0.275	0.188	2.000

Discussion:

Occultocytherels harthaensis sp. nov. can be easily distinguished from Occultocytherels hatraensis and Occultocytherels namrudia sp. nov. by its large size, undulating dorsal ridge and the type of punctation of the lateral surface; the latter is smaller and restricted to the median part of the surface in Occultocytherels hatraensis sp. nov., or pitted & in the dorsomedian part of the surface with some fine punctation at the ventral surface of the ventro-

lateral swelling of the carapace in the case of Occultocytherels namrudia sp. nov. .

Occultocytherels peristicta Siddiqui (1971) from the Lower Eocene of West Pakistan is a punctate species with several morphotypes, is of smaller size and differs in detail of ornamentation; there might be some phylogenetic relationship between Occultocytherels harthaensis sp. nov. and O. peristicta however.

Occurrence: Known so far from the Maastrichtian of the Anah Well-2 section of western Iraq.

Occultocytherels hatraensis sp. nov.

pl . 11 , figs. 2, 5, 9, 11 & 12

Name: With reference to the old city of Hatra, northern Iraq, 250 B.C. - 200 A.D.

Diagnosis: A species of Occultocytherels with straight dorsal ridge, and finely punctate median surface.

Holotype: Female carapace, OS 11261, pl . 11 , figs. 2 & 11 .

Paratype: OS 11262 - OS 11264, and OS 11271 - OS 11274

Material: 52 specimens, from the Anah Well-2 section, samples no. 15-17, at drilling depths of 2000' - 3050'.

Type Locality: Anah Well-2, western Iraq .

Type Horizon: Limey marl beds of the Hartha Limestone Formation of Maastrichtian age, sample no. 15, at drilling depths 2000' - 2010'.

Description: Carapace with narrowly rounded anterior margin and pointed posterior margin; dorsal and ventral margins straight and converging to the posterior; eye tubercle rounded and distinct; sub-central tubercle present in connection with an anteromedian

swelling inclined towards the anteroventral corner of the carapace.

A distinct marginal rim extends along the anterior, ventral and posterior margins, being better developed along the anterior and posterior than the ventral margin; the anterior margin has approximately 14-15 small spines, and there are 6 large spines at the ventral part of the posterior margin. Lateral surface is ornamented by small punctation which is restricted to the median part of the surface; a row of rounded reticulation lies along the ventromarginal rim. Dorsal ridge is straight and distinct, ending by a well developed and angular posterodorsal process which is confluent with a short vertical ridge terminating before reaching the mid-height, and with an oblique and weakly developed ridge running diagonally towards the anteroventral. There are two lateral swellings on the surface; an anteromedian swelling described above, and a small ventrolateral swelling lies posterior and parallel to the anteromedian swelling.

In dorsal view, the carapace has two parallel sides, with laterally compressed ends, and the well developed postero-dorsal process and the convergence of the dorsal ridges towards the anterior can be seen clearly; in ventral view the ventromarginal rims of both sides are parallel and distinct. Internal details are unknown.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11261	female (Holotype)	0.457	0.245	0.165	1.865
OS 11262	female	0.470	0.250	0.160	1.880
OS 11271	male	0.495	0.255	0.167	1.941
OS 11273	male	0.477	0.232	0.153	2.056

Discussion:

This species bears some resemblance to Occultocythereis makhulaensis sp. nov. from the Maastrichtian of the Makhul Well-2

section, northern Iraq, but the latter species is less punctate or has a smooth surface, the posterodorsal process is less angular and it lacks the three ridges, and has a weakly developed ventral ridge which is indistinct in O. hatraensis sp. nov.. For further discussion see Occultocythereis harthaensis sp. nov. .

Occurrence: Known so far from the Maastrichtian of the Anah Well-2, western Iraq.

Occultocythereis ishtaria sp. nov.

pl . 12 , figs. 1, 3, 4, 6 & 7

Name: With reference to the Babylonian goddess "Ishtar".

Diagnosis: A species of Occultocythereis with reticulate and sometimes striate median surface, and with a very short ventral ridge ending in the middle of the carapace.

Holotype: Female carapace, OS 11265, pl . 12 , figs. 1 & 6 .

Paratype: OS 11266 - OS 11268

Material: 7 specimens from the Middle/Upper Eocene Avanah Limestone Formation, of the Jabel Sinjar section, samples no. S82 - S84.

Type Locality: Jabel Sinjar section, Iraq.

Type Horizon: Limey marl beds from the Avanah Limestone Formation of latest Middle Eocene age, sample no. S82.

Description: Carapace elongate, length usually double the height; anterior margin narrow and obliquely rounded; posterior margin elongate and pointed slightly below the middle; dorsal and ventral margins are straight and converge towards the posterior. Eye tubercle rounded, small and bounded from below by a small sulcus; sub-central tubercle present, but it is not distinct relative to the developed anteromedian swelling; the latter runs diagonally from the area beyond the sub-central tubercle towards the anteroventral corner of the carapace.

Reticulation and sometimes striations cover the middle surface of the carapace, whereas the antero and posterolateral surfaces are smooth apart from an anterior row of quadratic shaped reticulation lying behind the anteromarginal rim. There are numerous normal pore canal openings on the entire surface of the carapace. Dorsal ridge straight and distinct, ending posteriorly by an angular posterodorsal process. This posterodorsal process is confluent with another very short vertical ridge which terminates ventrally by a small node or bend to the anterior. The median ridge is indistinct; the ventral ridge is weakly developed and very short, ending at the middle of the carapace where the surface abruptly slopes towards the posteroventral. Marginal rim extends along the anterior and posterior margins, there are 20-22 small spines along the anterior margin and 4-5 small spines at the posterior; the ventromarginal rim is weaker than at the anterior and posterior.

In dorsal view, carapace has subparallel sides or slightly converge towards the anterior, with both ends laterally compressed, and maximum width lying on the posterior third of the carapace. Internal details are unknown.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11265	female (Holotype)	0.530	0.255	0.185	2.078
OS 11266	female	0.475	0.232	0.175	2.047
OS 11268	male	0.525	0.237	0.180	2.215

Discussion:

See Occultocytherois babylonia sp. nov. and O. elongata sp. nov.

Occurrence: Known so far from the Middle/Upper Eocene of the Jabel Sinjar section, northwestern Iraq.

Occultocytherois makhulaensis sp. nov.

pl. 12, figs. 2, 5, 8 & 13

Name: With reference to the type locality Makhul Well-2, Iraq.

Diagnosis: A species of Occultocytherois in which the surface is mainly smooth, with weak punctations in the centre of the valves.

Holotype: Carapace, OS 11269, pl. 12, figs. 2 & 13

Paratype: OS 11270

Material: 2 specimens only from the type locality at drilling depths 1605' - 1610' and 1635' - 1640'.

Type Locality: Makhul Well-2, northern Iraq.

Type Horizon: Maastrichtian, sample no. 40, at drilling depths 1605' - 1610'.

Description: Carapace subrectangular in lateral view; anterior margin narrowly rounded, and posterior margin slightly pointed; dorsal and ventral margins straight and subparallel or slightly converging to the posterior. Eye tubercle rounded and distinct, sub-central tubercle marked by a swelling on the surface inclined towards the anteroventral corner of the carapace.

Lateral surface is smooth or weakly punctated in the middle of the carapace except for a row of weak reticulation along the anterior and ventral margins. Posterodorsal process is well developed and subangular with steep posterior edge. Dorsal ridge is well developed, and straight except for some undulation at the anterior part lying behind and below the eye tubercle; a ventral ridge is weakly developed and short, starting from the midventral area, ascending backwards and ending abruptly at the edge of the posterior slope of the lateral surface, just below the junction of the dorsal ridge with the postero-dorsal process. A well developed marginal rim extends along the anterior, ventral and posterior margins, being better developed along the anterior and posterior margins than the ventral. In dorsal view,

the carapace has parallel sides with laterally compressed ends. No internal features were observed.

Dimensions: (In mm.)

	L.	H.	W.	I/H
OS 11269 (Holotype)	0.470	0.250	0.157	1.880
OS 11270	0.450	0.243	0.177	1.851

Discussion:

Occultocythereis makhulaensis sp. nov. can be easily distinguished from other species of Occultocythereis of the Middle East area by its diagnostic features.

Occultocythereis indistincta Siddiqui (1971) from the Middle Eocene of West Pakistan, resembles this species, differing in the shape of the dorsal ridge and the posterodorsal process is more angular than that of this species. Because of the stratigraphical and geographical differences between O. makhulaensis and O. indistincta, it is best to separate them into two species, considering although they are obviously related to one another.

Occurrence: Known so far from the Maastrichtian of the Makhul Well-2 section, northern Iraq.

Occultocythereis namrudia sp. nov.

pl. 12, figs. 9-12

Name: With reference to the Assyrian city "Namrud", 1250 B.C. - 600 B.C. .

Diagnosis: A species of Occultocythereis in which the dorsomedian surface is pitted, some fine punctation present at the ventral surface of the ventrolateral swelling of the carapace, and dorsal ridge is straight and distinct.

Holotype: Male carapace, OS 11279, pl . 12 , fig. 9

Paratype: OS 11280 - 11284

Material: 15 specimens from the type locality and horizon only.

Type Locality: Anah Well-2, western Iraq.

Type Horizon: Limey marl beds of the Hartha Limestone Formation of Maastrichtian age, sample no. 15, at drilling depths of 2000' - 2016'.

Description: Carapace with moderately rounded anterior margin, and tapering posterior end; dorsal and ventral margins straight and converging to the posterior; eye tubercle rounded and distinct; sub-central tubercle distinct and in connection with an anteromedian swelling.

A distinct marginal rim extends along the anterior, ventral and posterior margins, being thickly developed along the anterior and posterior than the ventral margins; there are approximately 16 small spines decorating the anterior margin, and 4-5 spines at the ventral part of the posterior margin. Dorsomedian surface of the carapace is pitted, whereas the ventral surface of the weakly developed ventro-lateral swelling is finely punctated; posterodorsal process is prominent, and confluent with three ridges: a straight and distinct dorsal ridge; median ridge runs diagonally and faintly towards the ventrolateral swelling of the carapace, it becomes very faint or broken at mid-posterior due to the pitting of the surface; the third ridge is short runs vertically downwards and terminates at the mid-height.

In dorsal view, the carapace has two parallel sides, with laterally compressed ends; the prominent posterodorsal process can be seen clearly; in ventral view, the better development of the anterior and posterior marginal rims relative to the ventromarginal rim and the anteromedian and ventrolateral swellings of the carapace are clearly shown. Internal features were not observed.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11279	male (Holotype)	0.495	0.260	0.170	1.904
OS 11280	female	0.500	0.270	0.175	1.852
OS 11282	female	0.502	0.270	0.182	1.859
OS 11283	male	0.510	0.265	0.187	1.924

Discussion:

This species can be easily distinguished from other species of Occultocytherois in the Middle East by its pitted dorsomedian surface. Occultocytherois spilota Siddiqui (1971) from the Lower Eocene of West Pakistan shows a close affinity to Occultocytherois namrudia sp. nov., but differs in its smaller size, and the presence of a posteroventral process. For further comparison see Occultocytherois harthaensis sp. nov.

Occurrence: Known so far from the Maastrichtian of the Anah Well-2 section of western Iraq.

Genus Oertliella Pokorny; 1964

Type Species: Cythere reticulata Kafka, 1886

Oertliella petraensis sp. nov.

pl . 18 and pl . 19, figs. 1, 2 & 4

Name: With reference to the capital city of "Petra", 150 B.C. - 100 A.D. .

Diagnosis: A small species of Oertliella with a well developed spine on the sub-central tubercle; this spine bifurcates at the top.

Holotype: Male carapace, OS 11285, pl . 18, figs. 1 & 4

Paratype: OS 11286 - OS 11289, and OS 11422 - OS 11425.

Material: 36 specimens from the Lower Palaeocene (M.-U. Danian) of the Tell-Burma section, samples no. BMJ 845, BMJ 848, BMJ 850 & BMJ 853.

Type Locality: Tell-Burma section, Jordan.

Type Horizon: Lower Palaeocene (U. Danian), sample no. BMJ 850.

Description: Carapace small; anterior margin broadly rounded, posterior margin obliquely rounded or bluntly pointed below the middle, dorsal and ventral margins straight and converging to the posterior. The well developed eye tubercle protrudes and over-reaches the dorsal margin; some spines lie on its dorsal side. Sub-central tubercle marked, bearing a well developed bifurcating spine.

Lateral surface reticulate with some superimposed spines or pore cones and sieve-type pores (Mesh pores, according to Liebau, 1971) lying within the fossae; the reticulation ranges from quadratic-shaped reticules along the margins, to 3-5 sided towards the centre of the carapace; the most prominent anterior spines or pore cones are the "Aquarius, Capricornus, Scorpio and Beta" pore comuli; the "Leo, Gemini, Charon, Chi and Psi" pore comuli are prominent posteriorly. Dorsal ridge distinct and bearing 5 spines or pore cones; of these

the "Sagittarius" pore conulus (T3 according to Liebau's (1971) scheme) is strong; the posteriormost "Virgo" pore conulus (T5 according to Liebau) is the strongest and furcated at the top; there is a small ridge joining the latter pore conulus with the "Chi" pore conulus lying below it. (For definition of the pore conuli see fig.10 ; Liebau, 1969, 1971; and Benson, 1972). The ventral ridge is distinct and broken into 7 spines, the posteriormost spine being the strongest. A narrow marginal rim extends along the anterior, ventral and posterior margins, being weaker along the ventral margin. There are two rows of small spines around the anterior, ventral and posterior margins; the outer row has smaller spines or nodes and also extends around the dorsal margin.

In dorsal view, the carapace has a thorny appearance, with two parallel sides and laterally compressed ends; maximum width lies at the sub-central tubercle or the posteriormost spine of the ventral ridge; the dorsal row of the marginal spines or nodes can be seen clearly.

Internally, marginal areas narrow; very narrow vestibule is present at the anterior and posterior; selvage submarginal and prominent; radial pore canals numerous, straight and simple, 33-35 radial pore canals at the anterior, and 10-12 at the posterior. Hinge is Amphidont/Heterodont; the right valve hinge elements consisting of a conical anterior tooth, postjacent deep socket, smooth median groove, and bilobate posterior tooth; in the left valve the accommodative hinge elements are present. Muscle scars lie in a deep depression, consisting of 4 elongated adductors and a V-shaped frontal scar. The internal surface of the valve is perforated by numerous seive-type pore openings.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11285	male (Holotype)	0.680	0.392	0.360	1.735
OS 11286	male	0.655	0.390	0.337	1.679
OS 11287	female	0.603	0.360	0.335	1.675
OS 11289	female	0.562	0.357	-	1.574
OS 11422	female	0.570	0.345	-	1.652
OS 11425	male	0.730	0.380	0.305	1.921

Discussion:

Oertliella petraensis sp. nov. can be easily distinguished from other species of the genus by its small size and the presence of prominent bifurcating spine on the sub-central tubercle. Oertliella aculeata (Bosquet, 1852) differs in its larger size, better developed ventral ridge, well developed posteromarginal spines, and lacking the well developed spine on the sub-central tubercle. Oertliella ducassae Benson (1972) has larger size and different details of ornamentation. Oertliella horridula (Bosquet, 1854) described as „Trachyleberis" horridula by Deroo (1966), from the Upper Maastrichtian of Limbourg is similar to O. petraensis but differs in its slightly larger size, and in some details of ornamentation, notably the better development of the posteromarginal spines.

Occurrence: Known so far from the Middle-Upper Danian of the Tell-Burma section, Jordan.

Ordoniya gen. nov.

Name: From the arabic name of Jordan.

Diagnosis: A genus of Trachyleberidinae, with 3 longitudinal ridges; in the left valve the dorsal ridge divides posteriorly into two branches; the median ridge of both valves divides posteriorly into two branches, the stronger branch turning downwards. Surface ornamentation varies from wrinkled to reticulate. The dorsal-most adductor muscle scar divides into two.

Type species: Hazelina ordoniya Bassiouni, 1970

Description : Carapace subrectangular in lateral outline, with a pointed posterior margin. Males longer, lower, and slightly narrower than females. Left valve slightly overlaps the right in the regions of the anterior cardinal angle and the posterodorsal slope. Dorsal and ventral margins are straight, converging posteriorly to give a pointed posterior end. Eye tubercle distinct. There are 3 longitudinal ridges, with marginal rims along the anterior, posteroventral and ventral margins. The dorsal ridge splits close to its posterior end into two branches in the left valve, one of them turning vertically downward, while the other continues further to the posterior; the upper branch is not present in the right valve. The median ridge divides posteriorly into two branches, the relatively weaker branch ascending posteriorly toward the vertical branch of the dorsal ridge, the other branch turning downward to end behind the ventral ridge. The ventral ridge is straight and ends abruptly at the posterior.

Internally, the line of concrescence and the inner margin coincide, and run parallel to the outer margin; marginal area moderately wide, selvage prominent, marginal pore canals numerous (about 30 anteriorly and 10 posteriorly), simple and straight.

Muscle scars are in a deep depression, with a V-shaped frontal muscle scar and 4 adductor muscle scars; the dorsal-most adductor scar is divided into two, while the lower two scars are very close to each other and give the appearance of a single branched scar. Hinge Amphidont/ Heterodont, right valve hinge with an anterior smooth conical tooth, a postjacent deep smooth socket, followed by a median smooth groove, and a posterior smooth conical tooth; there is a smooth bar above the median groove.

Discussion: The new genus is divided into two subgenera, Ordoniya (Ordoniya) and Ordoniya (Pharkidata) which differ in the type of ornamentation developed between the longitudinal ridges (figs.6 & 8), The nominate subgenus is reticulate, while Ordoniya (Pharkidata) has a wrinkled surface. The subcentral tubercle is more distinct in Ordoniya (Ordoniya).

Bassiouni (1970) placed the species assigned to Ordoniya in the genus Hazelina Moos, 1966. The differences between the two genera are as follows:

Ordoniya has a pointed posterior end in lateral view, Hazelina is bluntly produced; the three longitudinal ridges are thicker and better developed in Hazelina; the dorsal ridge is simpler in Hazelina, without the saddle-shaped middle portion of some species of Ordoniya, and without the posterior division seen in the left valve of Ordoniya; the median ridge splits posteriorly in Ordoniya, but not in Hazelina where it curves upwards to join the posterior end of the dorsal ridge; Hazelina typically has spines or denticulation around the antero-ventral margin, whereas Ordoniya usually lacks these, although a few species have antero-ventral denticulations. Internally, the dorsal-most adductor scar is split into two in Ordoniya, which it is not in Hazelina, and the frontal scar is V-shaped rather than the

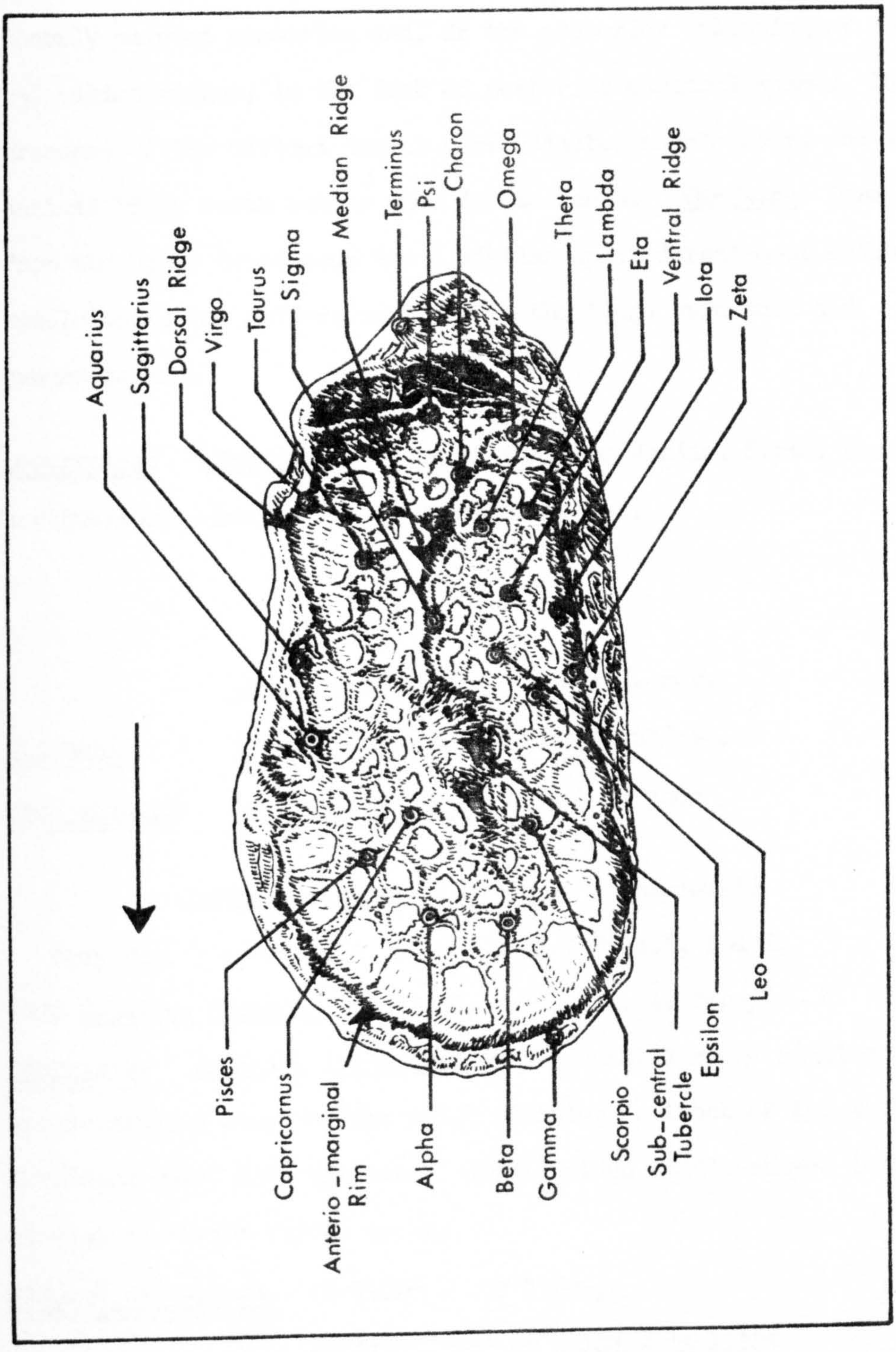


Figure 6 : Morphology of Ordoniya (Ordoniya) gen. et subgen. nov.; the left valve of the carapace. This diagram illustrates the terminology used for the main ornamental features and principle pore conuli (indicated by Zodiacal and Greek names). (After Benson,1972 with additions) .

J-shape of Hazelina; the hinge teeth of Hazelina are lobate unlike the simple conical teeth of Ordoniya. Ordoniya differs from Trachyleberidea Bowen 1953 (emend. Haskins 1963) in having a less sharply pointed posterior end, in the posterior splitting of the dorsal and median ridges, in the lack of posterior marginal spines, in the presence of the divided dorsal-most adductor muscle scar, and in having conical hinge teeth rather than lobate teeth. Curfsina Doroo 1966 from the Upper Cretaceous has a similar split dorsal-most adductor muscle scar, but differs markedly in the hinge structure and ornamentation.

Occurrance: Ordoniya is known so far from Jordan, Syria, western and northwestern parts of Iraq and eastern Egypt.

Ordoniya (Ordoniya) subgen. nov.

Diagnosis : Ordoniya with a reticulate surface.

Type species: Hazelina ordoniya Bassiouni 1970

Ordoniya (Ordoniya) ordoniya (Bassiouni)

Text fig. 7 ; pl . 13 and Pl . 14 , Figs.1, 3 & 4.

1970 Hazelina ordoniya Bassiouni, P.31, Pl . 4, figs.4 - 8

Diagnosis: Ordoniya (Ordoniya) with a ventral ridge running from the anteromarginal rim; median ridge starting in front of the well developed subcentral tubercle; dorsal ridge saddle-shaped in the middle; posterior furrow smooth.

Figured specimens: OS 11096 - OS 11199,

OS 11101, and OS 11103 - OS 11105

Material 111 specimens, including adults and juveniles from the M.Maastrichtian and lower Palaeocene (U. Danian) of Tell-Burma, Jordan, Sample numbers BMJ 62 and BMJ 847-853; and one specimen from the

L.Palaeocene of Bir Qdeim Section, Syria, sample number Jd 683.

Type Locality: Tell-Burma, Jordan .

Type Horizon : Lower Palaeocene .

Description: The postero-ventral margin may be smooth or denticulate. The anterior marginal rim joins the ventral ridge, the posterior marginal rim commences midway along the ventral margin, runs parallel to the postero-ventral margin, finishing at the Terminus pore conulus (See fig. 6 and Benson, 1977, p. 20, fig. 8A for definition). Dorsal ridge is short, straight and saddle-shaped in middle.

The whole surface, apart from the posterior furrow, is reticulate. The type of reticulation varies (fig. 7), with large quadratic shapes restricted to the areas behind the antero-marginal rim and the anterior part of the ventral ridge (row A), and with 3-5 sided shapes over the remainder of the valve, arranged in three anterior rows (B, C & D), subcentral row E, seven longitudinal rows (K, L, M, N, O, P & V) and a posterior group of reticulations (Q). Normal pore canal cones are present.

Internal details are as for the genus, with about 30 anterior and 10 posterior radial pore canals.

Dimensions (In mm.)

		L.	H.	W.	L/H
OS 11096	Male	0.650	0.337	-	1.9288
OS 11097	Female	0.625	0.350	0.275	1.7857
OS 11098	Female	0.618	0.325	0.250	1.9015
OS 11099	Male	0.700	0.350	0.277	2.000

Discussion: The ornamentation shows differences in detail between specimens of different ages. Older specimens have small reticulations, while younger specimens have a secondary ornamentation developed within

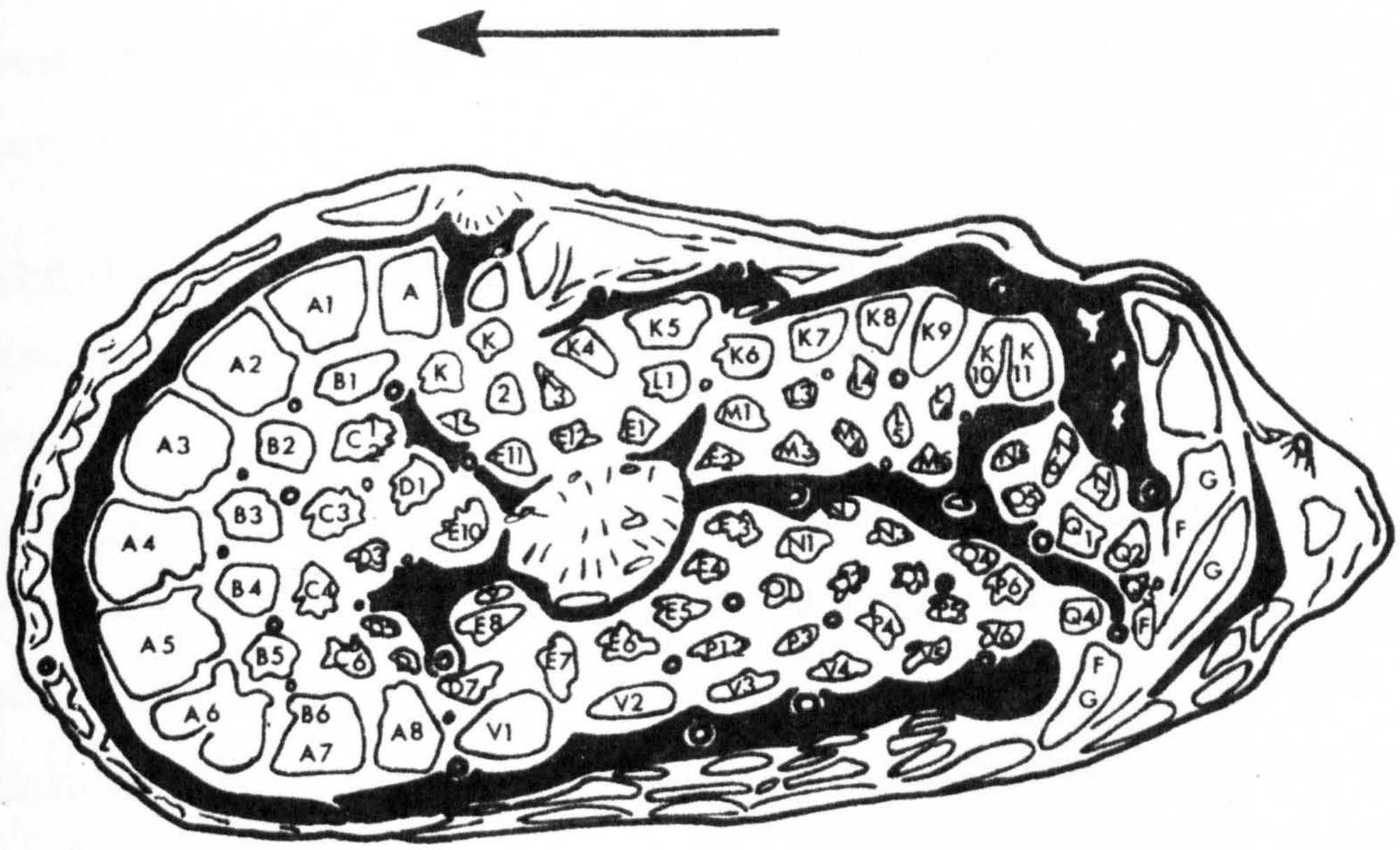


Figure 7 : Lateral reticulation of Ordoniya (Ordoniya) gen. et subgen. nov.; arrow indicates anterior, and dark areas illustrate the main ridges .

the primary reticulation (Pl. 13). These differences may be phylogenetic or due to some environmental factor. Six species have been placed in the new subgenus, O.(O.) ordoniya, O.(O.) deroii (Bassiouni, 1970), O.(O.) burmaensis (Bassiouni, 1970), O.(O.) maanensis (Bassiouni, 1970), O.(O.) sinjariya sp. nov. & O.(O.) anahensis sp. nov. The type species can be distinguished by the presence of a well-developed sub-central tubercle, a smooth furrow separating the postero-marginal rim from the rest of the valve, and the ventral ridge which runs from the antero-marginal rim.

Ordoniya (O.) deroii has a straight dorsal ridge, a ventral ridge intersecting the antero-ventral marginal rim and a reticulate posterior furrow.

Ordoniya (O.) burmaensis has less distinct longitudinal ridges and posterior furrow, with better developed reticulation than O.(O.) deroii, and a ventral ridge which does not join the anterior marginal rim.

Ordoniya (O.) sinjariya has a less prominent subcentral tubercle than the other species while Ordoniya (O.) anahensis has a median ridge starting from just behind the antero-marginal rim and a star-shaped reticulation.

Occurrence: This species is known so far from the Tell-Burma section of Jordan, ranging from Middle Maastrichtian (One juvenile specimen only) to the Middle Palaeocene as described by Bassiouni (1970), and from a selected sample from the Lower Palaeocene of the Bir-Qdeim section, Syria.

Ordoniya (Ordoniya) deroii (Bassiouni)

Pl . 14, Figs. 2, 5, 7 & 11

1970, Hazolina deroii Bassiouni; P.29, Pl . 4, figs. 1 & 2.

Diagnosis : Ordoniya (Ordoniya) with a reticulate posterior furrow, ventral ridge joining the anterior marginal rim and poorly developed reticulation in the central and ventral parts of the valve.

Figured specimens: OS 11106 & OS 11107

Material : 6 specimens from samples BMJ 848 and BMJ 849, from the Upper Danian of the Tell-Burma section, Jordan.

Type Locality: El-Hasa, Jordan .

Type Horizon: Lower Palaeocene .

Description: Dorsal and ventral margins converge towards the posterior, the dorsal margin is straight, while the ventral margin of the female is curved at the posterior end. The anterior marginal rim begins at the posterior of the eye tubercle and runs parallel to the anterior margin.

In the left valve, the well-developed posterior marginal rim becomes faint before joining the dorsal branch of the dorsal ridge, while in the right valve it ends behind the vertical branch of the dorsal ridge. The ventral ridge is distinct, commencing at the intersection of the anterior and ventral marginal rims, and ending below the point of branching of the median ridge, with a weak branch running towards the posteroventral marginal rim. The posterior part of the ventral ridge is less distinct due to the lateral swelling of the postero-ventral portion of the carapace. Surface reticulation varies, with a large quadratic-shaped row (A) lying just behind the anterior marginal rim, followed by 2 rows (B & C) of small 3-5 sided reticulations anterior to the median ridge. The reticulation amongst

the longitudinal ridges and in the ventral area is close and small, becoming smaller and giving an almost smooth surface toward the ventral area. The posterior area between the two branches of the median ridge has semi-rounded reticulations, whilst the posterior furrow has two vertical rows of large reticulations. Secondary ornamentation is present within the primary reticulation. No internal features seen.

Dimensions: (In mm.).

		L.	H.	W.	L/H
OS 11106	Female ?	0.713	0.375	0.250	1.9013
OS 11107	Male ?	0.675	0.345	0.275	1.9565

Discussion: Ordoniya (Ordoniya)deroii (Bassiouni) from the lowermost U. Danian probably evolved into Ordoniya (O.) burmaensis (Bassiouni), which appears in the uppermost Danian and ranges into the M. Palaeocene, showing an increase in size of reticulation with the longitudinal ridges becoming less distinct.

Occurrence: This species is known so far from the Lower Palaeocene (U. Danian) of the Tell-Burma section and the L.-M.Palaeocene of the El-Hasa area (Bassiouni, 1970).

Ordoniya (Ordoniya) burmaensis (Bassiouni)

Pl .14, Figs. 6, 8-10; Pl .15, Figs. 1, 3, 4 & 7.

1970, Hazelina burmaensis Bassiouni; P.32, Pl . 5, Figs. 3 & 4

Diagnosis: Ordoniya (Ordoniya) in which the reticulation between median and ventral ridges is arranged in rows; the dorsal ridge is straight.

Figured specimens: OS 11108 & OS 11110 - OS 11112

Material: 18 specimens from samples BMJ 851-853, from the Upper Danian of the Tell-Burma section, Jordan, and one specimen from the Lower Palaeocene of the Bir Qdeim section, Syria, sample No. Jd 630.

Type Locality: Tell-Burma .

Type Horizon : Middle Palaeocene .

Description : Anterior, antero-ventral and posteroventral margins are denticulate. Anterior rim extends ventrally as a ventro-marginal rim ending midway along the ventral margin; posteroventral marginal rim also present. Median ridge starts in front of the muscle area, gradually ascending to the posterior, with a slight thickening over the faint sub-central tubercle, and ending with the typical branching of the genus. Ventral ridge is straight, commencing behind the anterior and anteroventral marginal rims, finishing below the point of branching of the median ridge. A very weak branch runs from the end of the ventral ridge towards the posteroventral marginal rim and parallel to the lower branch of the median ridge. Reticulation varies, with quadratic shapes in the anterior region, 5-6 sided in the dorsal region and rectangular shapes arranged in rows between the median and ventral ridges.

Internal details are as for the genus.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11108	Male	0.750	0.400	0.290	1.8750
OS 11109	Female	0.718	0.393	0.283	1.8269
OS 11110	Male	0.750	0.383	0.275	1.9582

Discussion: As with Ordoniya (O.) ordoniya, specimens of different ages show some differences in the reticulation: older specimens have smaller reticulation, while younger specimens have a secondary

ornamentation within the primary reticulation (Pl .14 , figs. 6, 8-10). Ordoniya (O.) maanonsis (Bassiouni) from the Lower Eocene of Jordan differs from this species by its arched dorsal ridge and differing reticulation between the longitudinal ridges, which are all 5-6 sided and weakly developed (Bassiouni, 1970).

Occurrence: Known so far from the Middle and Lower Palaeocene of the Tell-Burma section, Jordan, and from the Lower Palaeocene of the Bir Qdeir section, Syria.

Ordoniya (Ordoniya) sinjariya sp. nov.

Pl .15 , figs. 6, 9 & 10; Pl .16 , figs. 1-6, 8, 9 & 11

Name : After Sinjar town, Iraq.

Diagnosis: A species of Ordoniya (Ordoniya) with a ventral ridge running from the antero-marginal rim, weak sub-central tubercle, saddle-shaped dorsal ridge, and an indistinct posterior furrow which is reticulate

Holotype: Female carapace (OS 11086); Pl .16, figs. 1 & 4.

Paratype: OS 11087 - OS 11094

Material: 19 specimens from samples S71, 77, 79, 82, 84-87, 90, 92 & 96, and one specimen from Anah Well-2 section, sample No. 9.

Type Locality: Jabel Sinjar section, IRAQ .

Type Horizon : Marly beds from the Middle Eocene part of the Jaddala Formation, sample No. S77 .

Description: Dorsal ridge short, undulating or saddle-shaped in the middle; median ridge begins as a thickening upon the weak sub-central tubercle; the ventral ridge extends from the antero-marginal rim, ending below the point of branching of the median ridge.

The entire surface is reticulate, with a row of relatively large quadratic reticules lying parallel to the anterior margin (row A), and 3-5 sided reticulation covering the rest of the surface. Secondary ornamentation is present on the sides of the primary reticulations. The anterior half of the dorsal surface behind the eye tubercle has three rows of tiny reticulation present on both valves, followed by one row of larger reticulation covering the posterior half of this surface.

Internal details are unknown.

Dimensions: (In mm.)

	L.	H.	W.	L/H
OS 11086 Female (Holotype)	0.630	0.337	0.313	1.8694
OS 11087 Male	0.595.	0.303	0.263	1.9318
OS 11088 Male	0.663	0.35-	0.250	1.9086
OS 11089 Female	0.605	0.335	0.280	1.8059

Discussion: This new species shows some resemblance to Ordoniya (Ordoniya) ordoniya (Bassiouni), but it differs in its less developed sub-central tubercle, and in the median and ventral ridges. Furthermore O.(O.) ordoniya has a smooth posterior furrow, which is indistinct in O.(O.) sinjariya, but when present is reticulate. Specimens from younger horizons than the type specimens have a fainter median ridge with less pronounced posterior branching, and the reticulation covering the whole surface relative to the size of the quadratic reticule present along the anterior margin is slightly larger. Paratypes (OS 11088 & OS 11089) from sample No. S82 have larger and slightly protruding eye tubercles in the left valve, rising over the dorsal margin (Pl . 16, figs. 2 & 3).

A single specimen from the U. Eocene part of the Jaddala Formation and referred to as Ordoniya (Ordoniya) sp. (OS 11095,

Pl . 16 , figs. 7, 10 & 12), can be easily distinguished from O.(O.) sinjariya by its well developed ventro-marginal rim and ventral ridge which turns upward posteriorly toward the lower branch of the median ridge.

Occurrence: This species is known so far from the M. Eocene part of the Jaddala Formation and the M.-U. Eocene Avanah Limestone Formation, all of the Jabel Sinjar section and from the M.-U. Eocene Jaddala Formation of Anah Well-2 at a drilling depth of 990' - 995'.

Ordoniya (Ordoniya) anahensis sp. nov.

Pl .15 , figs. 2, 5 & 8

Name : With reference to Anah town, Iraq.

Diagnosis: Ordoniya (Ordoniya) with a median ridge commencing just behind the antero-marginal rim, and with a star-shaped reticulation.

Holotype: Female right valve (OS 11119), Pl .15 , fig. 2 .

Paratype: OS 11120 - OS 11122

Material: 8 specimens from samples 1, 3, 4, 5, 7 & 9, Anah Well-2 section, at drilling depths 800' - 995'.

Type Locality: Anah Well-2, Iraq .

Type Horizon : Marly limestone beds from the M.-U. Eocene Jaddala Formation, at drilling depth 920' - 925', sample No. 5 .

Description: Eye tubercle is small and indistinct; median ridge commencing just behind the antero-marginal rim and ending with two branches, the lower branch distinct and turning vertically downwards; ventral ridge is distinct, extending from the antero-marginal rim and ending behind its intersection point with the lower branch of the median ridge.

Surface is entirely covered by semi-rounded reticulations with a secondary ornamentation of small spines projecting into the alveoles of the reticulation, giving a star shape (see Pl .15 , fig. 8).

Although the material consists of single valves, the only internal feature observed is the hinge; in the right valve the hinge consists of a conical anterior tooth, a postjacent socket, a crimulated median groove and posterior tooth which is probably lobate.

Dimensions: (In mm.)

	L.	H.	W.	I/H
OS 11119 Female (Holotype)	0.575	0.300	-	1.9166
OS 11121 Female	0.625	0.325	0.265	1.9231
OS 11122 Male	0.675	0.325	0.232	2.0769

Discussion: Ordoniya (O.) anahensis differs from O.(O.) ordoniya in lacking the smooth posterior furrow, in the non-undulated dorsal ridge, in the more distinct median ridge and in the details of reticulation.

Ordoniya (O.) doroii and Ordoniya (O.) burmaensis are larger than O.(O.) anahensis, with a different ventral ridge which does not join the antero-marginal rim.

Ordoniya (O.) anahensis also differs from O.(O.) sinjariya in the details of the dorsal and median ridges and in the shape of reticulation.

Occurrence: Only known so far from the M.-U. Eocene Jaddala Formation of Anah Well-2 .

Ordoniya (Pharkidata) subgen. nov.

Type species: Ordoniya (Pharkidata) bassiounii sp. nov.

Name : Greek pharkidodes = wrinkled

Diagnosis: Ordoniya with wrinkled surface amongst the longitudinal ridges.

Ordoniya (Pharkidata) bassiounii sp. nov.

Pl. 17, figs. 1, 2 & 4

Synonym: 1970, Hazelina sp. Bassiouni; P. 31, Pl. 4, fig. 3

Name : In honour of Dr. Mohamed A. Bassiouni.

Diagnosis: Ordoniya (Pharkidata) in which the median ridge starts behind the anterior marginal rim, joining the weakly developed sub-central tubercle, and with a ventral rib running between the ventral ridge and the ventro-marginal rim.

Holotype: Male carapace OS 11113, Pl. 17, figs. 1, 2 & 4

Paratype: One female carapace OS 11114

Material: 2 specimens from sample BMJ 843.

Type locality: Tell-Burma, Jordan.

Type Horizon : L. Palaeocene (Upper Danian).

Description: Median ridge commences from the faintly developed second row of reticulation, lying behind the anterior marginal rim, passing with some thickening through the weakly developed sub-central tubercle, and splitting posteriorly into two branches. Ventral ridge starts just behind the antero-marginal rim, thickening upon the ventrolateral swelling of the carapace, and ending abruptly below the branching point of the median ridge. The ventral half of the carapace is swollen laterally and bounded by the median and ventral ridges.

Ornamentation consists of two anterior rows of faint reticulation, with other traces of reticulation below the dorsal

ridge, while the rest of the surface between the longitudinal ridges is wrinkled; the posterior furrow is smooth (fig. 8).

Concentration of the wrinkles produce three principle ribs additional to the 3 longitudinal ridges; a dorsomedian rib between the dorsal and median ridge, starting from a confluence of two weak ribs, then running backward with some disturbance in the middle, a second rib in a ventromedian position, starting just below the sub-central tubercle and running backward parallel to and between the median and ventral ridges and ending above the postero-ventral marginal rim; and a third rib commencing at the end of the ventro-marginal rim, climbing the ventral face of the ventrolateral swelling of the carapace and ending with the second intermediate rib, below the end of the ventral ridge.

Muscle scars as for the genus, other internal details unknown.

Dimensions: (In mm.)

	L.	H.	W.	L/H
OS 11113 Male (Holotype)	0.675	0.362	0.250	1.864
OS 11114 Female	0.707	0.400	0.275	1.767

Discussion: Ordoniya (Pharkidata) bassiounii sp. nov. is easily distinguished from O.(P.) bilobatus sp. nov. from the M.-U. Eocene of Iraq, by its smaller size and its median ridge which starts in front of the weak sub-central tubercle. O.(Pharkidata) hasaensis (Bassiouni) from the U. Palaeocene of Jordan, shows more resemblence in size to O.(P.) aff. bilobatus, but differs in outline and the presence of weak reticulations between the dorsal and median ridges.

O.(Pharkidata) bilobatus sp. nov. differs from O.(P.) hasaensis by its slightly larger size, and a well marked bilobated sub-central tubercle which is not a part of the anterolateral swelling

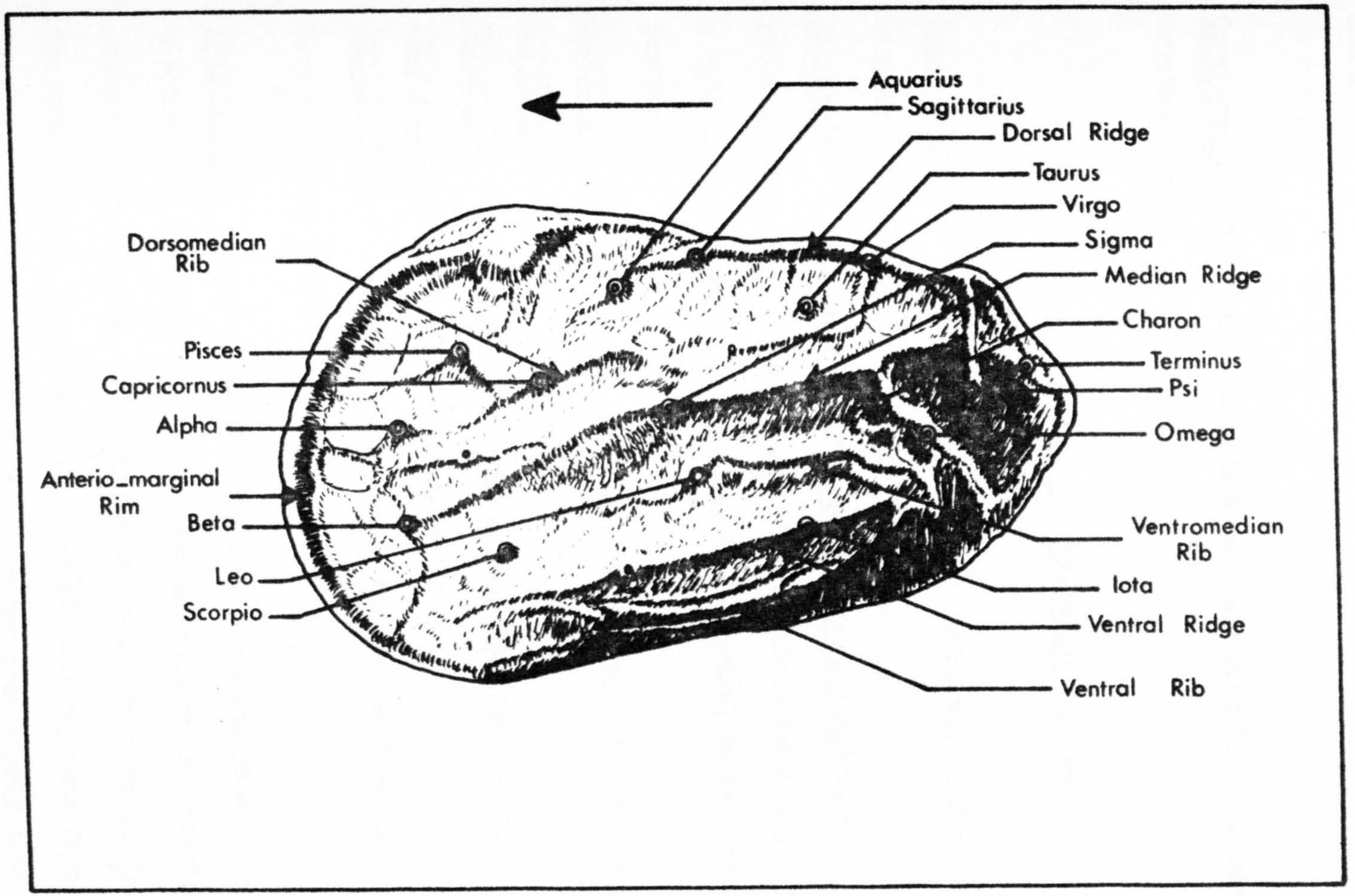


Figure 8 : Morphology of Ordoniya (Pharkidata) gen. et subgen. nov.;the left valve of the carapace. This diagram illustrates the terminology used for the main ornamental features and principle pore conuli (indicated by Zodiacal and Greek names). (After Benson,1972 with additions).

as in O.(P.) hasaensis. Bassiouni's figured specimen of O.(P.) bassiounii sp. nov. from the lower Palaeocene of Tell-Burma, Jordan, is a male.

Occurrence: This new species is known only from the Tell-Burma section, Jordan.

Ordoniya (Pharkidata) bilobatus sp. nov.

Pl .17 , figs. 7 - 12

Name: bi (L.) = twice, lobus (L.) = Lobe, with reference to the bilobated subcentral tubercle.

Diagnosis: A large species of Ordoniya (Pharkidata) with a median ridge starting from a long bilobated sub-central tubercle, and with a well developed marginal rim along the anterior, ventral and posterior margins.

Holotype: Probably a male carapace, OS 11115, Pl . 17, figs. 7 - 9

Paratype: OS 11116 and OS 11117

Material: 8 specimens from samples S83, S84, S86 and S92.

Type Locality: Jabal Sinjar section, Iraq.

Type Horizon : 2m. thick marly bed in the Avanah Formation from the M.- U. Eocene, Sample S84.

Description: Large carapace, with a marginal rim starting from the distinct eye tubercle, passing continuously along the anterior, ventral and posterior margins, and ending just beyond the vertical branch of the dorsal ridge. Median ridge is short, clearly runs from a long bilobated sub-central tubercle and branches posteriorly into two as for the genus.

Ornamentation consists of 2-3 rows of faint reticulations behind the antero-marginal rim, and some other weak reticulations present between the dorsal and median ridges. The remainder of the

surface between the longitudinal ridges is wrinkled. A rib lies above and parallel to the bilobated sub-central tubercle. The surface between the median and ventral ridges is higher than the rest of the surface of the valve, due to lateral swelling. No internal details observed.

Dimensions: (In mm.)

	L.	H.	W.	L/H
OS 11115 Male ? (Holotype)	0.825	0.425	0.375	1.9412
OS 11116 Female ?	0.830	0.432	0.332	1.9213
OS 11117 Male ?	0.788	0.400	0.325	1.9700

Discussion: See Ordoniya (Pharkidata) aff. bilobatus

Occurrence: Only known so far from the M. - U. Eocene of Jabel Sinjar section, Iraq.

Ordoniya (Pharkidata) aff. bilobatus sp. nov.

Pl . 17, figs. 2, 5 & 6.

Figured Specimen OS 11118

Dimensions: (In mm.)

L.	H.	W.	L/H
0.800	0.425	0.320	1.8828

Discussion: Ordoniya (Pharkidata) aff. bilobatus sp. nov. from the Palaeocene Aaliji Formation of the Jabel Sinjar section of Iraq, differs from O.(P.) bilobatus sp. nov. in: the ventromarginal rim, the anterior margin which is slightly inclined backwards towards the dorsal margin, and in the ventral ridge which extends more or less from the antero-marginal rim.

Phylogenetic Discussion:

The suggested evolution of the genus is shown in fig. 9 . The presence of a single specimen of a juvenile Ordoniya (Ordoniya) ordoniya in the Maastrichtian of Jordan suggests that this species may have been ancestral to the other species. Moderate radiation presumably occurred in the U. Cretaceous, so that in the L. Palaeocene of Jordan and Syria 3 species belonging to the 2 subgenera occur together. In the uppermost Middle Palaeocene the genus spread to Iraq, where new species of both subgenera are found. In the L. Eocene Ordoniya (O.) maanensis is present in Egypt as well as in Jordan.

Bassiouni (1970, P.35) recorded a carapace from the U. Palaeocene of the El-Hasa section of Jordan, which has some features suggesting an intermediate position between the M. Palaeocene Ordoniya (O.) burmaensis and the L. Eocene Ordoniya (O.) maanensis.

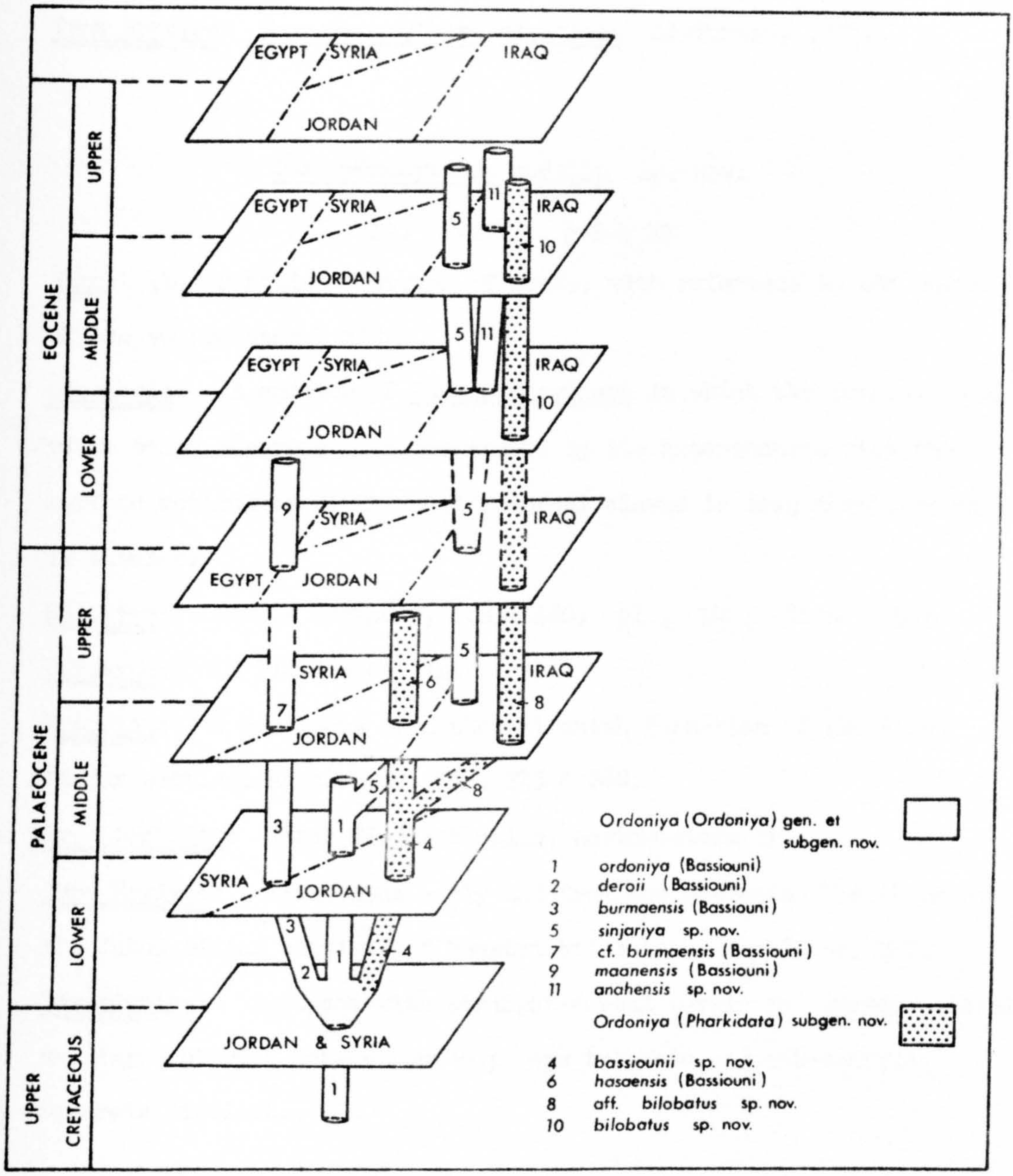


Figure 9 : Evolution and distribution of the genus Ordoniya nov. in the Middle East .

Genus Paragrenocythere Al-Furaih, 1975

Type Species: Paragrenocythere biclavata Al-Furaih, 1975.

Paragrenocythere monilis sp. nov.

pl. 19, figs. 3, 5-8 & 12

Name: (L.) monilis = string of beads, with reference to the shape of the ventrolateral ridge.

Diagnosis: A species of Paragrenocythere in which the ventrolateral ridge bears a series of nodes formed by its intersection with the surface reticulation; the posterodorsal clavae is less developed and is tubular.

Holotype: Female carapace, CS 11426, pl. 19, figs. 3 & 5

Paratype: OS 11427 - OS 11429

Material: 6 specimens from the Shiranish Formation of the Jabel Sinjar section, samples no. S17, S25 & S28.

Type Locality: Jabel Sinjar Section, northwestern Iraq.

Type Horizon: Bituminous marly bed from the Shiranish Formation of the Jabel Sinjar section, of Maastrichtian age; sample no. S28.

Description: Carapace with straight dorsal margin and curved ventral margin; anterior margin rounded; eye tubercle and sub-central tubercle distinct.

Lateral surface reticulate, the reticulation varying from quadratic-shaped reticules along the anterior margin to 3-5 sided or rounded reticules elsewhere. Dorsal ridge distinct and sometimes broken into spines, ending by a posterodorsal clavae. The latter is less developed than in the type species of the genus, and if preserved it is tubular in shape. Ventro-lateral ridge well developed, bearing a series of 7 nodes which increase in size towards the posterior; the nodes are formed by the intersection of the ridge with the surface reticulation. Marginal rim extends along the

anterior, ventral, and posterior margins; there are traces of marginal spines at the anterior margin and the ventral part of the posterior marginal rim. Some pore cones are present on the lateral surface, of which "Capricornus and Scorpio" pore comuli are present anteriorly, "Leo and Charon" at the centre of the valve, and "Terminus" at the posterior.

In dorsal view, the carapace is wedge-shaped with both sides converging towards the anterior and with laterally compressed ends; maximum width lies at the posterior end of the ventro-lateral ridge. No internal features were observed.

Dimensions: (In mm.)

		L.	H.	W.	L/H
DS 11426	female (Holotype)	0.800	0.430	0.457	1.860
DS 11427	female	0.847	0.470	0.480	1.802
DS 11428	male	0.885	0.455	0.525	1.945

Discussion:

Paragrenocythere monilis sp. nov. can be easily distinguished from Paragrenocythere biclavata Al-Furaih (1975), P. gladius (M.S.) Al-Furaih, 1976, P. gravis (M.S.) Al-Furaih, 1976, and P. ponticulata (M.S.) Al-Furaih, 1976 from the Uppermost Cretaceous - Palaeocene of Saudi Arabia, by its diagnostic features, size, and the details of reticulation, notably the better development of the muri between the anterior rows of reticulation (rows A & B), which are more or less joined together in the case of the Saudi species.

Occurrence: Known so far from the Maastrichtian of the Jabel Sinjar Section, Iraq.

Genus Poloriops Al-Abdul-Razzaq, 1979

Type Species: Poloriops sphaerommata Al-Abdul-Razzaq, 1979

Poloriops levisulcata sp. nov.

pl. 19, figs. 9-11; pl. 20, figs. 1, 3, 4, 6-8 & 10

Name: (L.) Levis = smooth + sulcatus = furrow, with reference to the two smooth furrows on the surface of the valves.

Diagnosis: A species of Poloriops with a smooth and tuberculate surface; a smooth furrow lies posterior to and below the highly protruding eye tubercle.

Holotype: Male carapace, OS 11443, pl. 19, figs. 9-11; pl. 20, fig. 4

Paratype: OS 11444 - OS 11448

Material: 7 specimens (including 2 broken valves), from the Shiranish Formation of Maastrichtian age; and the Hartha Limestone Formation, Upper Campanian? - Maastrichtian age; Makhul Well-2; samples no. 41, 42, 56 & 79, at drilling depths of 1620' - 2100'.

Type Locality: Makhul Well-2, northern Iraq.

Type Horizon: Marly limestone beds of the Shiranish Formation, of Maastrichtian age; sample no. 41, at drilling depths 1620' - 1625'.

Description: Carapace subrectangular, anterior margin rounded, posterior margin bluntly pointed to the posterior, dorsal and ventral margins straight, subparallel or slightly converging to the posterior; eye tubercle extremely well developed and protruding; hinge ear of the left valve prominent; sub-central tubercle absent.

Lateral surface smooth, with some tubercles or pore cones, and several seive-type pore canals. Dorsal ridge distinctly broken into 9 nodes: 3 of them lie anteriorly just behind the prominent eye tubercle, of which the dorsalmost node is the largest; whereas the other 6 nodes are joined together in a lump separated from the anterior nodes by a smooth furrow; the latter lies just below and

posterior to the eye tubercle, running below the first 3 nodes of the dorsal ridge, then turning upwards and separating these from the dorsal ridge nodes. Median ridge indistinct, ventral ridge divided distinctly into 4 vertical nodes, protruding ventrolaterally and overreaching the ventral margin in lateral view. Anterior marginal rim is thickly developed, and separated from the rest of the surface by a smooth furrow; the posterior marginal rim is distinct but less developed than the anterior marginal rim, and is decorated by 5 small spines. There are some 15 small spines along the anterior margin.

In dorsal view, the carapace has sub-parallel sides with projecting nodes, and with laterally compressed ends; the prominent eye tubercle and the lumpy posterior end of the dorsal ridge can be seen clearly; maximum width lies at the posterior nodes of the ventral ridge. Internally, only the anterior parts of the left and right valves were found; the marginal area is moderately wide, inner margin and line of concrescence coincide, selvage prominent; the anterior hinge of the right valve consists of a strong semi-conical tooth pointing towards the anterodorsal corner, a postjacent socket to accomodate a small conical tooth of the left valve; the muscle scars were not observed but lie in a shallow depression.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11443	male (Holotype)	0.662	0.360	0.325	1.839
OS 11444	female	0.600	0.350	0.305	1.714
OS 11445	male	0.707	0.365	0.305	1.937
OS 11446	female	0.670	0.387	0.345	1.731

Discussion:

The three species described by Al-Abdul-Razzaq (1979), Poloriops sphaerommata from the Cenomanian of Kuwait, Poloriops

elassodictyota from the Campanian and ? Turonian of Kuwait, and Peloriops tetrancota from the Upper Cretaceous of Kuwait and coastal Fars Province of Iran, can be distinguished from this Maastrichtian species by their very fine reticulation, their shape and the development of the dorsal and ventral ridges.

Peloriops ulosa Al-Abdul-Razzaq (1979) from the Cenomanian of Kuwait, shows some resemblance to Peloriops levisulcata sp. nov. in having a non-reticulate and tuberculate surface, but differs in the general outline of the carapace where it tapers to the posterior end; the nodes of the dorsal and ventral ridges of the latter species are also more developed.

Cytherois gr. malzi Bischoff (1963) described by Grosdidier (1973) from the Albian of Iran shows some similarity to this species, but differs in having a small non-prominent eye tubercle, and has a less developed dorsal ridge.

Occurrence: Known so far from the Maastrichtian of Makhul Well-2, northern Iraq.

CHAPTER _ 6

SYSTEMATIC DESCRIPTIONS _ B

Genus Paracosta Siddiqui 1971

Type species: 1971 Costa (Paracosta) declivis Siddiqui, p. 29, pls . 13 & 14

Diagnosis: Trachyleberidinae with 4 longitudinal ridges, sometimes with a tendency for a fifth ridge to form between the two median ridges.

Description: Carapace subrectangular in lateral outline; dorsal and ventral margins straight, subparallel or slightly converging posteriorly; anterior margin moderately rounded, posterior margin triangular; eye tubercle prominent. There are 4 longitudinal ridges (see figs.10 & 11), with a tendency for a fifth ridge to form between the two median longitudinal ridges. Dorsal ridge starts from or just above the sub-central tubercle, curving upwards, over-reaching the dorsal margin in lateral view. In the left valve the dorsal ridge divides into two, the upper branch extending further backwards toward the posterior cardinal angle, while the lower branch turns down toward the "Terminus" pore conulus, in the right valve only the lower branch is present. The upper median ridge commences from the "Gamma" pore conulus at the anterior margin, ascending gradually through the sub-central tubercle, and ending posteriorly with two branches, the upper branch turning upward then downward to the "Psi" pore conulus, the second lower branch turning down towards the "Charon" pore conulus where it joins the fifth longitudinal ridge, if the latter is developed. The lower median longitudinal ridge starts below the "Beta" pore conulus running parallel to the other longitudinal ridges, and ending below the branching point of the first median ridge. In some species, a branch commences from the end of the lower median ridge, and turns down towards the "Phi" pore conulus. The ventral ridge starts at

the anterior marginal rim, and in some species over-reaches the ventral margin, giving a convex shape to the ventral outline. There is an eye rib linking the eye tubercle and the sub-central tubercle.

Surface ornamentation between the longitudinal ridges varies from nearly smooth to reticulate. Internally, marginal area moderately wide, selvage prominent; a narrow anteroventral vestibule is present in most species, the muscle scars consist of 4 adductors and a V-shaped frontal scar; the hinge is Amphidont/Heterodont, the right valve having anterior tooth with low distal part and a posterior continuation running below the postjacent socket, followed by a crenulated median groove, ending with a conical smooth or bilobate posterior tooth directed outwards.

Discussion:

The genus is divided into two subgenera; Paracosta (Paracosta) Siddiqui and Paracosta (Paleocosta) Benson, which differ in the degree of development of the surface ornamentation including the longitudinal ridges intercalated by coarse reticulation.

Paracosta (Paracosta) has less well-developed longitudinal ridges, with a tendency to form a fifth longitudinal ridge, while the surface between those ridges is covered by small and unequal reticulation.

The genus Paracosta can easily be distinguished from the genus Costa Neviani 1928, by the presence of the 4 longitudinal ridges, the discontinuity of the antero-marginal rim in some species and the presence of the anterior vestibule.

Benson (1977) discussed the differences between Paracosta (Paleocosta) and the genus Oblitacythereis Benson (1977); the latter has different antero-marginal area and lacks an eye tubercle. In

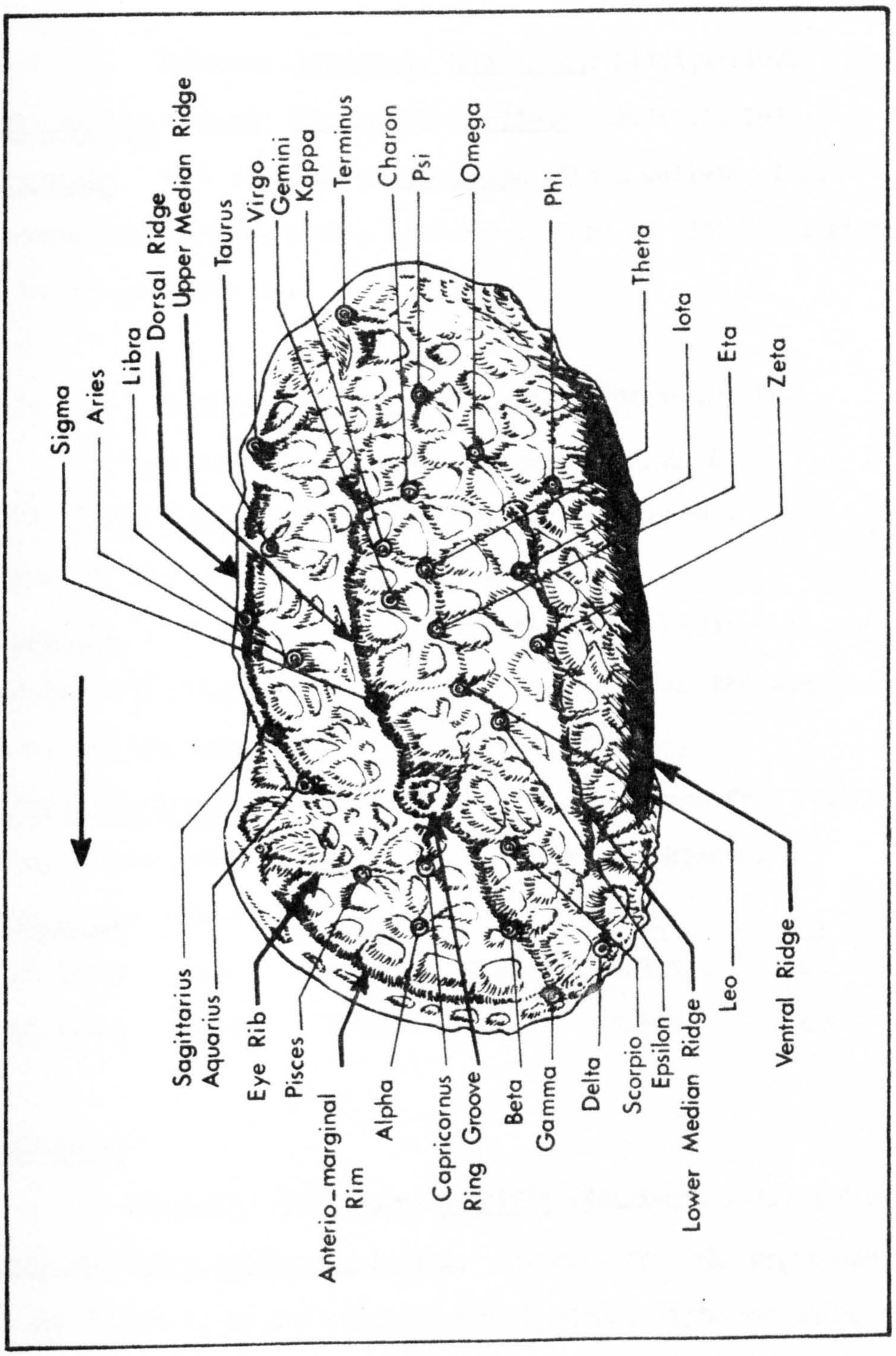


Figure 10 : Morphology of Paracosta Siddiqui,1971; the left valve of the carapace. This diagram illustrates the terminology used for the main ornamental features and principle pore conuli (indicated by Zodiacal and Greek names). The same terminology used for the genus Allocosta nov.. (After Benson,1972 with additions).

addition, Oblitacythereis has a distinct eye rib, which is not present in Paracosta (Paleocosta).

Subgenus Paracosta (Paracosta) Siddiqui, 1971

Type species: Costa (Paracosta) doclivis Siddiqui, 1971

Diagnosis : A subgenus of Paracosta with 4 well-developed longitudinal ridges, with a tendency to form an additional fifth ridge in some species.

Paracosta (Paracosta) doclivis Siddiqui ,1971

Text fig. 11; pl . 21, figs. 1, 3, 4, 6

1971 Costa (Paracosta)doclivis, Siddiqui, p.29, pl . 13, figs. 8, 10 - 14; pl . 14, figs. 1 & 2.

Diagnosis : A species of Paracosta (Paracosta) with well-developed longitudinal ridges and rounded reticules covering the surface between them, and the posterior part of the carapace.

Figured Specimens: OS 11123 & OS 11124, Topotypes from Pelletispira Beds, sample 3662; U. Eocene age, Rakhi Nala, Pakistan.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11123	Male	0.838	0.412	0.355	2.034
OS 11124	female	0.738	0.400	0.375	1.845

Discussion :

Paracosta (Paracosta) doclivis (Siddiqui, 1971) differs from Paracosta (Paracosta)maaloulaensis sp. nov. from the uppermost Middle Eocene of Syria, by its straight dorsal ridge, different shape of the frontal scar ring-groove (see fig. 10 for definition) lying upon the subcentral tubercle, and lacking the strongly developed marginal spines.

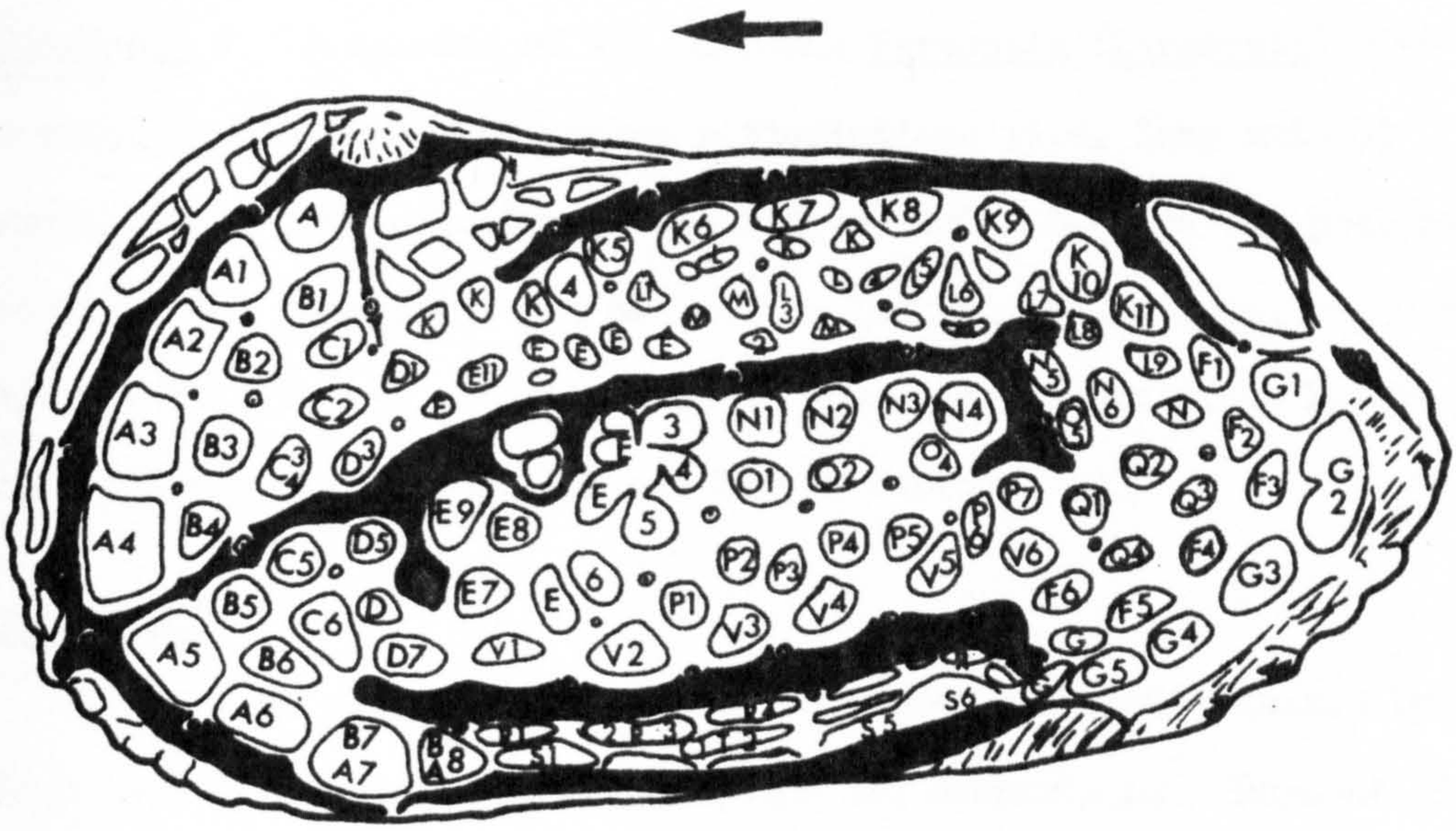


Figure 11 : Lateral reticulation of Paracosta (Paracosta) declivis Siddiqui(1971) , male; arrow indicates anterior, and dark areas illustrate the main ridges .

Occurrence: Known from the Upper Eocene of the Rakhi Nala section, Pakistan.

Paracosta (Paracosta) warriensis (Reyment)

1960, Veenia warriensis Reyment, p.180, pls . 12 & 18

1966, Costa dahomeyi (Apostoloscu, 1961) n. subsp. 1, Salahi, p. 23, pl . 5, figs. 18-20.

Diagnosis : A species of the subgenus Paracosta (Paracosta) with vertically standing rectangular reticulations (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, and with a rib parallel to the anterior part of the upper median ridge keeping the reticules A4, B4, C3 & 4 and E10 in between.

Discussion:

A specimen of this species has been gratefully loaned by Professor R.A. Reyment for examination and comparison. Reyment (1960) indicated a close relationship between Paracosta (Paracosta) warriensis and Paracosta (Paracosta) grekoffi (Reyment), but according to the result of his analysis of the variance between them, suggested the high improbability of them representing the same species.

P.(Paracosta) grekoffi differs from P.(Paracosta) warriensis in having smaller reticulation, strongly developed, broad, shallow anterodorsal pits, and in the presence of smooth, concave areas posterior to the hinge ear and eye tubercle. The appearance of P.(Paracosta)warriensis in older beds than P.(Paracosta) grekoffi suggest that the latter species is probably descended from P.(Paracosta) warriensis.

Occurrence: Known so far from the Upper Maastrichtian - Upper Palaeocene of Nigeria, and the Palaeocene of Libya.

Paracosta (Paracosta) arabica (Bassiouni)

Text fig. 12; pl . 21, figs. 2, 5, 7-12

1969a, Costa arabica Bassiouni, p. 3, pl . 1, figs. 4-5

1977, Palaecosta libyaensis Benson, p. 36, pl . 3, fig. 4

Diagnosis: A species of the subgenus Paracosta (Paracosta) with a dorsal ridge becoming straight from (Sagittarius) pore conulus; indistinct anteromarginal rim; 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.

Figured Specimens: TKH 11742, female carapace from Lower (Middle?) Palaeocene of the Yarmuk area, Jordan; and OS 11125 - OS 11126, female and male carapace from the Lower Palaeocene of the Tell-Burma section, Jordan.

Material: 262 specimens including: 226 specimens from the Lower Palaeocene of Jordan; 22 specimens from the Lower - Middle Eocene of Jabel Sinjar, northwestern Iraq; and 14 specimens from the Palaeocene - Lower Eocene of Syria.

Dimensions: (In mm.)

Yarmuk, Jordan :		L.	H.	W.	L/H
TKH 11742	female	0.710	0.405	0.370	1.753
TKH 11744	male	0.815	0.425	0.350	1.918
Tell-Burma, Jordan :					
OS 11125	female	0.635	0.375	0.325	1.827
OS 11126	male	0.835	0.405	0.340	2.062
Jabel Sinjar, Iraq :					
OS 11134	female?	0.730	0.400	0.300	1.825
OS 11133	male	0.820	0.420	0.345	1.952
Syria :					
OS 11136	female?	0.720	0.387	0.300	1.860
OS 11137	male?	0.760	0.400	0.290	1.900

Discussion:

Some differences in the degree of development of the longitudinal ridges and the reticulation can be recognized within this species; specimens from northern Jordan, including the type species have slightly thicker longitudinal ridges and less developed reticulation than specimens from southern Jordan (Tell-Burma).

Another difference can be recognized between specimens of different ages; older specimens have an indistinct anteromarginal rim, thick and bluntly developed longitudinal ridges, and traces of a rib parallel to the anterior part of the upper median ridge; whereas the younger specimens found in Iraq, Syria and Libya?, have a more or less distinct anteromarginal rim, sharply developed longitudinal ridges, and an ill-defined rib parallel to the anterior part of the upper median ridge.

The material described by Benson does not show any variation between specimens (personal communication), but this is perhaps because he had only a few specimens from a single sample from Libya (Benson, 1977, p.36).

Benson (1977) suggested Paleocosta libyaensis of Libya was probably conspecific with Paracosta (Paracosta) praecrassireticulata (Bassiouni, 1969a) from Jordan. He appears to have overlooked the species Paracosta (Paracosta) arabica, which is here regarded as the senior synonym of Paleocosta libyaensis because of their similarity in shape, size and in the details of ornamentation. Paracosta (Paracosta) praecrassireticulata differs by its larger size, well developed antero-marginal rim and stronger longitudinal ridges.

Paracosta (Paracosta) warriensis (Reyment, 1960) differs in the details of reticulation, notably between the dorsal and the two

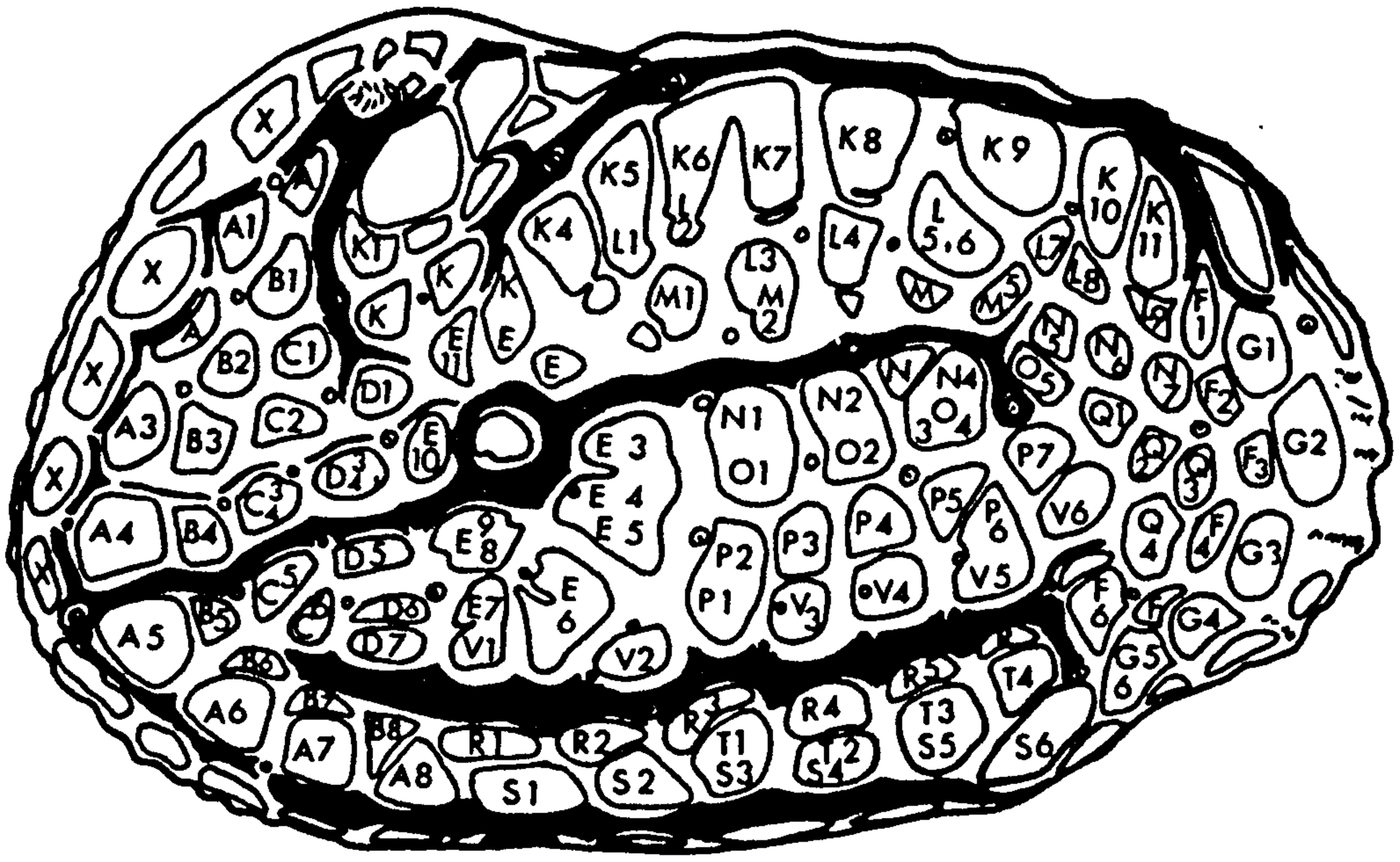


Figure 12 : Lateral reticulation of Paracosta (Paracosta) arabica (Bassiouni,1969a), female; arrow indicates anterior, and dark areas illustrate the main ridges .

median ridges and in the better developed rib running parallel to the anterior part of the upper median ridge; the carapace outline is also different, with the dorsal and ventral margins being more convergent posteriorly than in Paracosta (Paracosta) arabica (Bassiouni).

A phylogenetic relationship perhaps exists between Paracosta (Paracosta) grekoffi (Reyment) from the Upper Maastrichtian of Nigeria and the Palaeogene species P.(Paracosta) arabica. They have a close resemblance in ornamentation, but the latter species differs from P.(Paracosta) grekoffi in having better developed longitudinal ridges, and in the details of reticulation, while the dorsal ridge is straight.

The eye rib is better developed in some specimens of P.(Paracosta) arabica; however, this species can be easily distinguished from the genus Allocosta gen. nov., by its unequal reticulation, lack of the protruding and well developed eye tubercle and the moderately developed longitudinal ridges.

Occurrence: Known so far from the Palaeocene of Jordan, the Palaeocene -Middle Eocene of Syria and northwestern Iraq, and the Palaeocene to probably the Lower-Middle Eocene of Libya.

Paracosta (Paracosta) bicristata sp. nov.

Text fig. 13; pl . 22, figs. 1, 3, 4, 6, 7 & 10

Name: bi (L.) = twice, crista (L.) = crest, with reference to the curved dorsal ridge, which over-reaches the dorsal margin from both sides of the carapace.

Diagnosis: A small species of the subgenus Paracosta (Paracosta), with dorsal ridge strongly curved upwards; and coarse reticulation between the longitudinal ridges.

Holotype: Female carapace OS 11139, pl . 22, figs. 1, 4, 6 & 10

Paratype : OS 11140 & OS 11174

Material : 4 specimens from sample BMJ 850

Type Locality: Toll-Burma, Jordan

Type Horizon : Lower Palaeocene (Upper Danian) part of the Taqiye Marl Formation, sample No. BMJ 850.

Description: Small carapace of subquadratic shape, eye tubercle small, anterior marginal rim commencing behind the eye tubercle, running faintly towards the anterior margin to the posterior of X3, X4, & X5 (see fig. 13), then to the anterior of A4 changing abruptly into a thick marginal rim extending ventrally as a ventral ridge. Longitudinal ridges are well developed; the reticulation varies, with small reticulation anteriorly in a triangular area bounded by the eye rib, the anterior part of the upper median ridge and the upper part of the antero-marginal rim, and posteriorly in the area between the two posterior branches of the upper median ridge; otherwise the rest of the surface is covered by coarse reticulation. The anterior margin has 15-16 denticules, the ventral part of the posterior margin has 6 small spines.

Internally, the posterior tooth of the right valve is bilobate; other internal features as for the genus.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11139	female (Holotype)	0.662	0.400	0.337	1.655
OS 11140	female	0.650	0.375	-	1.733
OS 11174	male	0.935	0.370	0.315	2.527

Discussion

Paracosta (Paracosta) bicristata sp. nov. differs from P.(Paracosta) arabica (Bassiouni) by its small size and subquadratic

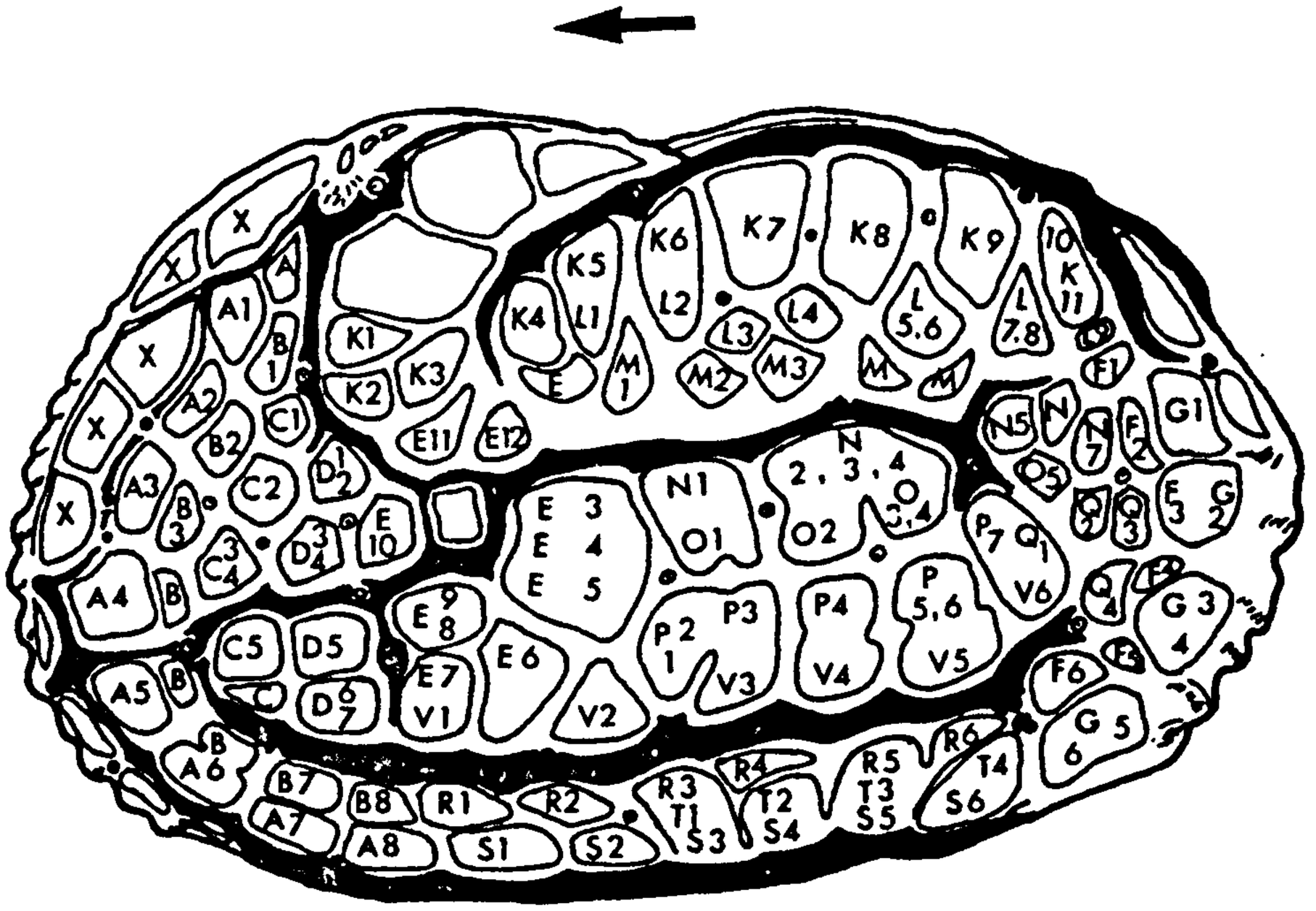


Figure 13 : Lateral reticulation of Paracosta (Paracosta) bicristata sp. nov. , female; arrow indicates anterior, and dark areas illustrate the main ridges .

shape; the better developed longitudinal ridges; and in the details of reticulation. It differs from P. (Paracosta) warriensis (Reyment) in shape and in lacking the rib above the anterior part of the upper median ridge.

Paracosta (Paleocosta) crassireticulata (Bassiouni, 1969b) differs from this species in shape, the strongly developed longitudinal ridges, marginal rim and in the details of reticulation.

Occurrence: This species is known so far from the Upper Danian of the Tell-Burma section of Jordan.

Paracosta (Paracosta) praecrassireticulata (Bassiouni)

Text fig. 14; pl . 22, figs. 2, 5, 8, 9 & 11-13

1969a, Costa praecrassireticulata Bassiouni, p.5 pl .1 fig. 1

1961, ? Bradleya sangalkamensis Apostolescu

1971, Costa (Paracosta) compitalis Siddiqui

1977, ? Paleocosta kefensis Benson

Diagnosis: A species of Paracosta (Paracosta), with a ring-groove (see fig. 10 for definition); a small unequal reticulation between the longitudinal ridges, and with a tendency to form an additional fifth longitudinal ridge between the two median ridges.

Figured Specimens: TKH 11746 and TKH 11747 from the Middle Eocene of Jabel Thuleithuwat, Jordan; OS 11141 from the Middle Eocene of the Rakhi Nala section, Pakistan (described before as Costa (Paracosta) compitalis Siddiqui, 1971); OS 11142 from the M. Eocene of the Jabel Sinjar section, Iraq; and OS 11153 - OS 11154 from the Palaeocene of Syria.

Material : 113 specimens, including 11 specimens from Jordan (Jabel Thuleithuwat and Yarmuk areas); 1 specimen from the Rakhi Nala section, Pakistan; 84 specimens from the Jabel Sinjar section, Iraq;

9 specimens from the Makhul Well-2, Iraq; 4 specimens from the Mityaha Well-1, Iraq; and 4 specimens from the Palaeocene of Syria.

Dimensions: (In mm.)

			L.	H.	W.	L/H
Jordan:						
TKH 11745	female	(Topotype)	0.775	0.445	0.400	1.741
TKH 11746	male	(Topotype)	0.850	0.450	-	1.888
Pakistan:						
OS 11141	female		0.925	0.500	0.460	1.850
Iraq:						
OS 11142	female		0.905	0.500	0.415	1.810
OS 11144	male		0.910	0.425	0.355	2.141
Syria:						
OS 11153	female		0.890	0.475	0.375	1.874
OS 11154	male		0.975	0.500	0.410	1.950

Discussion

Paracosta (Paracosta) praecrassiroticulata (Bassiouni) resembles Paracosta (Paracosta) hammurabii sp. nov. from the uppermost Middle-Upper Eocene, the only difference being in the coarse reticulation of the latter. Paracosta (Paleocosta) crassiroticulata (Bassiouni) also has coarse reticulation and in addition has lamella type longitudinal ridges, and lacks a ring-groove.

Within the species P.(Paracosta) praecrassiroticulata (Bassiouni) there are some very slight differences which could be attributed to the geographical and stratigraphical distribution. The longitudinal ridges in the specimens from Syria, Iraq and Pakistan are present and distinct but they are not as thick as in the type material from Jordan, and the ring-groove of the type material contains two weakly developed reticules, which are distinct in other specimens from

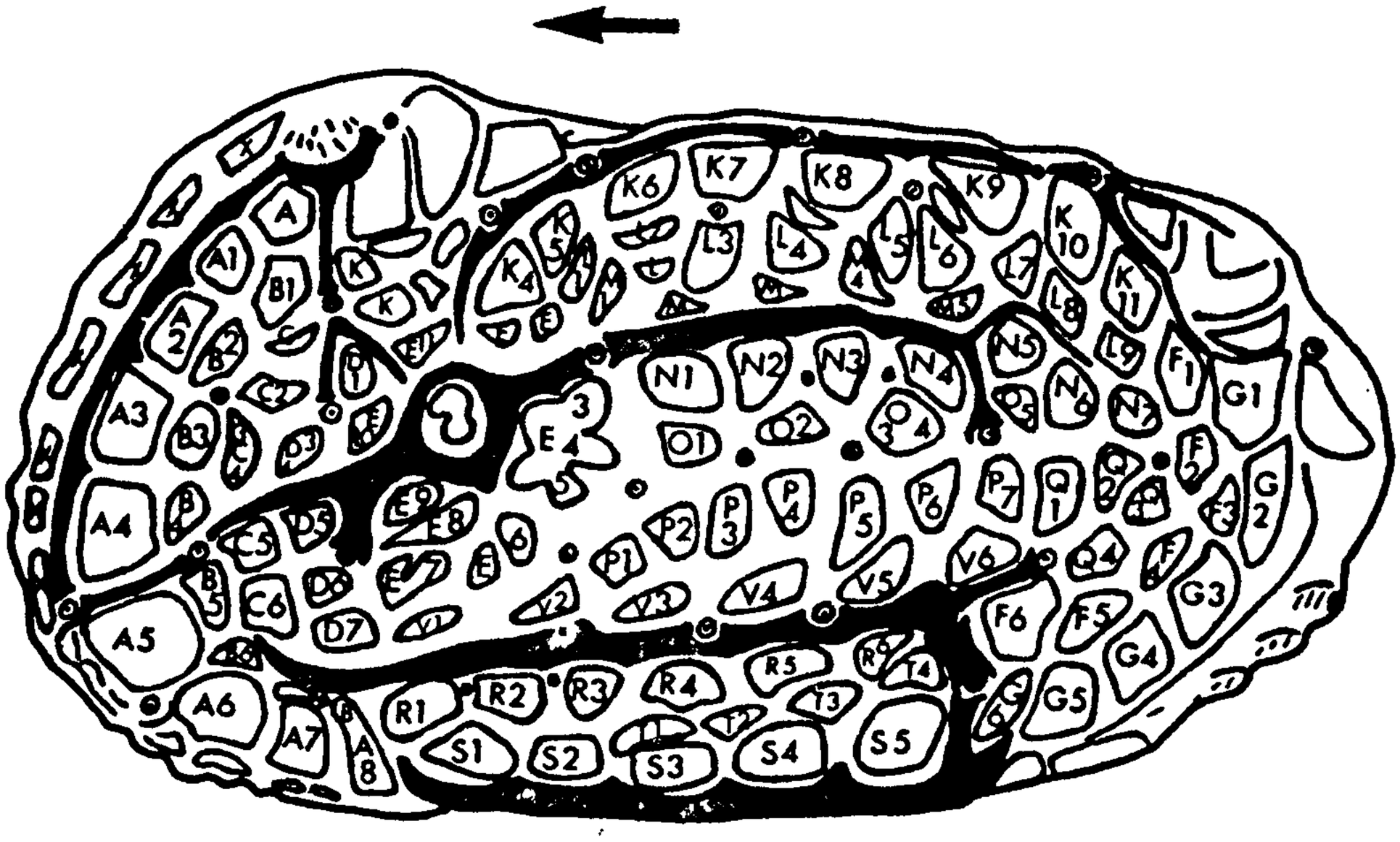


Figure 14 : Lateral reticulation of Paracosta (Paracosta) praecrassireticulata (Bassiouni,1969a),male; arrow indicates anterior, and dark areas illustrate the main ridges .

other localities. Specimens from Tunisia and Senegal have strongly developed marginal spines which become less developed in the Eocene specimens of the Middle East. Paleocosta kefensis Benson (1977) from Tunisia, has been doubtfully synonymized with this species due to its larger carapace and the presence of the eye rib extending from the eye tubercle towards the lower median ridge. This also occurs in the genus Allocosta gen. nov., but Paleocosta kefensis has the other diagnostic characters of P.(Paracosta) praecrassireticulata (Bassiouni).

Occurrence: Known so far from the Lower Palaeocene of Senegal, the Palaeocene of Tunisia, the Palaeocene and Eocene of Syria and Iraq, the Lower and Middle Eocene of Jordan, and the uppermost Middle Eocene of Pakistan.

Paracosta (Paracosta) yarmukensis (Bassiouni)

1969a, Costa yarmukensis Bassiouni, p.7, pl . 2, figs. 1 - 2

Diagnosis: A species of Paracosta (Paracosta) with swollen longitudinal ridges, the upper median ridge splits into two, anterior to the ring-groove, with a row of rounded reticules between the two branches, the anterior part of the upper median ridge links with the lower median ridge by another rounded reticuleslying below the reticules row of the upper median ridge. A hinge ear is well developed in the left valve.

Occurrence: Known from the Middle Eocene of the southern Yarmuk-bank, Qa as Siq and Jabel Thuloithuwat, Jordan.

Paracosta (Paracosta) qdoimensis sp. nov.

Text fig. 15; pl . 24, figs. 1, 3-5 & 7

Name: After the type locality, the Bir Qdoim section, Syria

Diagnosis: Elongate species of Paracosta (Paracosta)with weakly developed longitudinal ridges and well-developed anteromarginal rim, especially at the anteroventral part.

Holotype: Male carapace OS 11163, pl. 24, figs. 1, & 4

Paratype: OS 11164 - OS 11166

Material: 4 specimens from the Upper Palaeocene - Lower Eocene Maliji/ Jaddala Formations of the Bir Qdeim section of Syria, "I.P.C. sample nos. Jd 714 and Jd 743".

Type Locality: Dolaa Camp, Bir Qdeim section, Syria.

Type Horizon: 2 metres chalky and marly limestone, whitish medium hard, with 10cm black flint at top; Lower Eocene, Jaddala Formation, I.P.C. sample no. Jd 743.

Description: Very elongate carapace with length more than double height. The dorsal ridge is the best developed longitudinal ridge, its upper posterior branch in the left valve is well developed and forms a nearly 90° posterior cardinal angle. The upper median ridge starts distinctly from the "Gamma" pore conulus, at the antero-marginal rim disappearing amongst the middle surface reticulation. An eye rib is present, running diagonally and uniformly from the eye tubercle towards the ventral ridge. Antero-marginal rim distinct, running from the eye tubercle and falling away slightly after the "Delta" pore conulus (see fig. 15); this rim is very high and distinct in its ventral part. A postero-marginal rim is also present, starting from the posterior cardinal angle, running around the posterior margin and joining the end of the ventral ridge. There are nearly 19 small spines along the anterior margin, and 5-6 small spines along the ventral part of the posterior margin. The whole surface is reticulate, sometimes the reticulation covering the middle of the carapace is small and very weak.

No internal details were observed.

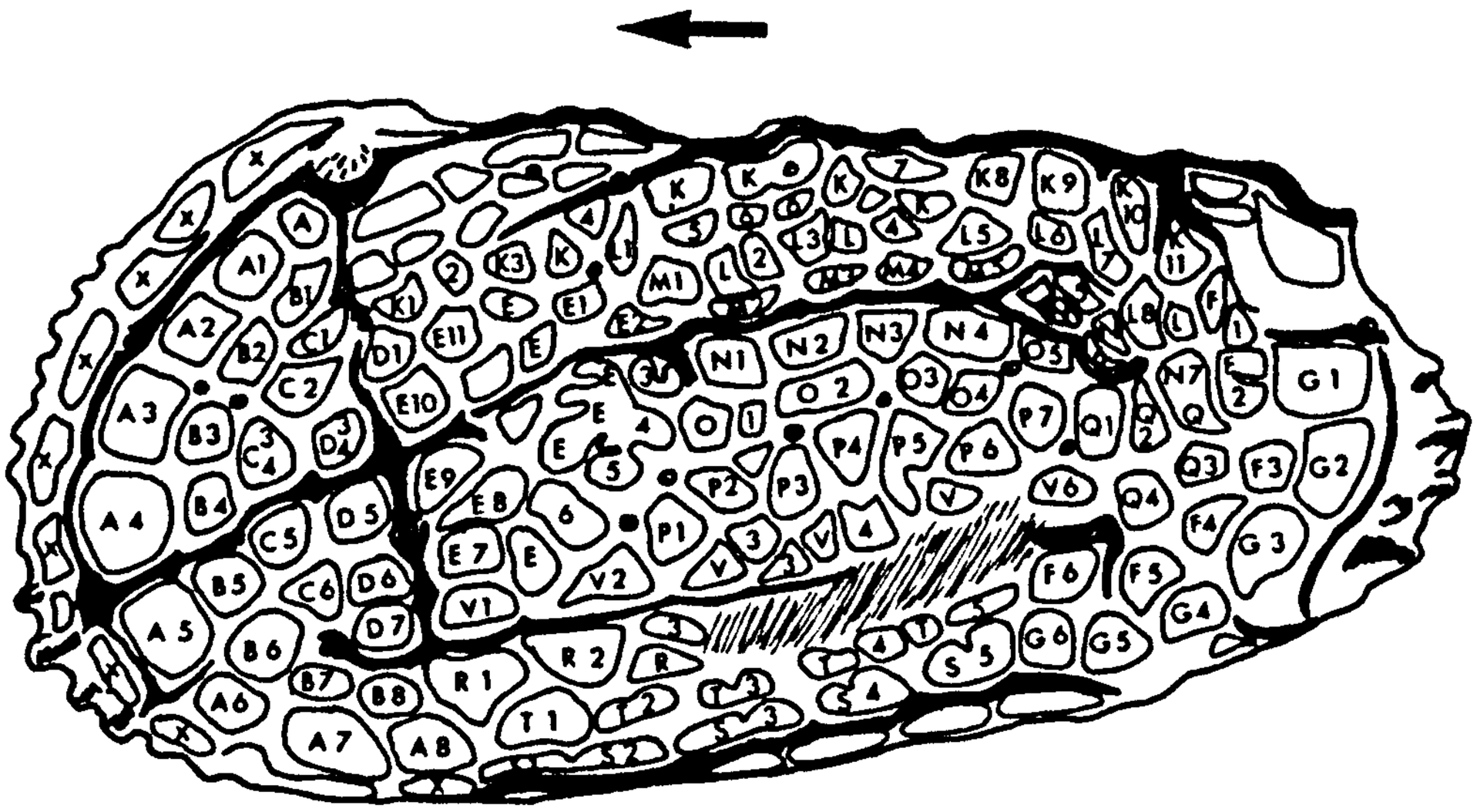


Figure 15 : Lateral reticulation of Paracosta (Paracosta) gdeimensis sp. nov., male; arrow indicates anterior, and dark areas illustrate the main ridges .

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11163	male (Holotype)	0.927	0.400	0.332	2.317
OS 11164	male	0.940	0.445	0.325	2.112
OS 11165	male	0.900	0.412	0.355	2.184
OS 11166	female	0.810	0.400	0.350	2.025

Discussion:

Paracosta (Paracosta) qdeimensis sp. nov. can be easily distinguished from most species of the genus by its elongate carapace; P.(Paracosta) heluanensis (Bassiouni) differs from P.(Paracosta) qdeimensis by its less pointed posterior and its better developed longitudinal ridges, and the presence of small nodes and spines between the regular reticulations. Paracosta (Paracosta) disintegrata (Siddiqui, 1971) is closely similar to this species, but is less elongated, has a more pointed posterior end, and has better developed longitudinal ridges.

Occurrence: Known so far from the Upper Palaeocene - Lower Eocene Aaliji Formation and the Lower Eocene Jaddala Formation of the Bir Qdeim section of Syria.

Paracosta (Paracosta) aff. qdeimensis sp. nov.

Text fig. 16; pl . 24, figs. 2 & 11

Diagnosis: Elongate species of Paracosta (Paracosta) with a developed sub-central tubercle, thick postero-marginal rim and indistinct longitudinal ridges.

Figured Specimen and Material: One specimen OS 11167, probably male, from the uppermost Middle Eocene of the Avanah Limestone Formation, of Jabel Sinjar section, Iraq; Sample no. S83

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11167	male ?	0.937	0.425	0.326	2.205

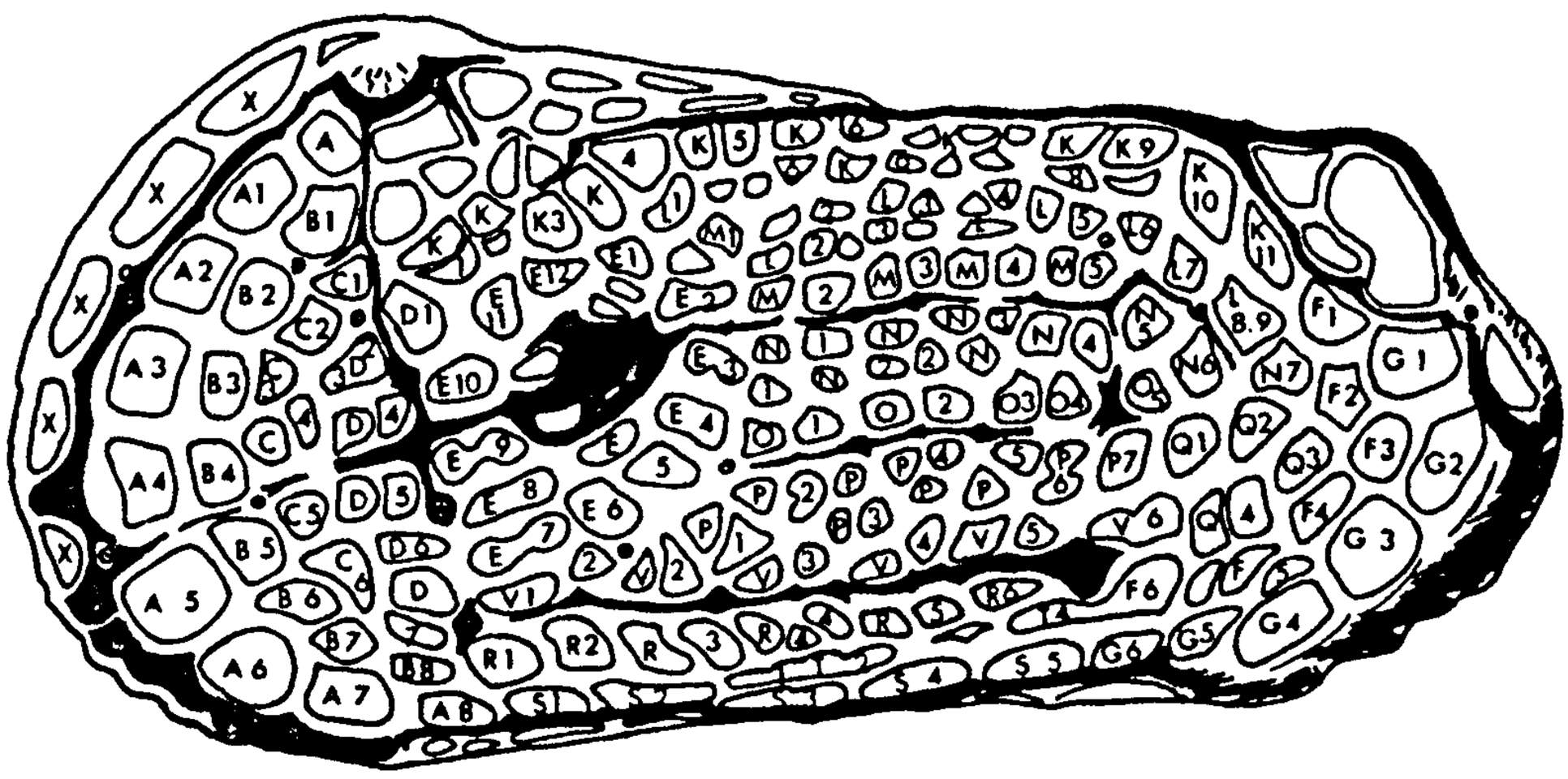


Figure 16 : Lateral reticulation of Paracosta (Paracosta) aff. qdeimensis sp. nov.; arrow indicates anterior, and dark areas illustrate the main ridges .

Discussion:

This differs from P.(Paracosta) qdoimensis in having a thicker postero-marginal rim, a better developed sub-central tubercle, smaller sized reticulation in the centre of the carapace, and a broader anterior end. It is probably a new species, but as one specimen only has been found no new taxon has been created.

Occurrence: Known so far from the Middle/Upper Eocene, Avanah Limestone Formation of the Jabel Sinjar section, Iraq.

Paracosta (Paracosta) enlilia sp. nov.

Text fig. 17; pl . 23, figs. 2, 5, 8, 9 & 12

Name: After Enlil, which is a Sumerian god, embodying energy and force in growing weather.

Diagnosis: A small species of the subgenus Paracosta (Paracosta) with large reticulations covering the anterior part of the carapace, while the surface between the longitudinal ridges and at the posterior is covered by smaller reticulation; ventral ridge starts interiorly with two branches parallel to the ventral margin, with a row of 6 reticules ending at midlength in between them.

Holotype: Female carapace OS 11175, pl .23, figs. 2 & 5

Paratype: OS 11176 - OS 11178

Material: 12 specimens from the uppermost Middle Eocene ? and Upper Eocene Avanah Limestone and Jaddala Formations of the Jabel Sinjar section.

Type Locality: Jabel Sinjar section, Iraq.

Type Horizon: 2 metres limy marl bed from the uppermost Middle Eocene? (Upper Eocene) of the Avanah Limestone Formation, Sample no.S82.

Description: Antero-marginal rim indistinct; the dorsal ridge is better developed than other ridges and curves upwards; ventral ridge starts with two branches running parallel to the ventral margin and

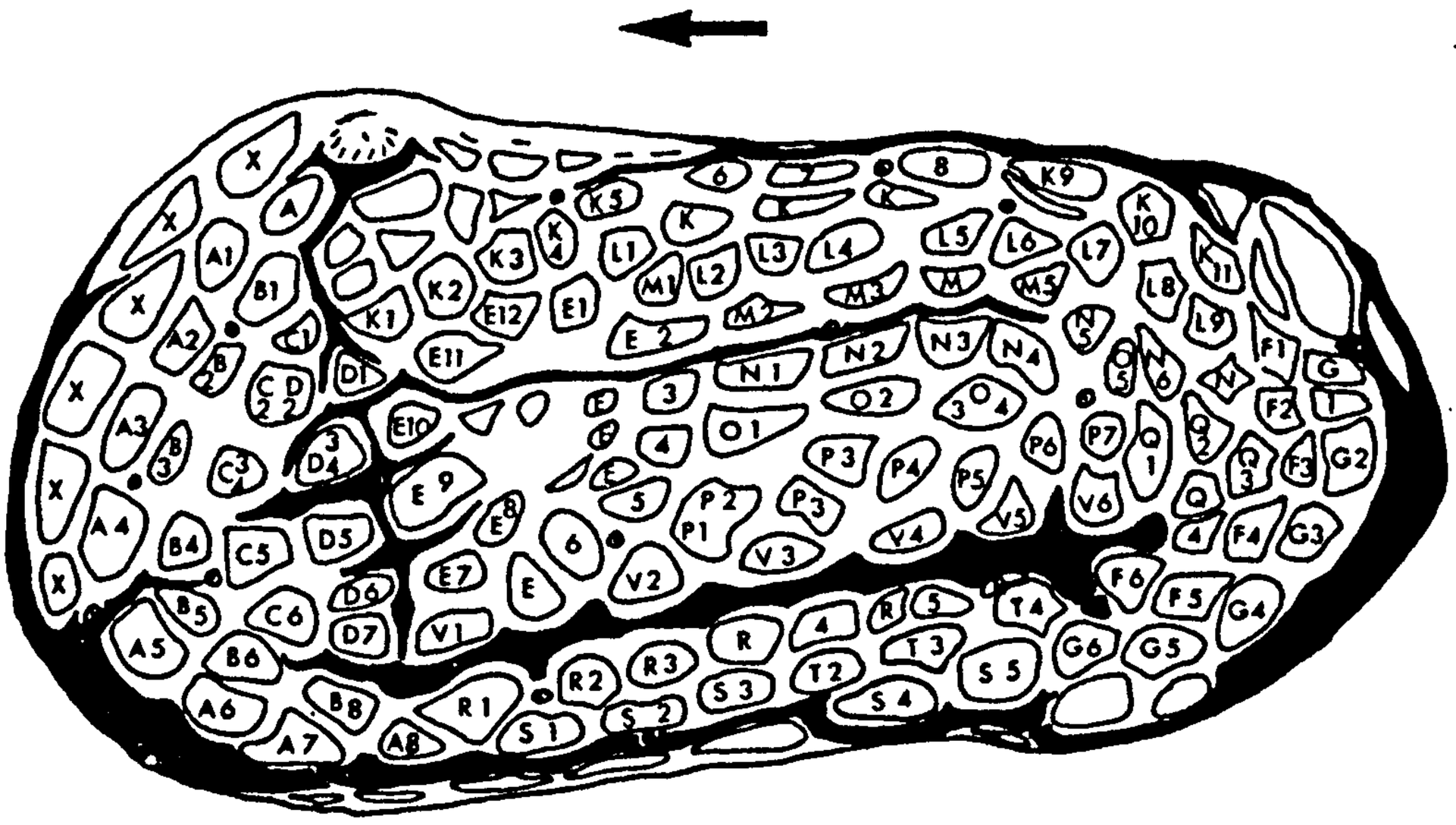


Figure 17 : Lateral reticulation of Paracosta (Paracosta) enlilia sp. nov., male; arrow indicates anterior, and dark areas illustrate the main ridges .

keeping a row of 6 reticules in between, this row is ending at mid-length. The entire surface is reticulate, the anterior surface reticulations have large quadratic shape, while the rest surface between the longitudinal ridge and at the posterior is covered by smaller 3-5 sided reticulations. No internal features observed.

Dimensions: (In mm.)

		L.	H.	W.	I/H
OS 11175	female (Holotype)	0.655	0.365	0.275	1.794
OS 11176	male	0.695	0.335	0.245	2.075
OS 11177	female	0.702	0.400	0.310	1.755
OS 11178	male	0.710	0.355	0.260	2.000

Discussion:

This species differs from P.(Paracosta) arabica (Bassiouni), by its smaller size, and the presence of the curved dorsal ridge, which is not straight as that of P.(Paracosta) arabica; but the latter species has a rib running parallel to the anterior part of the upper median ridge, and generally has better developed longitudinal ridges.

Occurrence: Known so far from the uppermost Middle? and the Upper Eocene of the Jabel Sinjar section, Iraq.

Paracosta (Paracosta) maaloulaensis sp. nov.

Text fig. 18; pl . 24, figs. 6 & 9

Name: After the type locality of Maaloula, north of Damascus, Syria.

Diagnosis: A species of Paracosta (Paracosta), with well developed longitudinal ridges; no tendency to form a fifth ridge between the two median ridges; rounded reticulation; and with thickly developed cross ribs between the longitudinal ridges.

Holotype: Male left valve, OS 11168; pl . 24, figs. 6 & 9

Paratype: OS 11169 - OS 11171

Material: 4 specimens found within the I.P.C. collection in the British Museum (Nat. Hist.), from the uppermost Middle Eocene of Maaloula area, Syria.

Type Locality: Maaloula area, north of Damascus, Syria.

Type Horizon: Chalky marl, slightly glauconitic, from the uppermost Middle Eocene, Jaddala Formation, I.P.C. sample no. CA 2235.

Description: Eye tubercle small; antero-marginal rim commencing from the eye tubercle, continuing as 3 spines from the "Delta" pore conulus downward. Anterior margin with 20-21 denticles, 7 of them lying at the anteroventral corner are longer; postero-marginal rim is well developed with 4 small spines along its ventral part, and 8 spines along the posterior margin, one of which is separate just below the posterior cardinal angle, while the remaining 7 lie below the "Terminus" pore conulus, with the middle one being the largest.

The longitudinal ridges are well developed, with cross ridges between them; in the middle of the upper median ridge, there is a ring-groove containing only one reticule. Generally the whole surface is ornamenting by rounded or 4 sided reticulation.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11168	male (Holotype)	0.895	0.462	-	1.937
OS 11169	male	0.905	0.410	-	2.207
OS 11170	female	0.852	0.485	-	1.757

Discussion:

This species differs from Paracosta (Paracosta) declivis (Siddiqui, 1971) in having a slightly curved dorsal ridge, well developed ring-groove, cross ridges between the longitudinal ridges; and in the presence of well developed marginal spines.

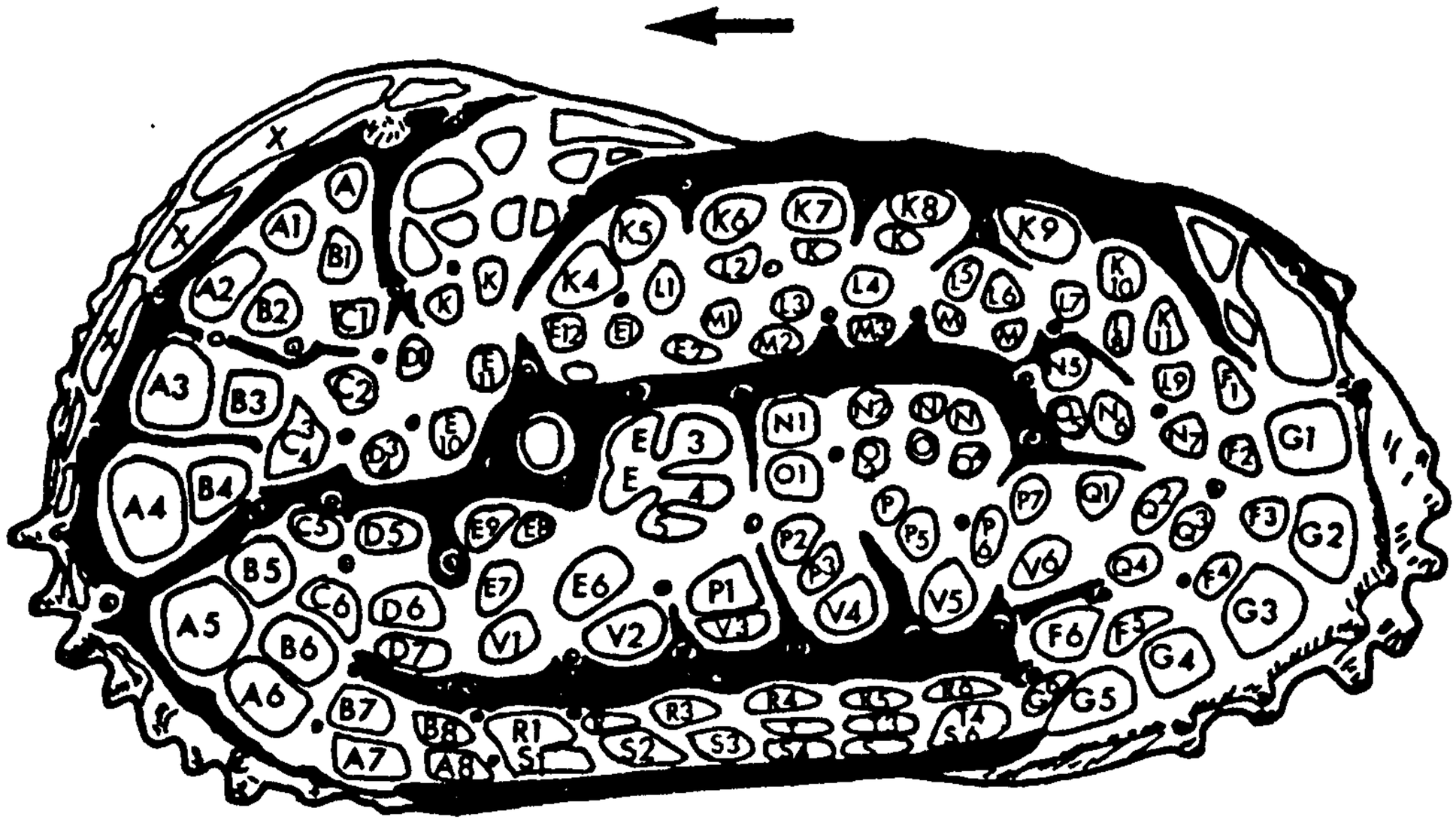


Figure 18 : Lateral reticulation of Paracosta (Paracosta) maaloulaensis sp. nov., male; arrow indicates anterior, and dark areas illustrate the main ridges .

Paracosta (Paracosta) maaloulaensis sp. nov. differs from P.(Paracosta) praecrassireticulata (Bassiouni, 1969b) in having smaller and rounded reticulation, only one reticule inside the ring-groove, and showing no tendency to form a fifth longitudinal ridge between the two median ridges.

Occurrence: Known so far from the uppermost Middle Eocene and probably in the Upper Eocene of the Maaloula area, Syria.

Paracosta (Paracosta) hammurabii sp. nov.

Text fig. 19;. pl . 23, figs. 1, 3, 4, 6 & 7

Name: After Hammurabi, the famous sixth Babylonian King, 792-750 B.C.

Diagnosis: A species of Paracosta (Paracosta), with a ring-groove in the middle of the upper median ridge, with coarse reticulation between the longitudinal ridges.

Holotype: Female carapace (OS 11157), pl. 23, figs. 1, 4 & 6

Paratype: OS 11158 - OS 11159 from the uppermost Middle Eocene of Maaloula area, Syria; OS 11160 - OS 11162 from the Middle/Upper Eocene of Anah Well-2, Iraq; and TKH 11749 - TKH 11753 from the Middle and Upper Eocene of Jabel Thuleithiwat, Jordan.

Material: 39 specimens including 4 specimens from the lowermost Upper Eocene of Jordan, 3 specimens from the uppermost Middle Eocene of Syria, I.P.C. sample no. CA 2235, and 32 specimens from the Middle-Upper Eocene of Anah Well-2 of Iraq, at drilling depths of 830' - 1225'.

Type Locality: Maaloula area (north Damascus), Syria

Type Horizon: Chalky marl, slightly glauconitic beds, from the uppermost Middle Eocene of Jaddala Formation, I.P.C. sample no. CA 2235.

Description: Antero-marginal rim distinct, starting from the spherical eye tubercle, running along the anterior margin towards the "Gamma" pore comulus, from which the marginal rim changes into a row of 3-4 small spines running parallel to the antero-marginal spines. Thore

are 20-21 small spines along the anterior margin, 8 of them, in the anteroventral corner are relatively larger than the others. There are 6 small spines at the posteroventral margin.

Longitudinal ridges distinct, showing a tendency to form a fifth ridge between the two median ridges; the fifth ridge starts from the "Leo" pore conulus passing through the "Eta and Theta" pore comuli , and joining the lower branch of the upper median ridge at the "Charon" pore comulus (see fig. 19). A ring-groove is present in the middle of the upper median ridge.

Internally, selvage distinct, list and 2-3 striae are present; inner margin and line of concrescence coincide; anteriorly there are more than 40 radial pore canals, which are straight, and slightly swollen in the middle; posteriorly there are nearly 18 radial pore canals. Other internal features as for the genus.

Dimensions: (In mm.)

Syria :		L.	H.	W.	L/H
OS 11157	female (Holotype)	0.795	0.462	0.400	1.721
OS 11158	male	0.887	0.440	-	2.016
Iraq :					
OS 11160	male	0.775	0.400	0.315	1.937
OS 11161	female	0.687	0.375	0.300	1.832
Jordan :					
TKH 11749	female	0.800	0.450	0.380	1.778
TKH 11750	male	0.875	0.450	-	1.944

Discussion :

This species includes the Upper Eocene specimens of Costa praecrassireticulata Bassiouni (1969a). For comparison with other species see Paracosta (Paracosta) praecrassireticulata (Bassiouni).

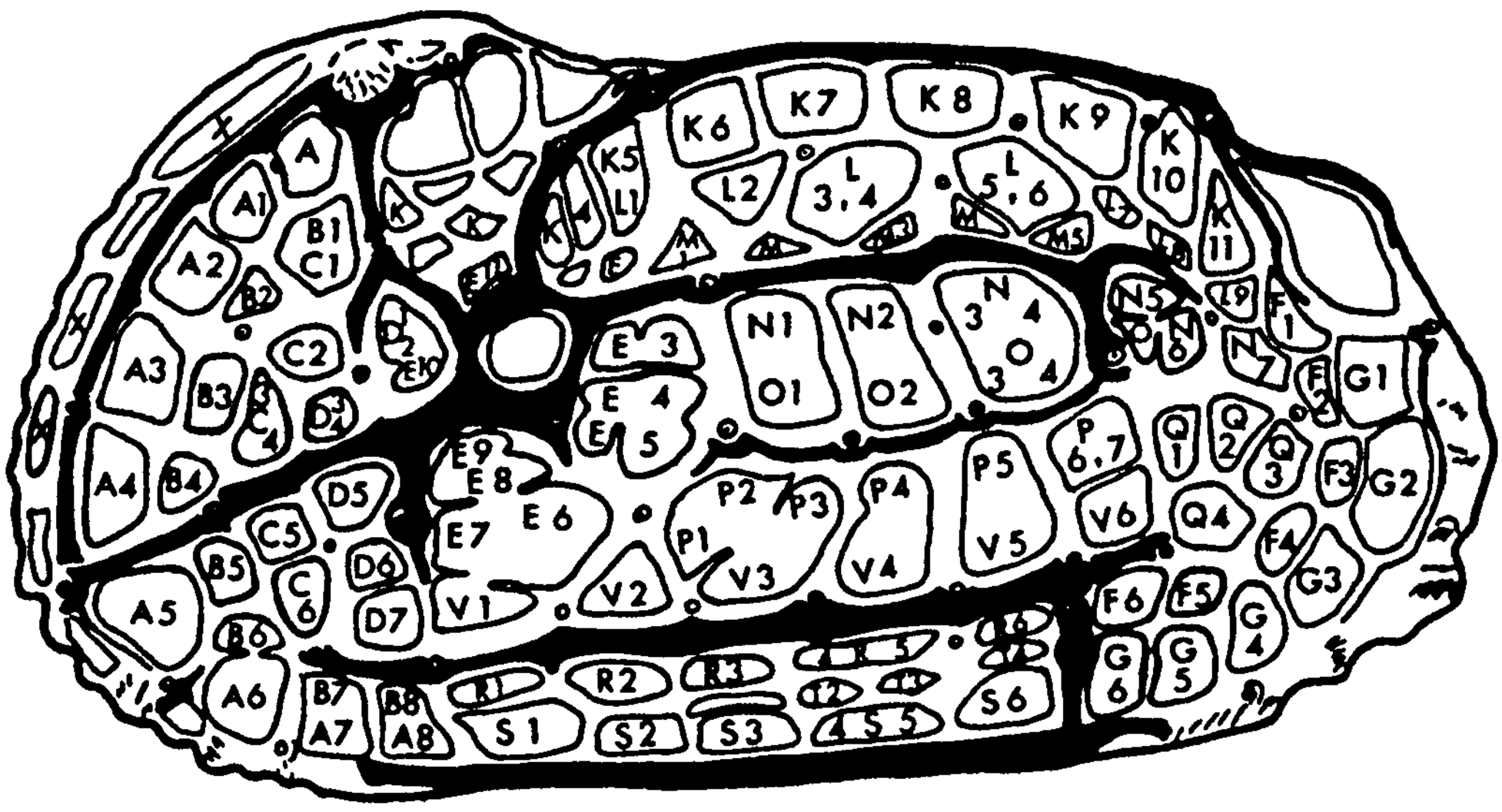


Figure 19 : Lateral reticulation of Paracosta (Paracosta) hammurabii sp. nov. , male; arrow indicates anterior, and dark areas illustrate the main ridges .

However, from Salahi's (1966) description and figures of the species Paracosta (Paracosta) n.sp. 2, it appears to be very similar to P.(Paracosta) hammurabii sp. nov. If it is the same species, the range of the latter species must be extended down to the lower Eocene, as the age of P.(Paracosta) n.sp. 2 (Salahi, 1966) is Lower and Middle Eocene.

Occurrence: Known so far from the lowermost Upper Eocene of Jabal Thuleithuwat, Jordan; the uppermost Middle Eocene Jaddala Formation of Maaloula area, Syria; and from the Middle-Upper Eocene Jaddala Formation of Anah Well-2, Iraq.

Paracosta (Paracosta) heluanensis (Bassiouni)

Text fig. 20; pl . 23, figs. 10 & 11

1969b, Carinocytherois (R.) heluanensis, Bassiouni, p.394, pl . 26, figs. 5 - 10

Diagnosis: A species of Paracosta (Paracosta) with a lateral surface covered by regular reticulations and spines, and with a short, distinct, antero-marginal rim.

Figured Specimens: TKH 11754 and TKH 11756 paratypes from the Upper Eocene of Heluan, Egypt.

Other Specimens: TKH 11755 from the Upper Eocene of Heluan, Egypt; and TKH 11757 - TKH 11758 from the Upper Eocene of Mokattam, Egypt.

Dimensions: (In mm.)

		L.	H.	W.	I/H
TKH 11754	female	0.705	0.405	0.350	1.741
TKH 11756	male	0.805	0.385	0.325	2.091

Discussion:

Bassiouni (1969b) discussed the differences between this species and P.(Paracosta) n.sp. 1 (Salahi, 1966), as "only the course of the middle ridge (upper median ridge) distinguishes the two

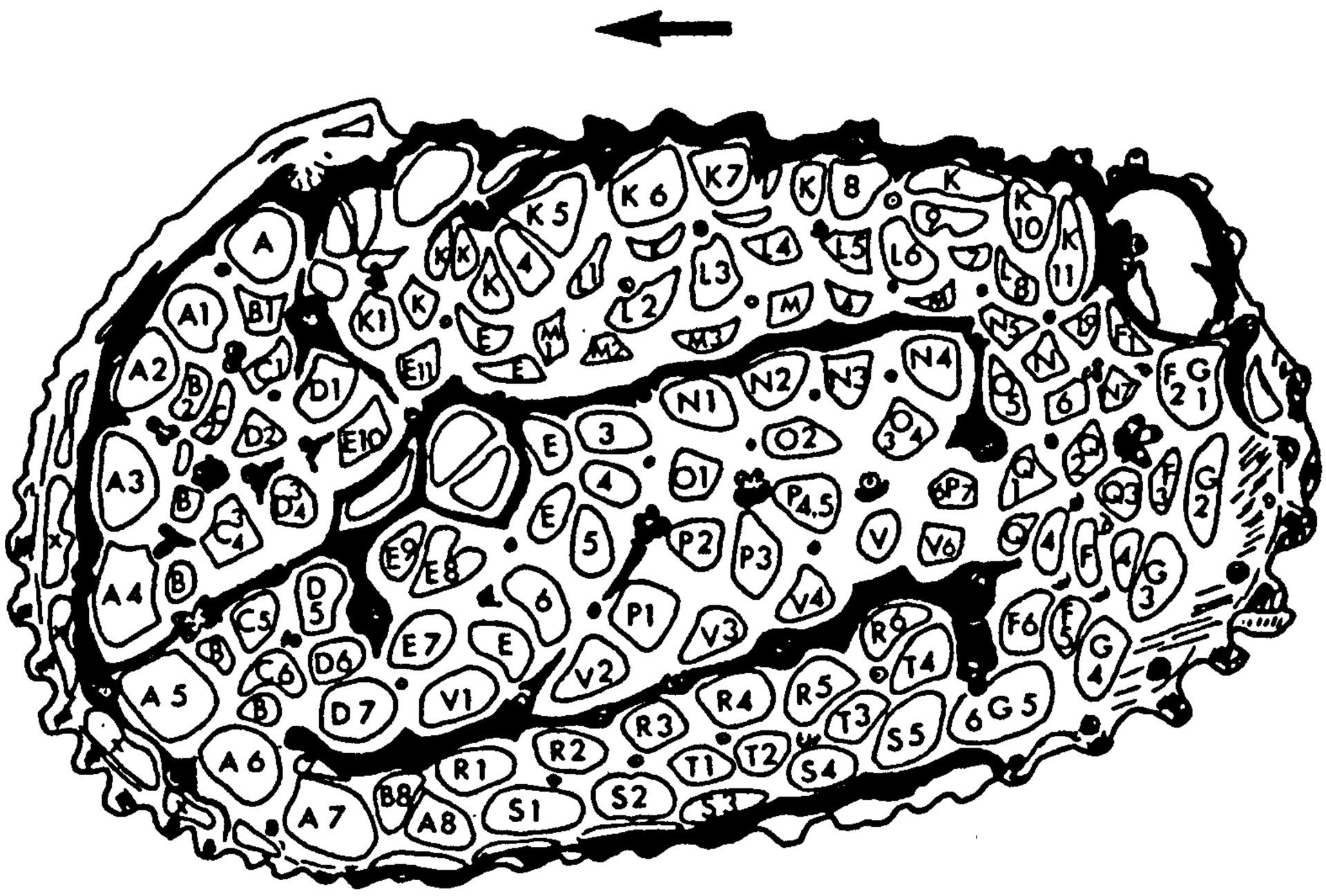


Figure 20 : Lateral reticulation of Paracosta (Paracosta) heluanensis (Bassiouni,1969b), female; arrow indicates anterior, and dark areas illustrate the main ridges .

species; in P.(Paracosta) holuanensis this ridge has a dimple in the area of the muscle field, which causes an angular course of the ridge at this point. Against that the ridge of the Libyan species has a straight course ...." (Translated from German). However, the anteromarginal rim in P.(Paracosta) holuanensis is short, while that of P.(Paracosta) n.sp. 1 (Salahi, 1966) extends around all the margin.

Occurrence: Known so far from the lowermost and mid Upper Eocene "Wadi Garawi Formation" of Egypt.

Paracosta (Paracosta) rogeri (Sonmez-Gokcen)

pl. 20, figs. 2, 5, 9, 11 & 12

1973, Costa rogeri Sonmez-Gokcen, p.81, pl. 10, figs. 8-11

Diagnosis: Large species of Paracosta (Paracosta) in which the longitudinal ridges are sharply developed; and rounded reticules with thick muri are covering the entire surface.

Figured Specimens: OS 11240 - OS 11242

Material: 6 specimens obtained gratefully from Dr. N. Gokcen, from the Upper Eocene - Oligocene of the southeastern Thrace, Turkey.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11240	male	0.970	0.472	-	2.055
OS 11241	female	0.930	0.435	-	1.917
OS 11242	male	0.975	0.475	0.420	2.052

Discussion:

Paracosta (Paracosta) rogeri (Sonmez-Gokcen) differs from Paracosta (Paracosta) declivis (Siddiqui, 1971) and Paracosta(Paracosta) maaloulaensis sp. nov. in its larger size, less developed longitudinal ridges and the thicker muri of the rounded reticules.

Occurrence: Known so far from the uppermost Upper Eocene - Oligocene of the Turkish Thrace.

In addition to the species described above, the subgenus Paracosta (Paracosta) includes several other species which are listed in Table 10. No material of these species was available for study, but the following comments seem pertinent for any discussion of the subgenus.

In West Africa P.(Paracosta) dahomeyi (Apostoloscu, 1961) is present in the Eocene of Dahomey, Togo and Nigeria, and P.(Paracosta) culcitosa (Apostoloscu 1961) in the Lower Eocene of Senegal. These both show strong similarities to P.(Paracosta) warriensis (Maastrichtian -Palaeocene) indicating a close phylogenetic relationship. The presence of 4 longitudinal ridges and fine reticulation place these two Eocene species into P.(Paracosta) rather than P.(Paleocosta). Bassiouni (1969a & b) assigned P.(P.) dahomeyi to the genus Chrysocythere Ruggieri 1962, and it is possible that this species was ancestral to Chrysocythere which is mainly developed in the Miocene and Pliocene.

Paracosta (Paracosta) olurebei (Reyment, 1963) from the Palaeocene of Nigeria shown some resemblance to Paracosta (Paracosta) n.sp. 1 (Salahi, 1966) from the Lower Eocene of Libya in the presence of marginal denticulations, and to Paracosta (Paracosta) n.sp. 2 (Salahi, 1966) from the Lower and Middle Eocene of Libya in the presence of the sub-caudal process and obliquely rounded anterior margin. P.(Paracosta) olurebei (Reyment, 1963) differs from P.(Paracosta) n.sp. 1 in the general outline, notably the obliquely rounded anterior margin, and also in the details of ornamentation. It differs from P.(Paracosta) n.sp. 2 mainly in the details of ornamentation, where the reticulation of the latter species is quadratic and coarser than the rectangular reticulation of P.(Paracosta) olurebei. Following

Table 10 : List of the species belonging to the genera Paracosta Siddiqui (1971) and Allocosta nov., and their geographical distributions; the numbers are for figs. 21, 29 & 30; (*) to indicate species which are not described in the text.

Paracosta (Paracosta) Siddiqui, 1971

1. warriensis (Reyment, 1960); Nigeria and Libya
2.* grekoffi (Reyment, 1960); Nigeria
3.* barri (Neufville, 1973); non-Van den Bold (1960); Brazil
4.* acuticostata (Reyment, 1963); Nigeria
5.* ornatoreticulata (Reyment, 1963); Nigeria
6.* olurebei (Reyment, 1963); Nigeria
7.* ? tilemsiensis (Apostolescu, 1961); Mali
8. arabica (Bassiouni, 1969); Jordan, Syria, Iraq and Libya?
9. bicristata sp. nov.; Jordan
10. praecrassireticulata (Bassiouni, 1969); Senegal?, Tunisia, Jordan, Syria, Iraq and Pakistan
11.* fissicostis (Van den Bold, 1957); Trinidad
12.* variabilocostata seminuda (Van den Bold, in Neufville, 1973); Brazil
13.* n. sp. 2 (Salahi, 1966); Libya
14.* n. sp. 1 (Salahi, 1966); Libya
15.* dahomeyi (Apostolescu, 1961); Dahomey and Togo
16.* culcitosa (Apostolescu, 1961); Senegal
17. yarmukensis (Bassiouni, 1969); Jordan
18. qdeimensis sp. nov.; Syria
19. enlilia sp. nov.; Iraq
20. aff. qdeimensis sp. nov.; Iraq
21.* disintegrata Siddiqui, 1971; Pakistan
22.* praetricostata praetricostata (Bassiouni, 1969); Egypt
23.* capsella (M.S., Al-Furaih, 1976); Saudi Arabia
24. maaloulaensis sp. nov.; Syria
25. hammurarabii sp. nov.; Syria, Jordan and Iraq
26.* moka (Van den Bold, 1960); Trinidad

Table 10 continued

27.* barri (Van den Bold, 1960); Trinidad

28.* harmoniensis (Van den Bold, 1960); Trinidad

29. heluanensis (Bassiouni, 1969); Egypt

30.* praetricostata maadiensis (Bassiouni, 1969); Egypt

31. declivis Siddiqui, 1971; Pakistan

32. rogeri (Sonmez - Gokcen, 1973); Turkey

33.* lehneri (Van den Bold, 1960); Trinidad

Paracosta (Paleocosta) Benson, 1977

34. mokattamensis praemokattamensis (Bassiouni, 1969); Jordan

35. cf. crassireticulata (Bassiouni, 1969); Jordan

36. crassireticulata (Bassiouni, 1969); Jordan, Egypt and Iraq

37. ansaryi (Bassiouni, 1969); Jordan and Syria

38. aliena (Bassiouni, 1969); Egypt and Iraq

39. enkii sp. nov., Iraq

40. mokattamensis mokattamensis (Bassiouni, 1969); Egypt

41.* humboldti (Bassiouni, 1969); Egypt

Allocosta gen. nov.

42. proteros (Bassiouni, 1969); Jordan

43. syriaensis sp. nov.; Syria

44.* praescitula (Bassiouni, 1969); Jordan

45. ninurta sp. nov., Iraq

46. scitula (Bassiouni, 1969); Egypt and Jordan

the foregoing discussion, and from the palaeogeographical evidence, P.(Paracosta) olurobei may be regarded as ancestral to both Salahi's n.sp. 1 and n.sp. 2.

Figure 21 indicates that P.(Paracosta) barri (Neufville, 1973) non-Van den Bold (1960) is regarded as being ancestral to the Caribbean species of the subgenus found in the Eocene and Oligocene. Neufville (1973) discussed the similarities between this species found in the Danian of Brazil and the species originally described by Van den Bold (1960) from the Upper Eocene and Oligocene of Trinidad and with P.(Paracosta) harmoniensis (Van den Bold, 1960) from the Upper Eocene of Trinidad. He believed that the Brazilian form closely resembles P.(P.) harmoniensis, especially in the subdivision of the upper median ridge at the anterior. This feature is thought to be of some importance throughout the development of Paracosta (Paracosta) in the Carribbean region. A species described as Isocytherois? aff. fissicostis Triebel 1940 by Van den Bold in 1957, which is certainly not conspecific with Triebel's species nor does it belong to Isocytherois, is found in the Lower Eocene of Trinidad and appears to be intermediate between the Palaeocene and Upper Eocene species mentioned above when the details of ornamentation, shape and size are considered. P.(Paracosta) meka (Van den Bold, 1960) is another Upper Eocene species related to this group.

A species described from the Lower Eocene of Brazil as Costa variabilocostata semimuda Van den Bold 1958 by Neufville in 1973 differs from the original species, notably in the presence of a horizontal ridge on either the left or right valve (see Neufville p. 84-85) which curves between the dorsal and the upper median ridge. Van den Bold's species was described from the Oligocene-Miocene of Trinidad. Neufville suggested that his Lower Eocene species was intermediate between the two subspecies C.variabilocostata

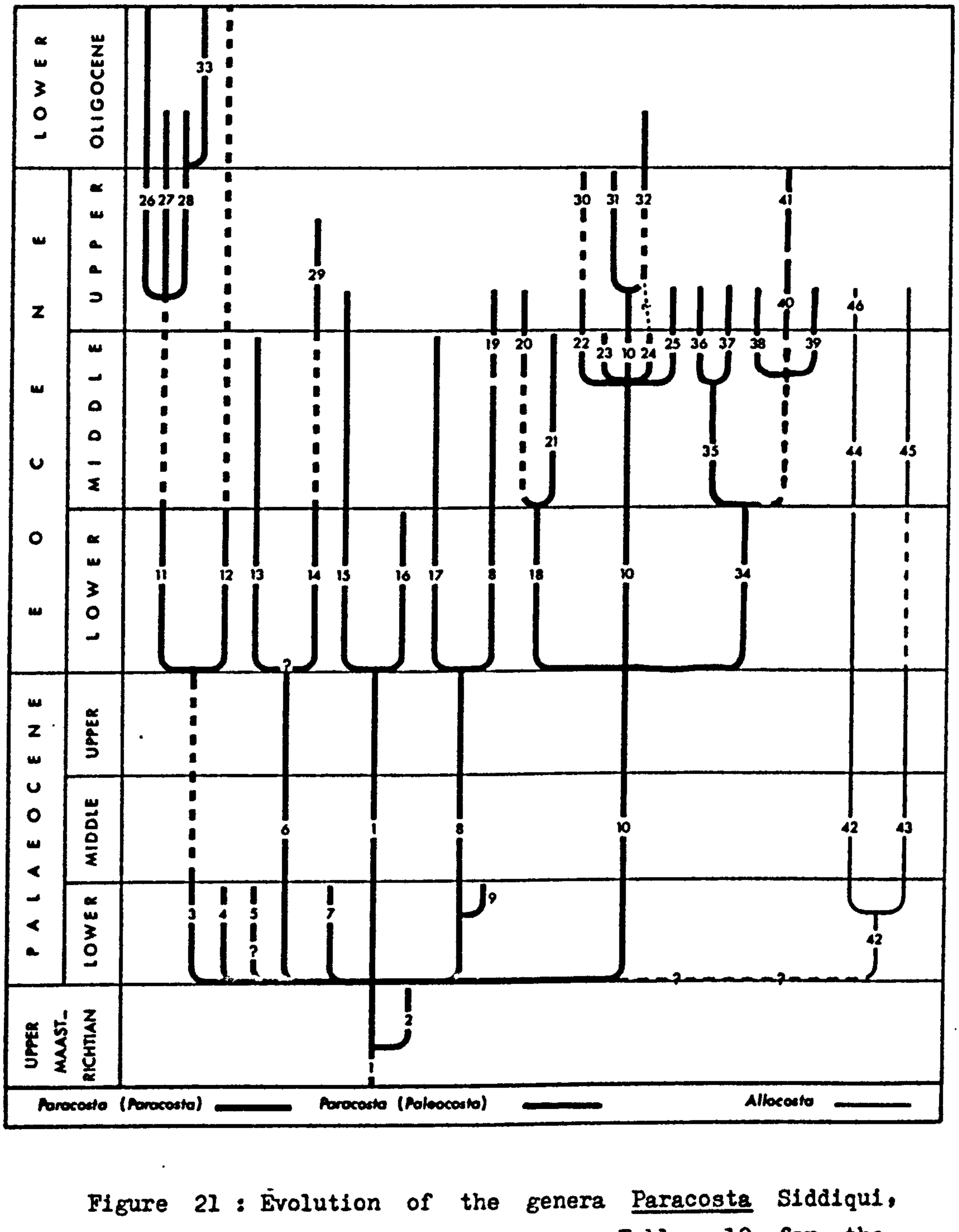


Figure 21 : Evolution of the genera Paracosta Siddiqui, and Allocosta nov.; see Table - 10 for the discriptions of the key numbers .

variabilocostata and C.variabilocostata seminuda. Considering the general picture of the evolution and dispersal of Paracosta (Paracosta) in the Americas it seems more likely that Neufville's Lower Eocene species is intermediate between the Palaeocene P.(P.) barri of Neufville and the Oligo-Miocene Costa variabiloobstata Van den Bold (1958).

Subgenus Paracosta (Paleocosta) Benson (1977), emend. Al-Shoikhly

Type Species: 1969b, Costa crassiroticulata, Bassiouni

Diagnosis : A subgenus of Paracosta with 4 extremely well developed longitulinal ridges, which may be thick or of lamella type; and with a coarsely roticulate or smooth surface between the ridges.

Paracosta (Paleocosta) crassiroticulata (Bassiouni)

Text fig. 22; pl . 25, figs. 1, 3, 4 & 6

1969b, Costa crassiroticulata Bassiouni, p.403, pl. 28, fig. 4 a-c

Diagnosis: Coarsely roticulate species of Paracosta (Paleocosta), with 4 lamella-type longitudinal ridges and strong cross ridges between them; anteromarginal rim starts just behind the eye tubercle.

Figured Specimens: TKH 11759 from the Upper Eocene of Mokattam, Egypt; and OS 11172 from the Middle/Upper Eocene of Anah Well-2, Iraq.

Material: 4 specimens, including 2 specimens from the Upper Eocene of Mokattam, and 2 specimens from the Middle/Upper Eocene Jaddala Formation of the Anah Well-2.

Dimensions: (In mm.)

		L.	H.	W.	L/H
TKH 11759	female	0.775	0.462	0.405	1.677
TKH 11760	male	0.350	0.455	0.367	1.863
OS 11172	female	0.795	0.475	0.407	1.674

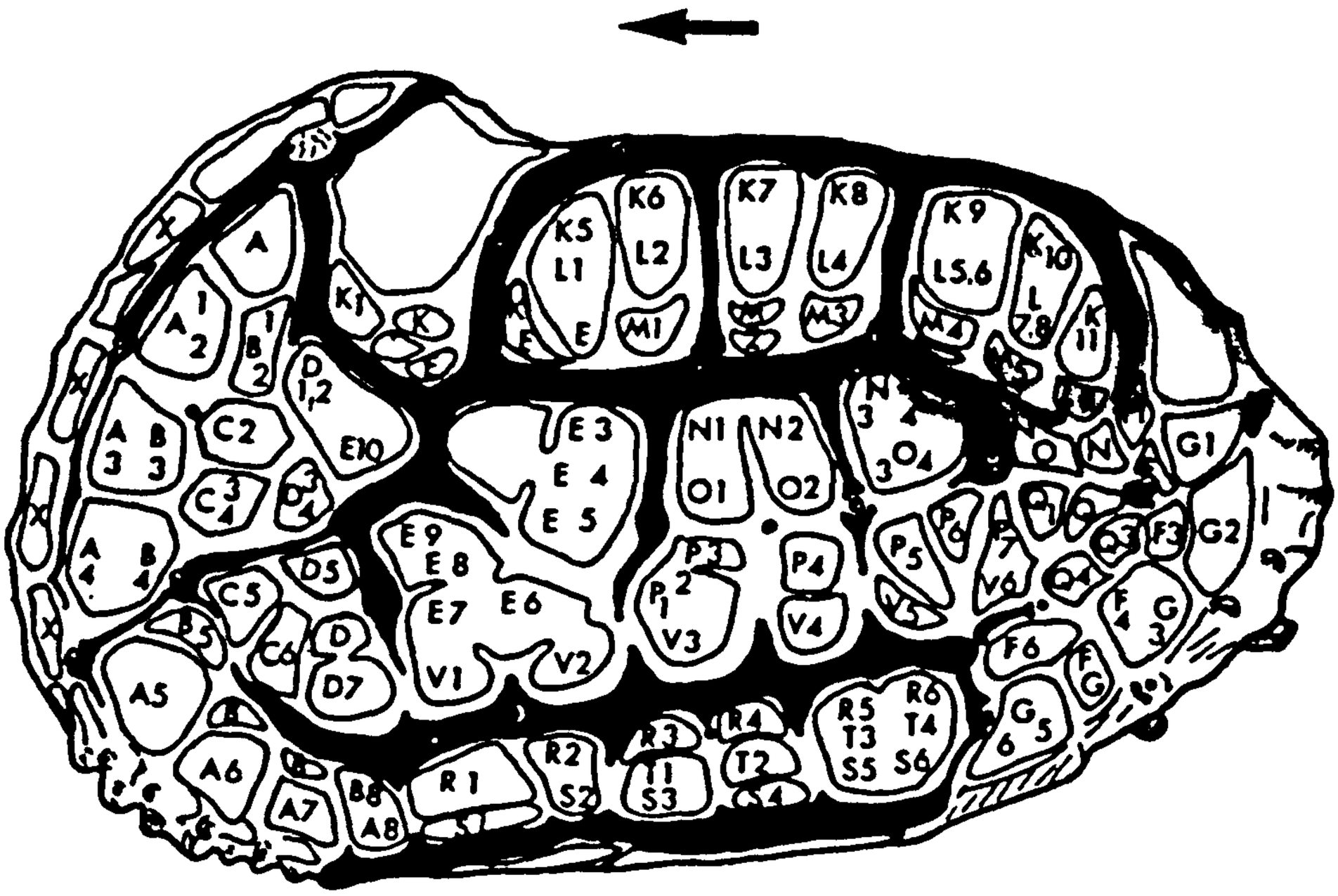


Figure 22 : Lateral reticulation of Paracosta (Paleocosta) crassireticulata (Bassiouni, 1969b), female ; arrow indicates anterior, and dark areas illustrate the main ridges .

Occurrence: Known so far from the Middle and the lowermost Upper Eocene of Jordan, Egypt and Iraq (Anah Well-2 section).

Paracosta (Paleocosta) mokattamensis (Bassiouni)

Diagnosis: A species of Paracosta (Paleocosta) with 2 to 3 ring-grooves in the upper median ridge, and with relatively smooth to faintly reticulate surface between the longitudinal ridges.

P.(Paleocosta) mokattamensis mokattamensis (Bassiouni)

Text fig. 23, pl . 24, fig. 8

1969b, Costa mokattamensis, Bassiouni, p.399, pl . 27, figs. 3-4

Diagnosis: A subspecies of P.(Paleocosta) mokattamensis in which the upper median ridge is broken anteriorly into nodes, and the surface between the longitudinal ridges is relatively smooth, intercalated by some nodes formed as remnants of the cross ridges and reticulation.

Figured Specimen: Female carapace TKH 11764, Upper Eocene of the Mokattam area, Egypt.

Dimensions: (In mm.)

	L.	H.	W.	I/H
TKH 11764 female	0.775	0.445	0.360	1.742
TKH 11765 female	0.815	0.462	0.400	1.764

Occurrence: Known so far from the lower and the lowermost middle parts of the Upper Eocene of Egypt.

P.(Paleocosta) mokattamensis praemokattamensis (Bassiouni)

1969a, Costa mokattamensis praemokattamensis, Bassiouni, p.10, pl . 1, figs. 6-7

Diagnosis: A subspecies of P.(Paleocosta) mokattamensis in which weak ribs are present anteriorly between the upper and lower median ridges; and traces of reticulations, and pore cones are also present anteriorly and posteriorly.

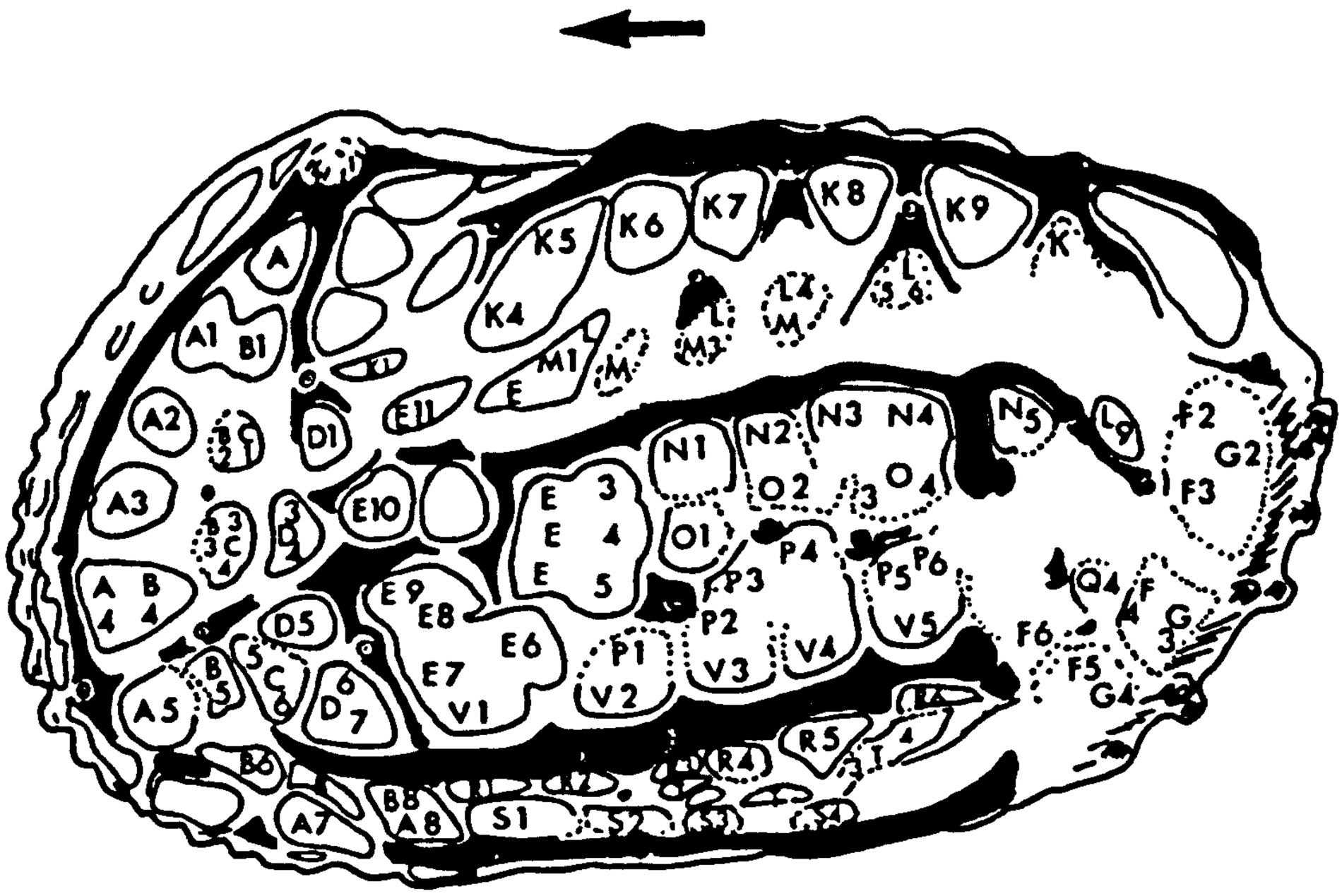


Figure 23 : Lateral reticulation of Paracosta (Paleocosta) mokattamensis mokattamensis (Bassiouni,1969b), female; arrow indicates anterior, and dark areas illustrate the main ridges .

Occurrence: Known so far from the Lower Eocene of Wadi Araba, southern Jordan.

Paracosta (Paleocosta) ansaryi (Bassiouni)

Text fig. 24, pl. 25, figs. 7 & 9-11

1969a, Costa ansaryi Bassiouni, p. 8 pl. 2, figs. 3-4

Diagnosis: A species of Paracosta (Paleocosta) with thick longitudinal ridges, having weakly developed coarse reticulation between them.

Figured Specimens: TKH 11761 & TKH 11762 topotypes from the Middle/Upper Eocene of Faydat ad Dahikiyah, Jordan; and OS 11172 from the uppermost Middle Eocene of Maaloula area, Syria.

Dimensions: (In mm.)

		L.	H.	W.	L/H
TKH 11761	female (Topotype)	0.725	0.400	0.350	1.812
TKH 11762	male (Topotype)	0.835	0.420	0.407	1.933
OS 11173	female	0.730	0.437	-	1.785

Occurrence: Known from the uppermost Middle Eocene and the lowermost Upper Eocene of Jordan and Syria.

Paracosta (Paleocosta) aliena (Bassiouni)

pl. 25, figs. 2, 5, 8 & 12

1969b, Costa ? aliena Bassiouni, p. 408; pl. 26, fig. 11, and pl. 28, figs. 7-8

Diagnosis: A species of Paracosta (Paleocosta) with smooth surface dominated by 4 longitudinal ridges and an antero-marginal rim.

Figured Specimens: TKH 11766 from the Mokattam, Egypt; and OS 11181 from the Anah Well-2, Iraq.

Material: 3 specimens including: 2 specimens from the U. Eocene of Mokattam area, Egypt; and 1 specimen from the U. Eocene part of the Jaddala Formation of Anah Well-2, Iraq, at drilling depths 800'-805'.

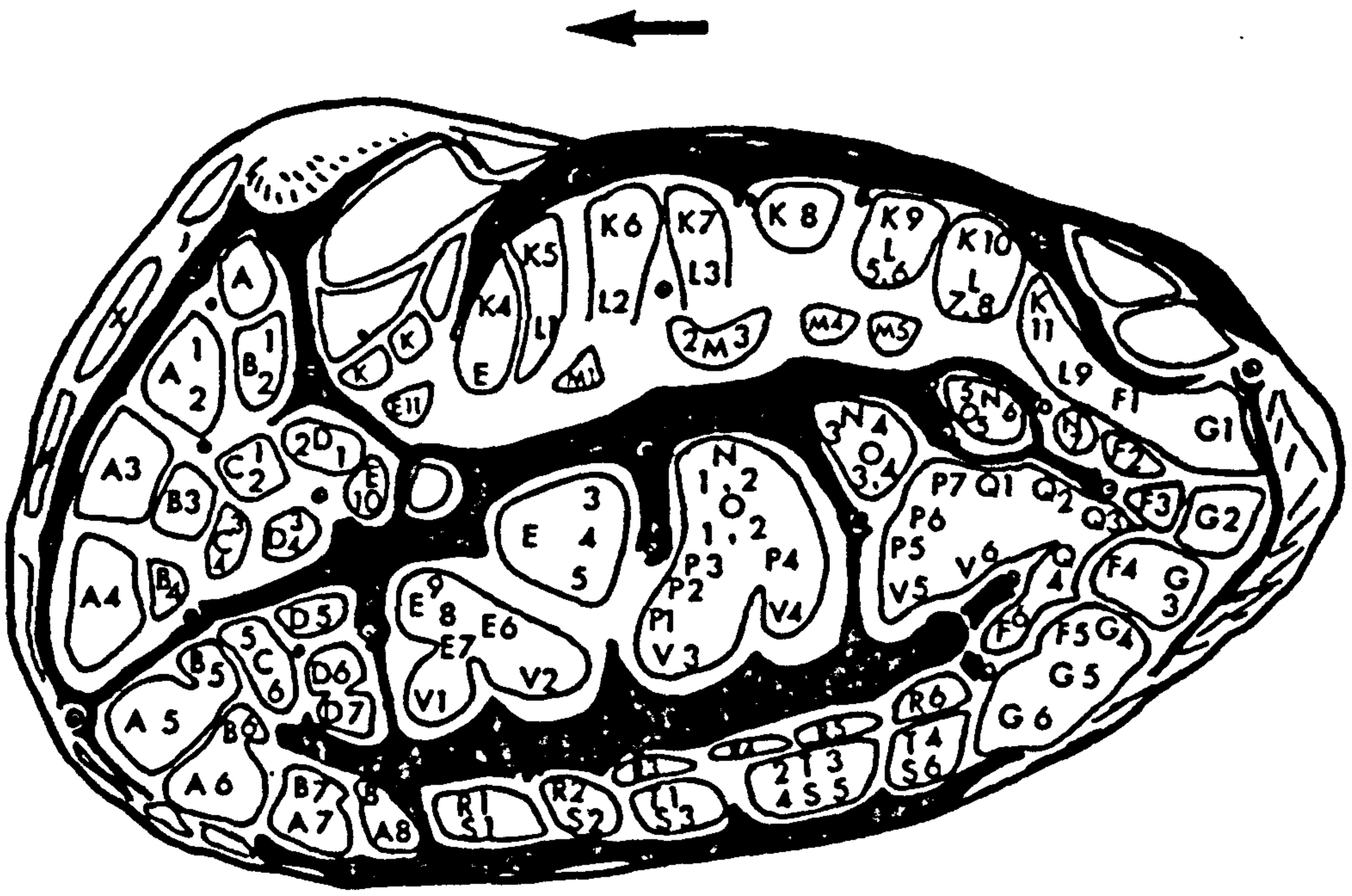


Figure 24 : Lateral reticulation of Paracosta (Paleocosta) ansaryi (Bassiouni,1969a), female; arrow indicates anterior, and dark areas illustrate the main ridges .

Dimensions: (In mm.)

	L.	H.	W.	L/H
TKH 11766	0.700	0.350	0.275	2.000
TKH 11767	0.700	0.352	0.250	1.989
OS 11181	0.305	0,405	0.295	1.933

Occurrence: So far known from the lowermost Upper Eocene of the Mokattam Formation, Egypt; and from the M./U. Eocene Jaddala Formation of the Anah Well-2, Iraq.

Paracosta (Paleocosta) enkii sp. nov.

pl . 24 , fig. 10

Name: After Enki, an Akkadian (Old Iraqi, 2250 B.C.) god of flowing sweet waters in the rivers.

Diagnosis: A species of Paracosta (Paleocosta) in which the surface between the longitudinal ridges is smooth, with only the pore cones as features.

Holotype: Broken left valve, OS 11179, pl .24, fig. 10

Paratype: Broken right valve OS 11180

Material: 2 specimens only

Type Locality: Anah Well-2, Iraq

Type Horizon : Uppermost Middle Eocene part of the Jaddala Formation, sample no. 13, at drilling depths 1220'-1225'.

Description :

There are 4 longitudinal ridges; the dorsal ridge starts from the "Aquarius" pore conulus (see fig. 10 for definition), the upper median ridge starts from the antero-marginal rim, ascends towards the subcentral tubercle and then undulates, with a break in the middle due to a small ring-groove below the "Sigma" pore conulus, ending posteriorly with two branches, the upper one being weak, the lower is stronger, and ending at the "Charon" pore conulus. There is only

one groove below the upper median ridge at the area of the sub-central tubercle. The lower median ridge is thick and distinct, starting and ending abruptly, and with two cross branches: the first is small and runs toward the "Scorpio" pore conulus, where another cross branch descends from the upper median ridge; the second cross branch starts just before the abrupt posterior end of the ridge, ascending toward the "Theta" pore conulus. The ventral ridge is distinct, extending from the antero-marginal spines at the anteroventral corner, and ending above the posteromarginal rim, just below the abrupt end of the lower median ridge. An antero-marginal rim is present, clearly beginning at the eye tubercle and ending at the "Gamma" pore conulus. An eye rib is present, but it is very weak and runs towards the subcentral tubercle.

Generally the surface is smooth with only the pore conuli seen (i.e. Taurus, Aries, Alpha, Psi, ... etc.) and with depressions above and below the subcentral tubercle.

No internal features were observed.

Dimensions: (In mm.)

	L.	H.	W.	L/H
OS 11179 (Holotype)	≈ 0.700	0.400	-	≈ 1.750
OS11180	≈ 0.745	0.435	-	≈ 1.713

Discussion:

Paracosta (Paleocosta) onkii sp. nov. differs from P.(Paleocosta) humboldti (Bassiouni, 1969b) in having an undulating upper median ridge, smoother surface with less cross ribs and pore cones, and weaker eye rib.

P.(Paleocosta)mokattamensis mokattamensis (Bassiouni) has 3 ring-grooves in the area of the subcentral tubercle, and the upper posterior branch of the upper median ridge is better developed than

in P.(Paleocosta) enkii sp. nov.. P.(Paleocosta) nokattamensis pracnokattamensis (Bassiouni) differs from its descendant species, in having weak reticulation, and the lower cross ribs of the upper median ridge reaching to the lower median ridge.

P.(Paleocosta) aliena (Bassiouni) has an elongate carapace with smooth surface dominated by 4 longitudinal ridges and antero-marginal rim. As a result of the differences cited above, it appears to be sensible to create a new species (P.(Paleocosta) enkii) even though the material is poor. For further discussion see the general discussion on the genus, Page no.143.

Occurrence: Known so far only from the Middle/Upper Eocene Jaddala Formation of the Anah Well-2, Iraq.

Allocosta gen. nov.

Name: allos (Gr.) means other.

Type Species: Carinocythereis (Reticulina) scitula proterps (Bassiouni, 1969)

Diagnosis: Trachyleberidinae with a reticulate surface, dominated by a distinct eye rib which runs diagonally across the carapace from the well-developed eye tubercle towards the ventral ridge.

Description: Carapace subrectangular in lateral outline, dorsal and ventral margins are straight, slightly converging towards the posterior, anterior margin uniformly rounded, while the posterior margin is bluntly pointed. Sexual dimorphism with males longer, narrower than females and may also be more weakly ornamented. Eye tubercle is spherical, very distinct and mostly protrudes over the dorsal margin.

The whole surface is reticulate, dominated by a distinct rib, running diagonally from the eye tubercle towards the ventral ridge; this rib is sometimes broken up into a row of small spines.

There are 2-4 longitudinal ridges varying in development and predominance; the dorsal and ventral ridges are usually present, either or both of the median ridges may be present or absent. The dorsal ridge starts just above the sub-central tubercle curving upwards; continuing horizontally toward the posterior, where it divides into two branches in the left valve, the upper branch continuing towards the posterior cardinal angle, the lower branch turning down and backwards toward the "Terminus" pore comulus; in the right valve only the lower branch is present. The upper median ridge if distinct, starting from the "Gamma" pore comulus at the anterior margin running over the sub-central tubercle and ending posteriorly in front of the lower branch of the dorsal ridge. The lower median ridge begins just beyond the eye rib, running parallel to the upper median and ventral ridges, and ending posteriorly with a node below the "Charon" pore comulus; from this node a small branch extends towards the ventral ridge. The distinct ventral ridge starts just before the eye rib, ending at the postero-marginal rim just below the branch of the lower median ridge. The postero-marginal rim has 4-6 marginal spines; the antero-marginal rim when present is distinct; the anterior margin has 18-20 denticles or small spines.

Internally, the inner margin and line of concrescence do not quite coincide, a small vestibule being present at the antero-ventral corner; selvage is prominant; the marginal pore canals are numerous, simple and mostly straight or slightly curved. The adductor muscle scars consist of 4 scars, the uppermost two are the longest; the frontal scar is V-shaped with a shorter anterior branch. Hinge is Amphidont, right valve elements consist of a button-like anterior tooth with low distal part, a postjacent socket, a narrow and finely cremulated nolian groove and a smooth posterior tooth.

Discussion:

Bassiouni (1969b) placed some species assigned to Allocosta in the genus Carinocytherois Ruggieri (1956), despite the differences which he discussed. Allocosta differs from Carinocytherois in the presence of well-developed reticulation covering the entire surface, the presence of the eye rib, and the existence of a smooth posterior hinge tooth instead of the crenulated posterior tooth of Carinocytherois. Carinocytherois has anterior and posterior vestibules, while Allocosta has only a small anterior vestibule.

The genus Paracosta (Siddiqui) is very similar to Allocosta, and the two genera are probably related. Paracosta differs in its larger and unequal reticulation, which is dominated by well-developed longitudinal ridges and anterior marginal rim; and the presence of less developed eye tubercle with a small eye rib ending at the sub-central tubercle. Allocosta differs from the genus Costa Neviani (1928) in the presence of 2-4 longitudinal ridges, the lack of well-developed anterior and posterior marginal rims, and the presence of a small anterior vestibule. Allocosta could be ancestral to the genus Oblitacytherois Benson (1977) from the Miocene-Recent of the Mediterranean and South Atlantic.

They show a close relationship in the shape, the presence of the distinct eye rib, and the internal details, but Oblitacytherois can easily be distinguished by the lack of the eye tubercle, its coarser reticulation, and by the lower median ridge extending from the anterior branch of the eye rib.

Occurrence: Known from the Palaeocene and Eocene of southern shelf of the Tethys.

Allocosta proteros (Bassiouni)

Text fig. 25; pl . 26; figs. 1-4 & 6

1969a, Carinocythereis (R.) scitula proteros Bassiouni, p.11;

pl . 1, fig. 8; pl . 2, figs. 6-7

Diagnosis: A species of the genus Allocosta in which the longitudinal ridges are scarcely developed; eye tubercle well-developed, protruding over the dorsal margin; eye rib uniform with some nodes and pore cones at the points of intersection.

Figured Specimens: OS 11182 - OS 11184

Material: 20 specimens from the Lower Palaeocene of the Tell-Burma section, Jordan.

Type Locality: Tell-Burma, about 145 Km. south of Amman, Jordan.

Type Horizon : Palaeocene

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11182	female	0.877	0.480	0.350	1.827
OS 11183	male	0.950	0.470	0.370	2.021

Discussion :

Allocosta proteros (Bassiouni) differs from Paracosta (Paracosta) arabica (Bassiouni) in having an evenly rounded anterior margin, which is straight at the top and rounded at the bottom in the latter species; furthermore, P.(P.) arabica does not have the protruding and well-developed eye tubercle as well as the eye rib; the surface is not evenly reticulated and there are 15 denticles along the anterior margin, and 5 spines at the posterior margin. Allocosta scitula (Bassiouni) differs from A.proteros in having lamella type dorsal and ventral ridge, and an eye rib which bifurcates at 1/4 height. However, the longitudinal ridges of Allocosta praescitula (Bassiouni) are intermediate in strength between A.proteros and A.scitula, and the eye rib bifurcates at 1/3 height.

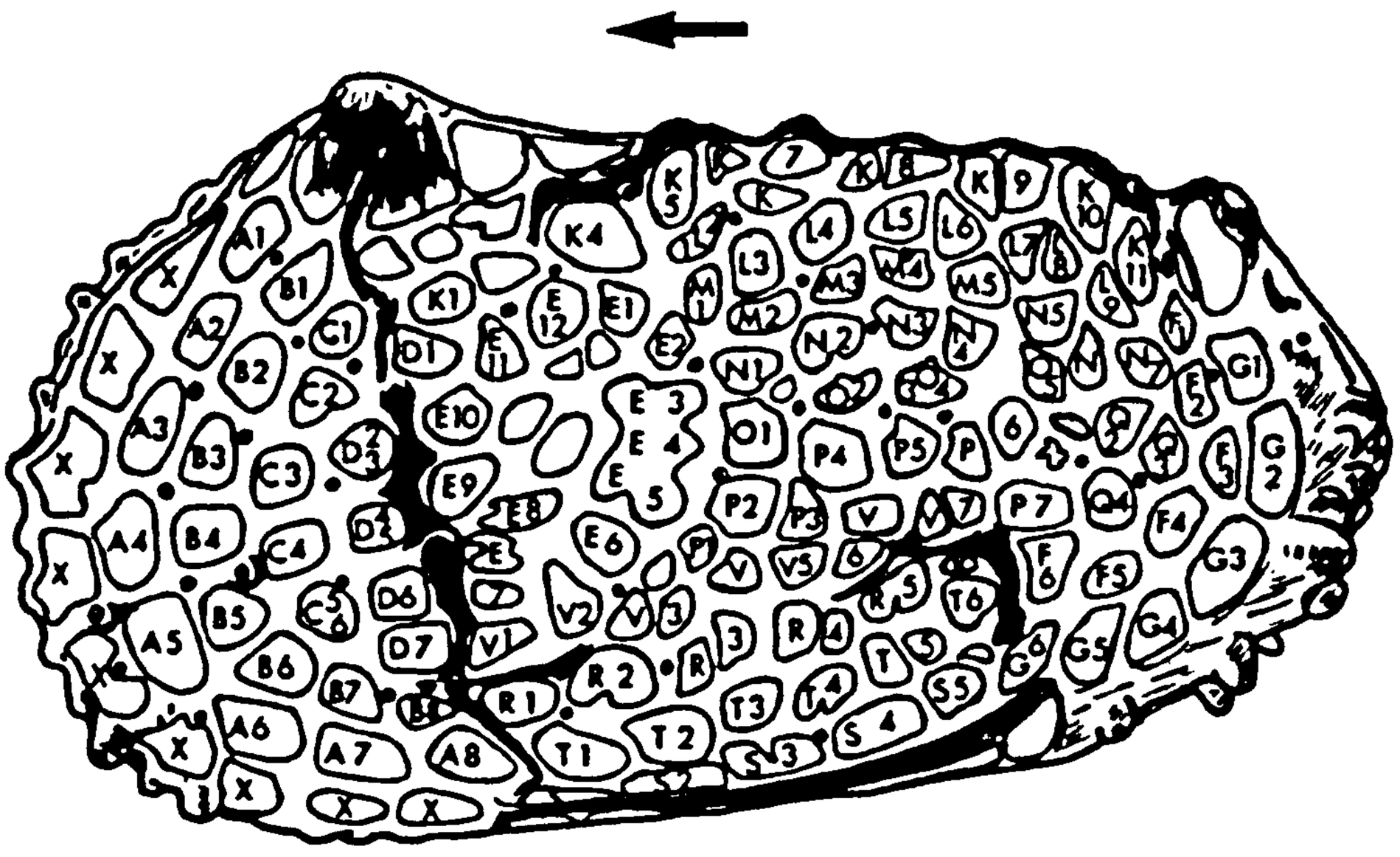


Figure 25 : Lateral reticulation of Allocosta proteros (Bassiouni,1969a), female; arrow indicates anterior, and dark areas illustrate the main ridges .

The Syrian-Iraqi species Allocosta syriaensis sp. nov. and Allocosta ninurta sp. nov., differ from other species of Allocosta in having very weakly developed longitudinal ridges, which made the eye rib very distinct. Allocosta scitula (Bassiouni) differs from Paracosta (Paracosta) helwanensis (Bassiouni) by its larger carapace; its bifurcate eye rib; and lacking the developed antero-marginal rim.

Occurrence: Known so far from the Palaeocene-Lower Eocene of Jordan in the following places: Tell-Burma, Ma'an and Wadi Araba.

Allocosta syriaensis sp. nov.

Text fig. 26; pl . 26, figs. 9, 10, 12 & 13

Name: After "Syria"

Diagnosis: A species of Allocosta, with small reticulations covering the mid surface of the carapace, and with some ventro-lateral swelling, causing a downward curving of the ventral ridge.

Holotype: Male carapace, CS 11190, pl . 26, 9 & 12

Paratype: CS 11191 - CS 11193

Material: 4 specimens from the Palaeocene of Syria, selected from I.P.C. Sample no. S/15732 - 15737, stored at the British Museum (Nat. Hist.), London.

Description: Large carapace with ventro-lateral swelling; dorsal ridge straight; ventral ridge curving downwards. The whole surface is reticulate; the reticulation in the middle of the carapace is smaller than at the anterior and posterior. There are a lot of pore cones between the surface reticulation. The carapace has a sinus in the area of the sub-central tubercle exactly below the "Aquarius" pore conulus, and passing down over the E1 reticule; it is bounded by E2, E3, E4 & E5 reticules at the posterior and the sub-central tubercle at the anterior. Internal details unknown.

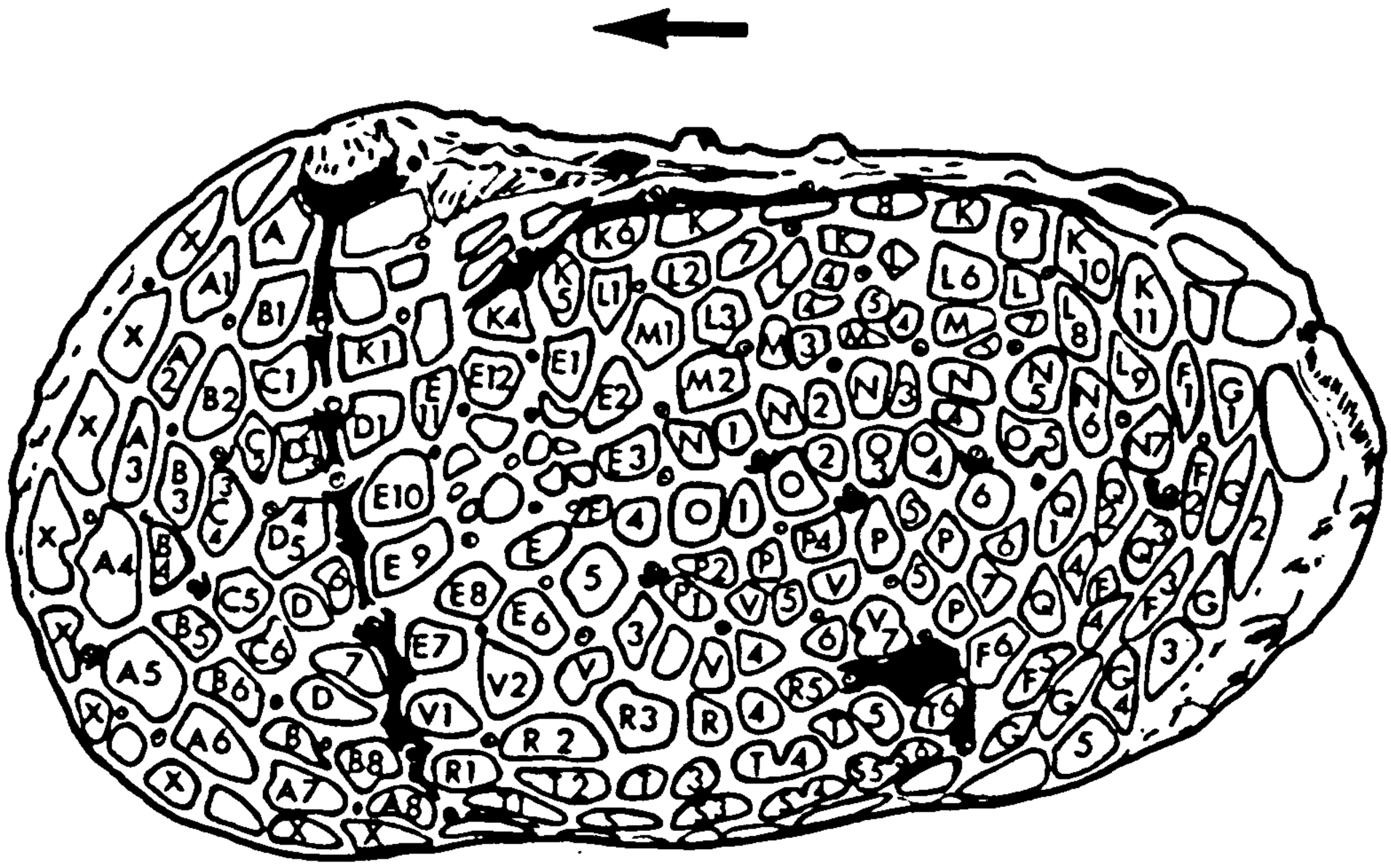


Figure 26 : Lateral reticulation of Allocosta syriaensis gen. et sp. nov., male; arrow indicates anterior, and dark areas illustrate the main ridges .

Dimensions: (In mm.)

	L.	H.	W.	L/H
OS 11190 male (Holotype)	0.920	0.487	0.425	1.889
OS 11191 female	0.875	0.485	0.400	1.804
OS 11192 female	0.875	0.482	0.375	1.815
OS 11193 male	0.900	0.462	0.420	1.943

Discussion:

Allocosta ninurta sp. nov. from the Eocene of Iraq differs from Allocosta syriaensis sp. nov. in its smaller size, more distinct eye rib, and reticulation being even; the mid surface reticulation of A. syriaensis sp. nov. is smaller than in the anterior and posterior areas; A. syriaensis has a better developed eye tubercle. See also Allocosta proteros (Bassiouni).

Occurrence: Known so far from the Palaeocene of Syria.

Allocosta ninurta sp. nov.

Text fig. 27; pl. 26, figs. 5, 7, 8 & 11

Name: After Ninurta, the Akkadian god of the thunder-showers and floods of spring.

Diagnosis: A species of Allocosta with an even reticulation arranged in rows surrounding the sub-central tubercle.

Holotype: Male carapace OS 11185, pl. 26, figs. 5, 8 & 11

Paratype: OS 11186 - OS 11189

Material: 29 specimens from the Middle-Upper Eocene Jaddala and Avanah Limestone Formations of the Jabel Sinjar section, Iraq.

Type Locality: Jabel Sinjar section, Iraq.

Type Horizon: 2 metres thick marly bed of the uppermost Middle Eocene part of the Jaddala Formation.

Description: The dorsal and ventral ridges are the only longitudinal ridges developed, and are weak; the dorsal ridge is sometimes broken up into a row of spines. The eye rib is well developed and uniform.

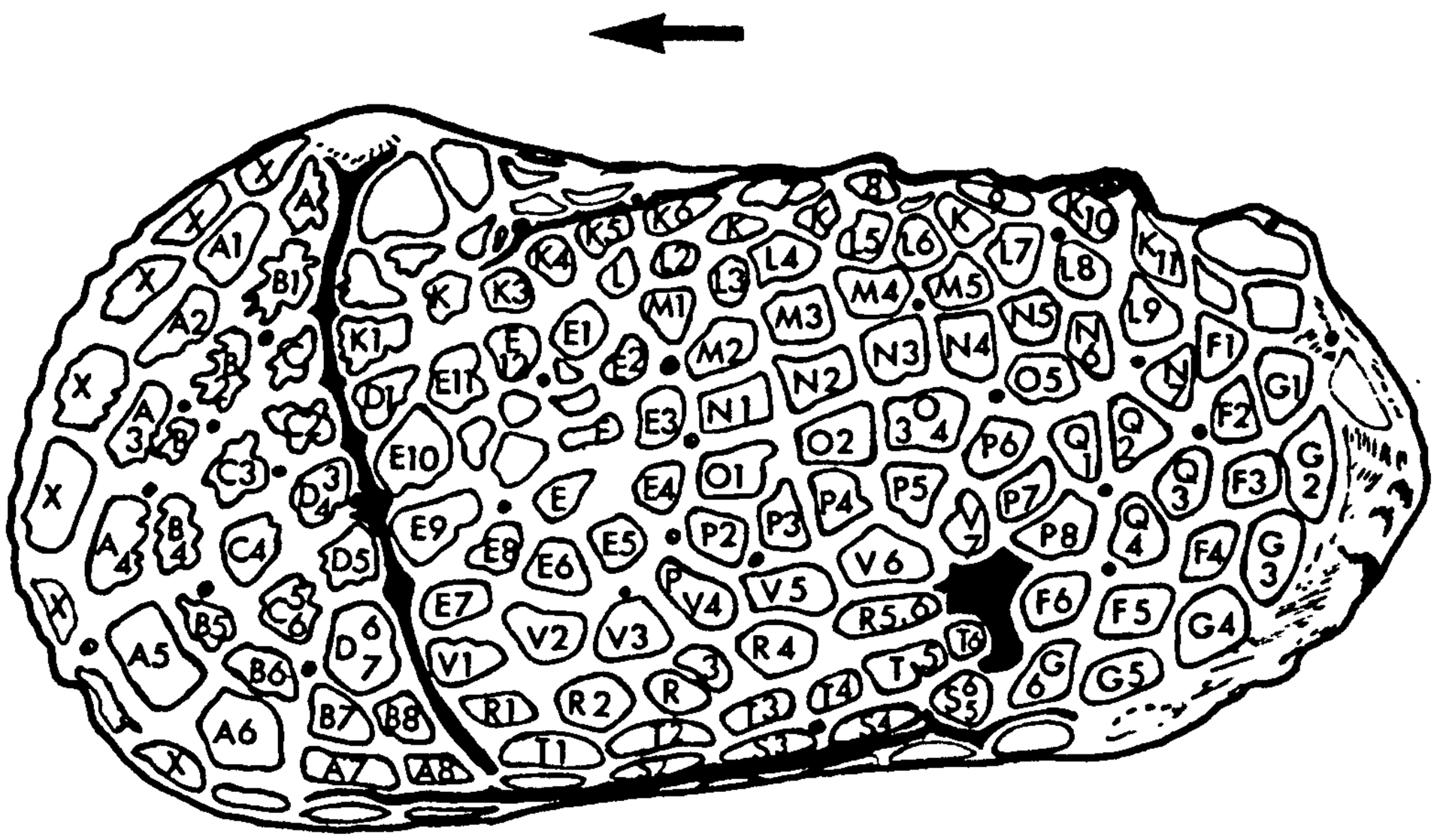


Figure 27 : Lateral reticulation of Allocosta ninurta gen. et sp. nov., male; arrow indicates anterior, and dark areas illustrate the main ridges .

The entire surface is covered by an even reticulation arranged or showing a tendency to be arranged in rows surrounding the sub-central tubercle; small spines may be present between the rows. Generally the reticulation present to the anterior of the eye rib has a secondary ornamentation. The anterior margin has 18-20 denticles, while the postero-marginal rim carries 4-5 small spines. In dorsal view, the sides of the carapace converges slightly to the anterior, with a shallow depression over the area of the sub-central tubercle, this depression is bounded anteriorly by the well marked eye rib; the carapace is laterally compressed at its posterior end. No internal details were observed.

Dimensions: (In mm.)

		L.	H.	W.	L/H
OS 11185	male (Holotype)	0.820	0.410	0.345	2.000
OS 11186	female	0.797	0.435	0.285	1.832
OS 11183	female	0.825	0.457	0.350	1.805

Discussion See Allocosta syriacensis sp. nov.

Occurrence: Known so far from the uppermost Middle-Upper Eocene of the Jabel Sinjar section of northwestern Iraq.

EVOLUTION & MIGRATION

Paracosta and the related genus Allocosta are important elements of the Palaeocene Ostracod fauna found in a wide area, stretching from West Africa eastwards through North Africa and the Middle East to Pakistan, and westwards via the Atlantic through Brazil to Trinidad. This distribution can be regarded as being along the southern margin of the Palaeogene Tethys. It also coincides with the important phosphatic belt of Palaeocene-Eocene age.

The oldest species of Paracosta so far known is from the Upper Maastrichtian of Nigeria and it is only in Nigeria that the genus

is recorded from the Cretaceous (see fig. 21).

On this evidence it is reasonable to suggest that Paracosta originated in West Africa. It is obviously important to examine rocks of Maastrichtian age in other regions to see whether the genus is present or not. No trace of Paracosta has so far been recorded from Maastrichtian strata of Libya (Barsotti, 1963; Salahi, 1966), Jordan (Bassiouni, 1970), or Iraq. However, biostratigraphical work carried out by Futyan (1963), Kassab (1976b) and Yassini (1979) on the Middle East indicates the absence of the uppermost part of the Upper Maastrichtian (Globotruncana aegyptiaca Zone) and parts of, or the whole of, the Lower Palaeocene. Nevertheless Paracosta (Paracosta) warriensis (Reyment, 1960) is found in Nigeria in beds older than the Lacuna of the Middle East. In South America no Paracosta are recorded before the Danian (Neufville, 1973b). It is difficult to determine exactly which species gave rise to Paracosta because a whole plexus of inter-related Cytherois species existed in the Cenomanian and Turonian epicontinental seas of the Southern Tethys. Species such as Cytherois mdaouerensis Bassoullet and Damotte (1969) from Algeria and Cytherois cretaria Van den Bold (1964) from Egypt and Palestine show great affinities to Paracosta. An earlier species, Cytherois aff. mdaouerensis, was described by Neufville (1973b) from the Cenomanian of Gabon, and is here considered to be ancestral to Bassoullet and Damotte's species. The Cytherois mdaouerensis lineage is regarded as the more probable ancestor because it is present at the correct time, and the geography of that time (fig. 28) allowed free communication between Algeria and West Africa. Allocosta is restricted to the Middle East region, appearing in the Lower Palaeocene. It shows some resemblance to Cytherois cretaria which may have been a distant ancestor.

The suggested migration of Paracosta is shown in figs. 28-30, with dispersal in three directions from its place of origin in West

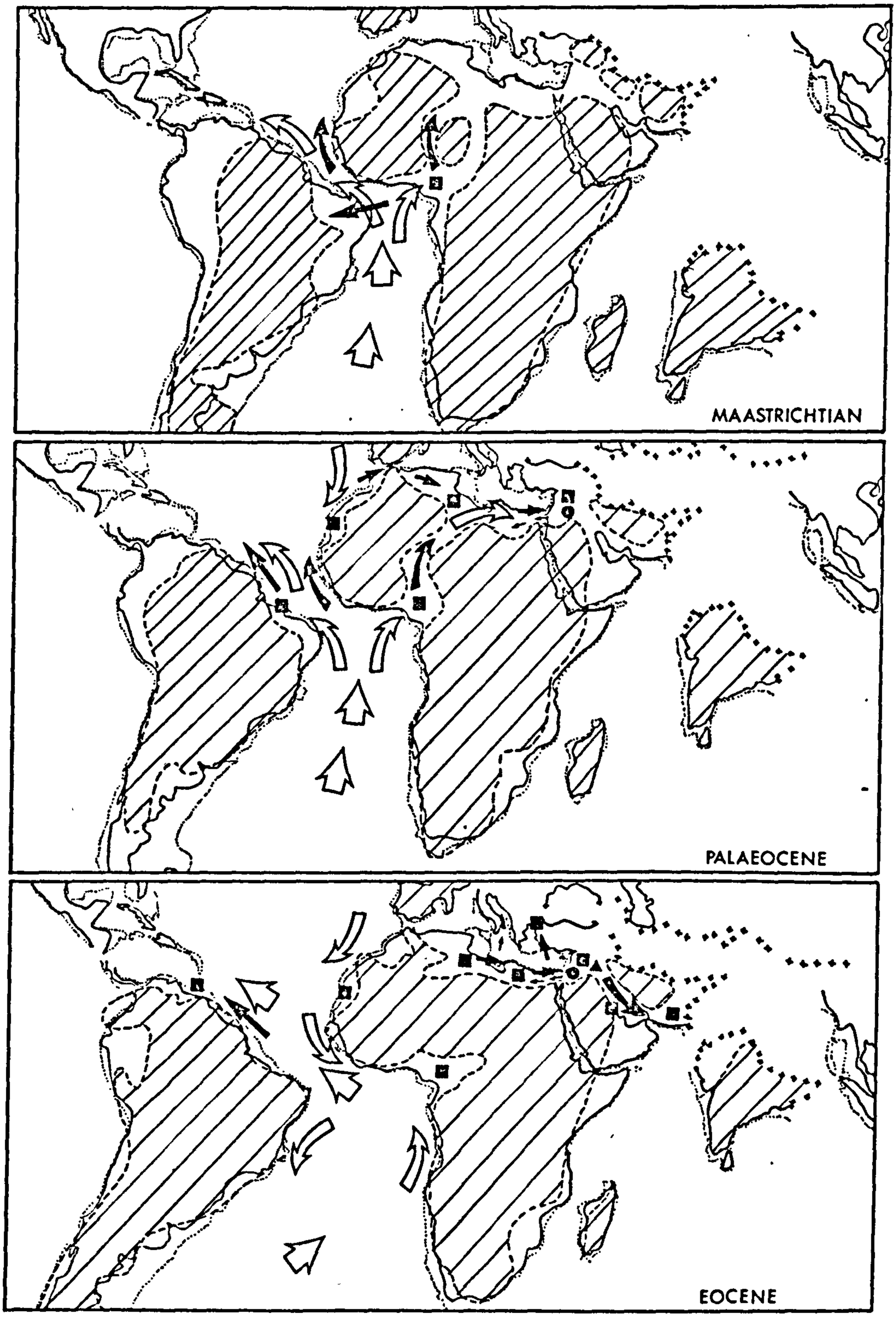


Figure 28 : Directions of migration of the subgenera Paracosta (Paracosta) Siddiqui,1971 "Black Squares" and Paracosta (Paleocosta) Benson,1977 "Black Triangle", and the genus Allocosta nov. "Black Circles" throughout the Maastrichtian, Palaeocene and Eocene .(White arrows indicate Oceanic Currents and black arrows are the ostracod migratory routes **,and the crosses line is an arbitrary line of separation of one continent from another).**

Africa. The assumption is made that the genus is monophyletic, originating in a single region. The first direction of migration was northwards through the epicontinental seas covering large parts of north and west Africa (figs. 28, 29) and thence eastwards along the southern shores of Tethys as far as Pakistan (fig.30). The second direction of migration was towards the northwest along the coast of W. Africa, and the third direction was westwards to Brazil and the Caribbean. These migration routes have been proposed by previous workers. Barsotti (1963) believed that the Palaeocene ostracod fauna of the Sirte Basin (Libya) had migrated from the southwest, i.e. Nigeria. Reyment (1966) considered seven West African Palaeocene-L. 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 Saharan seaway and around the Coast of West Africa to Senegal. Neufville (1973) and Van den Bold (1977) have both outlined the evidence for migration between West Africa and South America in the Late Cretaceous-Early Palaeogene.

Paracosta (Paracosta) warriensis (Reyment) is the oldest species of the genus, appearing in the Upper Maastrichtian of Nigeria (Reyment, 1960). It is labelled (1) on fig. 29 (Table (10) lists the species referred to by the numbers on figs. 29 & 30). A younger, closely related species, is also present in the Upper Maastrichtian of Nigeria, Paracosta (Paracosta) grekoffi (Reyment). P.(Paracosta) warriensis persists into the Upper Palaeocene of Nigeria and also spread northeastwards where it is found in the Palaeocene of Libya. The evidence for an epicontinental seaway connecting Nigeria and Libya through the Sahara has been given by Barsotti (1963, including a discussion of previous views) and Reyment (1966). Barsotti noticed

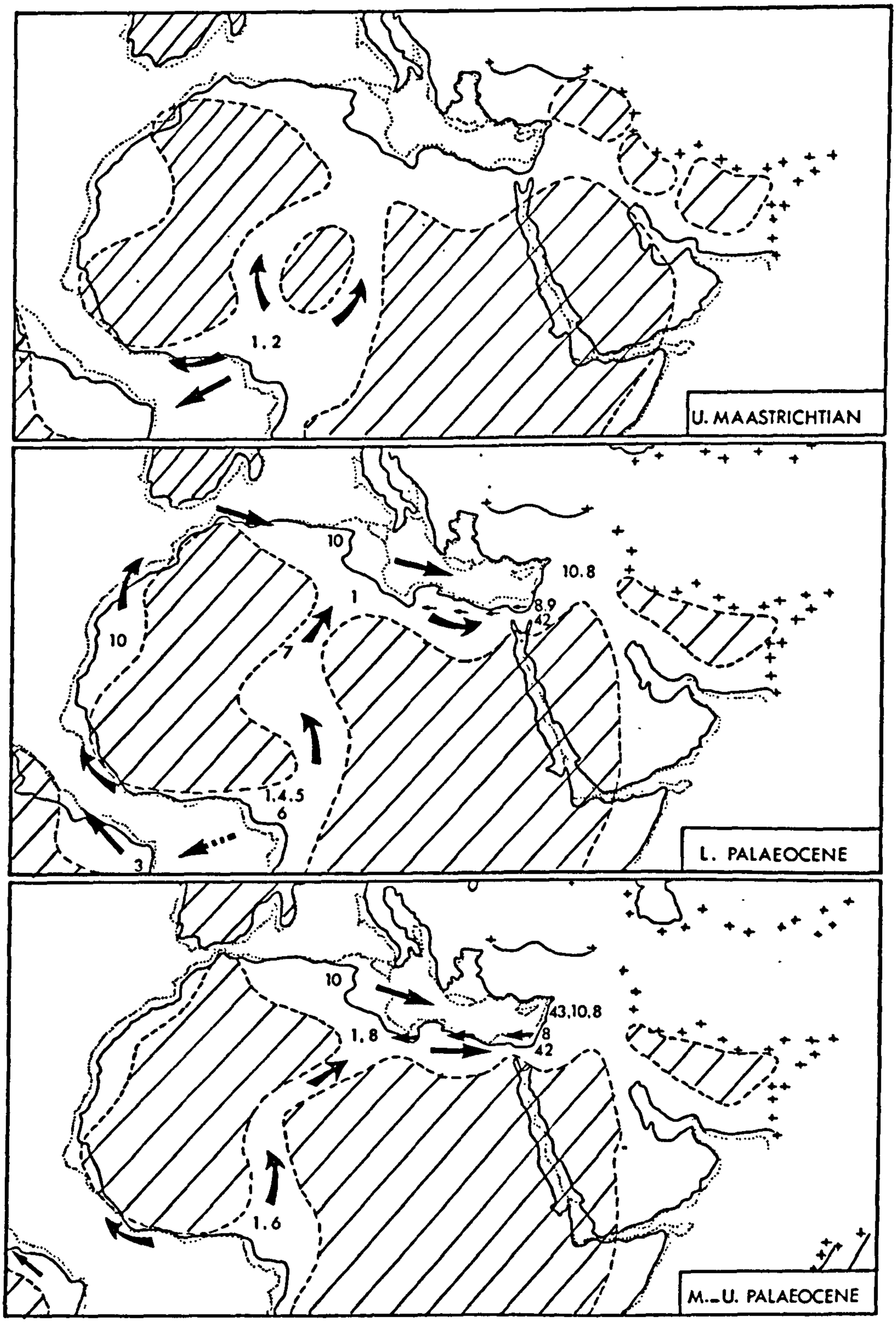


Figure 29 : Migration and distribution of the genera Paracosta Siddiqui , and Allocosta nov. on North Africa and the Middle East throughout the Maastrichtian and Palaeocene; see Table - 10 for the discriptions of the key numbers **(The crosses line is an arbitrary line of separation of one continent from another) .**

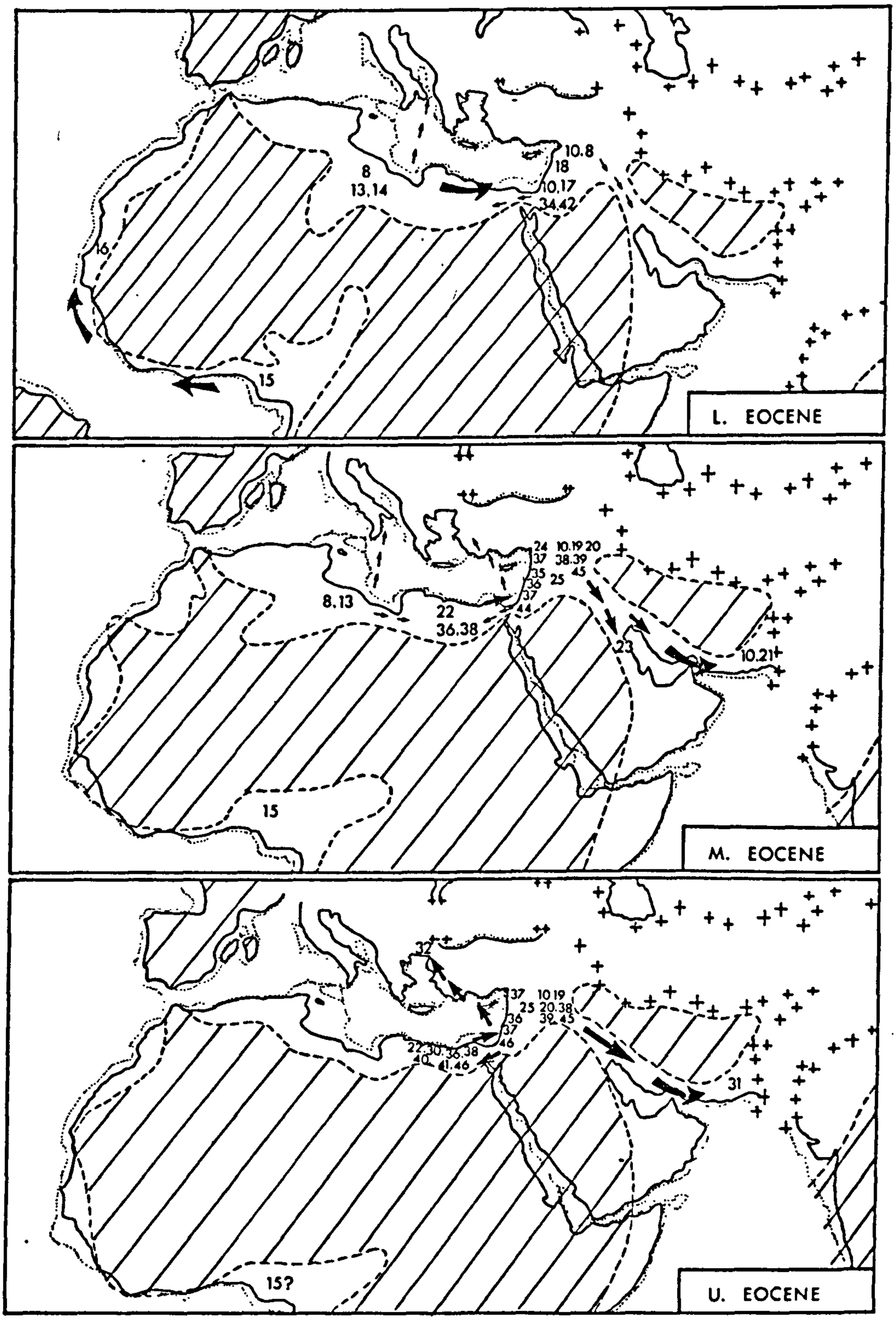


Figure 30 : Migration and distribution of the genera Paracosta Siddiqui , and Allocosta nov. on North Africa and the Middle East throughout the Eocene; see Table - 10 for the discriptions of the key numbers .

(The crosses line is an arbitrary line of separation of one continent from another) .

that of 23 ostracod species present in the Palaeocene of Libya, 20 commonly occur in West Africa. Reyment based his conclusions on the great similarities between ostracod, ammonite, and molluscan faunas of west and north Africa during the Late Campanian to Palaeocene. Petters (1978a, b; 1979) has argued against a connection of the Saharan seaway with the Gulf of Guinea, maintaining that the Upper Cretaceous - Palaeocene benthonic foraminiferal faunas of NW. Nigeria have strong affinities with those of the Mediterranean but are quite distinct from the faunas of Southern Nigeria. He believes that the two seas were separated by fringing marshes and lowland areas which formed a faunal barrier. It appears possible that there was a barrier for some benthonic organisms, but not for all. The strong similarity of the ostracods in the 2 seas suggests they were capable of crossing the barrier. Alternatively, the ostracods present in Libya may have migrated around the coast of Africa and through the Strait of Gibraltar. Migration around the northwestern coast of Africa clearly occurred, with the appearance of Bradleya sangalkamensis Apostlescu (1961) in the Lower Palaeocene of Senegal. This species is probably synonymous with Paracosta (Paracosta) praecrassireticulata (Bassiouni), but as no material has been examined this is not certain (see Paracosta (Paracosta) praecrassireticulata for further taxonomic comments). If these two species are conspecific, it appears to have migrated via the Strait of Gibralter eastwards to Tunisia, Jordan, Syria and northwestern Iraq, reaching Pakistan in the Middle Eocene. The stratigraphical evidence shows that the genus spread from west to east (fig. 28), but already in the Lower Palaeocene a second centre of dispersal had arisen in the Jordan-Syria area. Paracosta (Paracosta) arabica (Bassiouni) (No.8 on fig. 29) migrated westwards from this area to Libya, where it is found associated with Paracosta (Paracosta) warriensis (Reyment) in the M.-U. Palaeocene. Benthonic organisms are likely to spread more rapidly in the direction of the prevailing currents (Adams, 1967,.

discussing benthonic foraminifera dispersion). During the Tertiary the main direction of dispersal of Paracosta was from west to east (figs.29 & 30), presumably this was also the current direction.

The third direction of dispersal was westwards across the opening, but still narrow, South Atlantic. Neufville (1973) and Van den Bold (1977) have discussed the relationship between the S.American and W.African ostracod faunas of the Upper Cretaceous-Palaeocene. Neufville indicates that the two faunas became distinct during the Palaeocene, and that the affinities of the S.American faunas in the Eocene lie with the Caribbean province rather than West Africa.

Van den Bold suggests a fairly close relationship between S.American and W.African ostracod faunas in both the Palaeocene and Eocene, suggesting dispersal of species attached to plant material drifting in an east to west direction. He lists the genera Basslerites, Buntonia, Protobuntonia and Soudanella as migrating in this direction, with Togoina migrating in the opposite direction, i.e. from S.America to W.Africa. The first appearance of Paracosta in South America is a form referred to as Paracosta (Paracosta) barri (Van den Bold) by Neufville (1973) occurring in Danian strata, although it is probably different from Van den Bold's species (see taxonomic comments).

The Middle-Late Palaeocene and Early Eocene saw great changes in the palaeogeography. The South Atlantic had widened, forming an oceanic barrier, Tethys became separated from the Atlantic in the area of Gibralter, and the Saharan epicontinental sea ceased to exist. Tethys itself was divided into two bioprovinces in the Syria-Iraq area, referred to as the Mediterranean and Indopacific Bioprovinces by Buday (1973). These changes resulted in the formation of three different bioprovinces from Paracosta (figs. 28-30): a *Ca*ribbean bioprovince populated by descendants of species which migrated northwestwards during

the Eocene; a West African bioprovince seen in Dahomey, Togo, and Senegal; and a Tethyan Mediterranean Bioprovince where an important radiation of the genus occurred in the Lower Eocene. During this latter radiation a new subgenus Paracosta (Paleocosta) appeared (fig. 21), which is only present within the Mediterranean Bioprovince. No trace of Paracosta is found within the Tethyan Indopacific Bioprovince until the Middle Eocene.

A major transgression of the sea occurred in the Middle East during the M.-U. Eocene, as a result of which Paracosta underwent an adaptive radiation with the appearance of many species of both subgenera (fig. 30), often with localized distributions. During this time the genus spread eastwards into the Tethyan Indopacific Bioprovince, appearing in the Middle Eocene of Pakistan (Siddiqui, 1971) where it survived until the Late Eocene ,

Paracosta also spread to Turkish Thrace during the Latest Eocene, where Paracosta (Paracosta) rogeri (Sonmez-Gokcen, 1973) is found in Upper Eocene - Oligocene sediments. This is the only definite occurrence of the genus on the northern side of Tethys. It is absent from faunas described from the Pyrenees (Ducasse, 1972), northern Italy (Ascoli, 1969), Hungary (Monostori, 1975), Roumania (Olteanu, 1977), and southwestern USSR (Nikolaeva, 1971, 1978). It is worth considering the barriers which prevented the migration of Paracosta and Allocosta. Such barriers fall into three groups (Adams, 1967; Valentine, 1971, 1973; & Hallam, 1973): geographical barriers such as land or deep ocean; climatic barriers which operate principally in a latitudinal direction; and barriers due to habitat specialization. Applying these to Paracosta and Allocosta it appears that both genera lived in shallow seas and were restricted to a tropical climate. The absence of these genera along the northern shores of Tethys may be attributed to the barrier effect of a deep ocean (cf. Berggren and Phillips,

1969; and Hallam, 1971), with west to east oceanic currents strong enough to prevent migration across the ocean. However, benthonic Larger Foraminifera were capable of crossing Tethys as this was not a complete barrier to benthonic organisms. It is difficult to see the climate of northern Tethys being substantially different from southern Tethys in the Palaeogene, so climate was probably not a factor of any importance. It is possible that any individuals of Paracosta which managed to cross to northern Tethys found its niche already occupied by established northern ostracods with which it was unable to compete. It has already been mentioned that the distribution of Paracosta and Allocosta is related to the Tertiary phosphate belt (for discussion of the latter see Ctyroky and Karim, 1971), but considering that the genera occur in non-phosphatic as well as phosphatic horizons, it is difficult to understand the importance of this relationship. It is notable though, that Paracosta is rare and Allocosta absent in Saudi Arabia which lay outside the phosphate belt, although this is probably more easily explained by provincial differences, i.e. Saudi Arabia lay in the Tethyan Indopacific Bioprovince. Paracosta was able to migrate over large distances from west to east, so that its inability to cross Tethys suggests that the latter was a sufficient barrier to prevent successful colonization. Tethys also prevented southwards migration of the northern ostracod fauna, which is very distinct from that of southern Tethys.

CHAPTER _ 7

CONCLUSIONS

CONCLUSIONS

The direction of dispersal of Paracosta (Paracosta) during the Maastrichtian - Eocene period suggests that the prevailing currents of the southern shelf of Tethys were from west to east. Tethys was a sufficient oceanic barrier to prevent migration across it of the European ostracods on the one hand, and the North African - Middle East on the other, at least until the latest Eocene or Oligocene.

The ostracod faunal assemblages of the Jib'ab Marl Formation have added more evidence for separating the Jib'ab Marl Formation from the Shiranish Formation; rather than for the proposal of Buday (1973) to include the Jib'ab marl as an aberrant facies of the Shiranish Formation.

A comparative study of the Palaeogeography and Stratigraphy of the Middle East suggest that the Palaeocene Umm or Radhuma and Aaliji sediments of the north and west of the Ga'ara area (W. Iraq) and the Jabel Tenf area (S.E. Syria) respectively, are sublittoral and open lagoonal facies of the Taqiye Marl Formation of Jordan; and that the Lower Eocene sediments of the same areas are sublittoral limestone facies of the Sara Chalk and Flint Formation of Jordan. Both sediments are phosphate bearing and yield similar faunal assemblages to those of Jordan, with some intermixing with the Planktonic Foraminifera of the Aaliji and Jaddala open seas, but are quite unlike the lithology and faunal assemblages of the typical Aaliji and Umm or Radhuma Formations. Similarly, the uppermost Lower - Upper Eocene, shallow water sediments of the foregoing areas are more likely to be a transitional facies separating both the Mediterranean and Indopacific Bioprovinces, this transitional facies is composed of a mixture of the lithology and faunal assemblages of the Dammam, Jaddala and the Sara Chalk and Flint

Formations. During the Middle - Upper Eocene it extended northwards as far as the northern limit of the submerged Khleisia- Der ez Zor Uplift, which was in existance during the Upper Campanian - Maastrichtian and the Palaeocene - Lower Eocene transgressive cycles. The evidence for this is the restriction of the Mediterranean ostracod faunas to the west of the Khleisia - Der ez Zor Uplift until the latest Early Eocene; followed during the Middle - Upper Eocene by a free communication between the Mediterranean and Indopacific Bioprovinces, which permitted the migration of the subgenus Paracosta (Paracosta) to the east as far as Pakistan. In this transitional zone a brackish - littoral environment prevailed, reflected by the ostracode assemblages of the Mityaha Well-1 Section, i.e. Leptocythere, Loxoconcha, Paradoxostoma?, Pokornella, and Xestoleberis.

The Maastrichtian - Eocene of the Middle East has been divided into five Ostracod Biozones based on the subfamily Trachyleberidinae. One is of Maastrichtian age, one Palaeocene and three are of Eocene age. Three faunal breaks can be recognized, differing in duration and presence from place to place, and related to the cause of the tectonic movement (i.e. the Zagros Crush Zone) and the stable area (the Arabian Shield). The first faunal break is at the Maastrichtian - Palaeocene boundary, generally separating the Ostracod Biozone I & II; the second is local and only recognized in the Middle - Upper Palaeocene of Jordan; the third faunal break is present in Iraq at the Lower - Middle Eocene boundary, and separates the Ostracod Biozones III & IV.

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APPENDIX

APPENDIX

Preparation techniques for the S.E.M. examination of palaeontological and sedimentological material.

by

S.S.J. Al-Sheikhly and D.D.J. Antia

The scanning electron microscope (S.E.M.) is a very useful palaeontological and sedimentological tool, which can be used to aid palaeontological, diagenetic and sedimentological studies.

In this article the preparation techniques used by the authors for taxonomic, palaeontological, diagenetic and sedimentological studies are outlined, to assist future S.E.M. workers.

Methods

All samples were broken down using a jaw crusher to fragments less than 1 cm^3 and put in an appropriate preparation medium.

I Acetic acid preparations

(a) Used to extract non-carbonate material from calcareous sediments, e.g. fish scales, conodonts, phosphatic pebbles, etc.

(b) Place the sample into a 30% acetic acid solution (CH_3COOH) so that it is submerged and leave for 3 to 14 days in a fume cupboard. If a crust forms on the surface of the acid after a few days the solution needs to be replaced by fresh acid.

(c) Wash and sieve.

(d) If the sample is particularly clayey the sieved residue should be placed for a few hours in 30% hydrogen peroxide (H_2O_2) solution to clean it.

II Hydrogen peroxide preparations

(a) Used to extract carbonate material (e.g. ostracods, foraminifera etc.) from marls, limestones and clastics.

(b) Submerge about 200 gms of sample in 400 ml of 30% H_2O_2 solution, with 3-5 pellets of sodium hydroxide in a 1000 ml beaker. Shale will effervesce vigorously and may require a larger container or a smaller sample size (say 50 gms) to stop the sample bubbling out of the beaker. Leave hard material (e.g. limestones and sandstones) standing overnight and soft material (e.g. shales and muds) standing for 2-3 hours in a fume cupboard.

(c) Boil the sediment - H_2O_2 solution for about 3-4 hours if it is a hard rock. Alternatively if it is a soft sludge at this stage sieve the sample through a 65μ sieve to remove the clays. Then boil with a fresh 20% H_2O_2 solution for 1-2 hours. The boiling beakers should be periodically topped up with water.

(d) Wash and sieve.

III Paraffin method

(a) This method is used to extract delicate material from soft shaley often hydrocarbon rich sediments.

(b) Cover the sample in paraffin and leave to stand for 4 to 6 hours.

(c) Filter the sample to remove the paraffin for re-use.

(d) Wash the sample onto a 65μ sieve to remove the solid paraffin residue.

(e) Boil the sample in water in a fume cupboard for 30 to 60 minutes.

(f) Wash and sieve.

The processed residue is collected on a number of sieves (e.g. 65μ, 125μ , 250μ , and 1000μ sizes) and dried in an oven at 200°C. This residue is then picked under a binocular microscope. Residues off the -

(1) 65μ sieve contain chitinozoans, fish debris, shell debris, megaspores, foraminifera, juvenile ostracods, quartz grains etc.

(2) 125μ sieve as above, but with small adult ostracods, and fish scales.

(3) 250μ sieve. This is the best sample size for adult ostracods, foraminifera and mineral crystals.

(4) 1000μ sieve. Large ostracods, fish debris, foraminifera, bivalves, brachiopods etc.

If the specimens to be examined on the S.E.M. are not clean enough the following cleaning methods can be used.

I Dacon method

After the specimen has been soaked in Dacon overnight, any remaining dirt particles can be removed using a fine sable hair brush or a needle which consists of a thin tapering piano wire attached to a handle.

II Hydrogen peroxide method

After the specimen has been soaked in 20% H_2O_2 solution for 1-3 hours the remaining dirt particles are removed as above. The soaking duration is dependent on the strength of the specimen and the thickness of the dirt coating.

III Ultra sonic method

(a) Put the specimen in a small glass vial and fill with water.

(b) Set the ultra sonic instrument at 50-55,000 cycles per second. Immerse the vial for less than one second in the ultrasonic field. Repeat again if required. The specimen should be examined after each immersion. (Delicate specimens may be damaged by this cleaning method, similarly prolonged immersion may result in a recrystallisation of the specimen).

S.E.M. studies fall into three basic groups, viz. (1) taxonomic studies, (2) general studies, (3) statistical studies. Each study has its own mounting requirements. Taxonomic specimens generally require specific orientations of specimens, while in general and statistical studies orientation is less important.

Specimens have to be mounted (glued onto) an S.E.M. stub (a 1 cm diameter holder) before they can be viewed under the S.E.M. The advantages and disadvantages of a variety of mounting mediums are discussed below.

I. Pritt

Pritt is a cheap quick drying solid adhesive made by Henkel Ltd. of West Germany and is sold in most newsagents. It is the best S.E.M. mounting adhesive the authors have found for specimens less than 2 mm in length. To use (a) smear the stud with a thin film of adhesive (b) put the specimen on the adhesive using a damp brush under a binocular microscope within fifteen mins. (c) dry the stub under a desk lamp or any other heat source for 30 minutes. (d) scratch the surface of the glue to improve the surface contact between the stub and coated specimens (e) coat the specimens (f) examine specimens under the S.E.M. (g) to remove a specimen from the stub - (1) immerse it in a drop of water under the binocular microscope (2) and remove it from the stub using a wet brush.

II. Kaiser's glycerol gelatin for microscopy.

Like Pritt this adhesive allows easy removal of specimens from the stubs. However, the preparation of stubs using this mounting medium is more complex. To use -

(a) take some developed exposed photographic paper and stick it to the stub using double sided sellotape. The stub should completely overlap the photographic paper.

(b) paint the edge of the photographic paper and the adjacent exposed stub with silver paint, to improve conductivity between the stub and coated specimens.

(c) smear the photographic paper with glycerol gelatin.

(d) mount the specimen on the glycerol using a damp brush within a few days.

(e) dry under a source of heat for 30 minutes.

(f) coat and examine under the S.E.M.

(g) to remove the specimens use a drop of water and a brush.

This method is for specimens less than 2 mm in length.

III. Kodaflat

This adhesive is manufactured by Kodak and is useful for mounting specimens less than 2 mm in length.

To use -

(a) Smear the stub with a thin layer of Kodaflat.

(b) Put the specimen on the Kodaflat using a damp brush under a binocular microscope within about 10 minutes.

(c) Leave the stub to dry for 12 to 24 hours.

(d) Coat and examine.

(e) To remove the specimen from the stub use acetone to dissolve the Kodaflat. Then soak the removed specimen in a container of acetone for 5 minutes to remove any remaining Kodaflat.

IV. Durafix

This adhesive is manufactured by Rawlplug Co. Ltd. a subsidiary of Burmah Company. Its main use is for mounting specimens larger than 0.5 cm.

To use -

(a) Put a small drop of durafix on the stub.

(b) Put the specimen on the durafix under binocular microscope within 15 seconds of applying the durafix to the stub.

(c) Leave the stub to dry for 12 to 24 hours.

(d) Coat and examine.

(e) To remove the specimen use the same procedure as for Kodaflat.

V. Silver dug.

This adhesive is supplied by Cambridge instruments. Its main use is for mounting specimens larger than 0.5 cm. It provides better results under the S.E.M. than durafix. Its method for use is the same as for durafix. Specimens can be removed from the stubs using glycerine and a needle, or by immersing the whole stub in acetone for five minutes to dissolve the silver dug.

After a specimen has been mounted in a stub it should be coated with gold or aluminium in a coating machine. The thickness of the coatings required depends on the material but as a general rule, fossils and grains require a 500 Å thickness coating while sediment requires a 750 Å coating.

A specimen removed from an S.E.M. stub should be soaked in 20% H_2O_2 for up to 2 hours (dependent on the condition of the specimen) to clean it.

Of the techniques which are outlined, acetic acid extraction is recommended for phosphatic fossils while H_2O_2 extraction is recommended for carbonate fossils. The paraffin extraction technique is regarded as being too dangerous for common laboratory usage.

The ultrasonic cleaning technique is regarded as being likely to damage specimens. Of the mounting mediums, Pritt is highly recommended since it is simple to use, quick drying and cheap. It also has the advantage in taxonomic photographic work of producing a good readily obtainable black background. Silver dug is beyond doubt the best mounting medium we have used for large specimens.

There are other extractions and mounting techniques which we have not used. These include the use of dilute hydrochloric acid to remove foraminifera from limestone (Conkin et al. 1968) and the use of an ultrasonic method to remove ostracods from chert (Tillman & Murphy, 1973).

For further details of palaeontological techniques we recommend Kummel & Raup (1965).

The uses for which we have used the S.E.M. are -

(1) Taxonomical work on ostracods.

(2) The development of a weathering scale on fish debris.

(3) A study of abrasive features on quartz grains and fish debris.

(4) A study of sediment and grain diagenesis.

(5) An examination of microborings.

Other uses for which the S.E.M. can be used include a study of microtrace fossils, other microfossil groups, progressive destruction of grains, environmental interpretations of sediment based on abrasive and weathering features, metamorphic cleavage studies,

metasomatic studies, weathering and crystallisation studies of igneous and metamorphic rocks.

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Kummel, B. and Raup, D., 1965; Handbook of Palaeontological techniques, Freeman & Co., 852 p.

Tillman, J.R. and Murphy, S.E., 1978; Ostracodes of the Superfamily Hollinacea from Middle Dovonian rocks of Central Ohio, J. Paleontology, v.52, pp. 411-439.

PLATES

PLATE - 1

Acanthocythereis (Acanthocythereis) cornioculus sp. nov.

Fig. 1 : OS 11194 (Holotype); female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X45.

Fig. 2 : OS 11195 (Paratype); male, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X45.

Fig. 3 : OS 11200 (Paratype); male, stereoscopic paired photographs, left valve; Chemchemal Well-2, Iraq, sample 119, drilling depth 5555'-5560'; Maastrichtian?; X45.

Fig. 4 : OS 11194 (Holotype); female, dorsal view; X45.

Fig. 5 : OS 11198 (Paratype); female?, left valve, internal view; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X45.

Fig. 7 : OS 11199 (Paratype); stereoscopic paired photographs, muscle scars, left valve; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X200.

Fig. 8 : OS 11195 (Paratype); male, ventral view; X45.

Acanthocythereis (Canthylocythereis) quinquespinosa sp. nov.

Fig. 6 : OS 11208 (Holotype); female, stereoscopic paired photographs, left valve; Tell Burma, Jordan, sample BMJ 843; L. Palaeocene (U. Danian); X65.

Fig. 9 : OS 11211 (Paratype); female, left valve; Tell-Burma, Jordan, sample BMJ 849; L. Palaeocene (U. Danian); X65.

Fig. 10: OS 11208 (Holotype); female, dorsal view; X65.

Fig. 11: OS 11216 (Paratype); male, right valve; Tell-Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X65.

PLATE _1

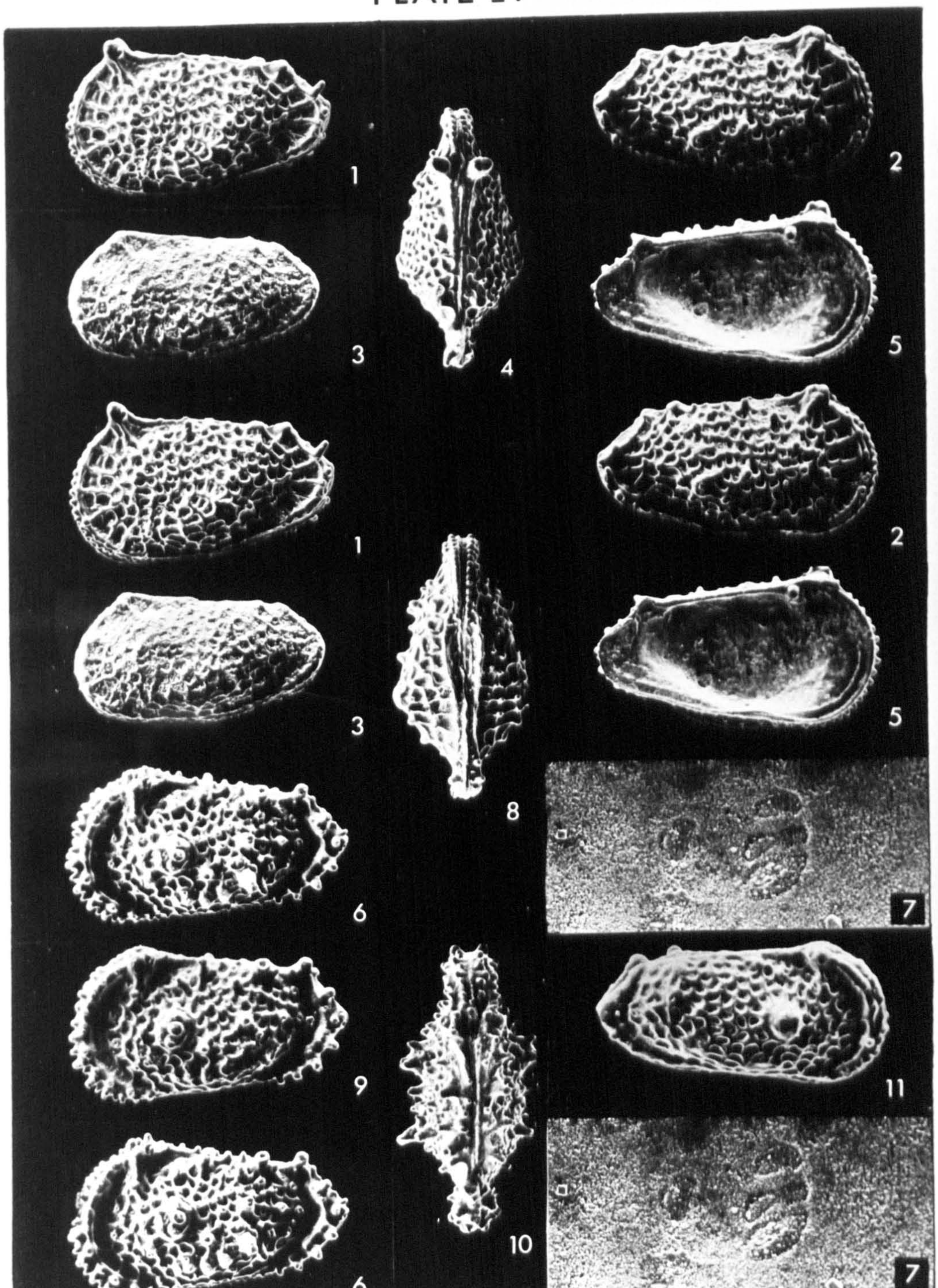


PLATE - 2

Acanthocythereis (Canthylocythereis) quinquespinosa sp. nov.

Fig. 1 : OS 11217 (Paratype); female, stereoscopic paired photographs, left valve; Tell Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X65.

Fig. 2 : OS 11209 (Paratype); male, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 3 : OS 11213 (Paratype); male, stereoscopic paired photographs, right valve, internal view; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X65.

Fig. 4 : OS 11210 (Paratype); female, ventral view; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 5 : OS 11213 (Paratype); male, stereoscopic paired photographs, muscle scars, right valve; X250.

Acanthocythereis (Canthylocythereis) taqiyeansis sp. nov.

Fig. 6 : OS 11224 (Paratype); male, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 850; L.Palaeocene (U. Danian); X55.

Fig. 7 : OS 11221 (Holotype); female, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X55.

Fig. 8 : OS 11222 (Paratype); male, ventral view; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X55.

Fig. 9 : OS 11226 (Paratype); female, left valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X55.

Fig. 10: OS 11221 (Holotype); female, dorsal view; X55.

Fig. 11: OS 11222 (Paratype); male, right valve; X55.

PLATE - 2

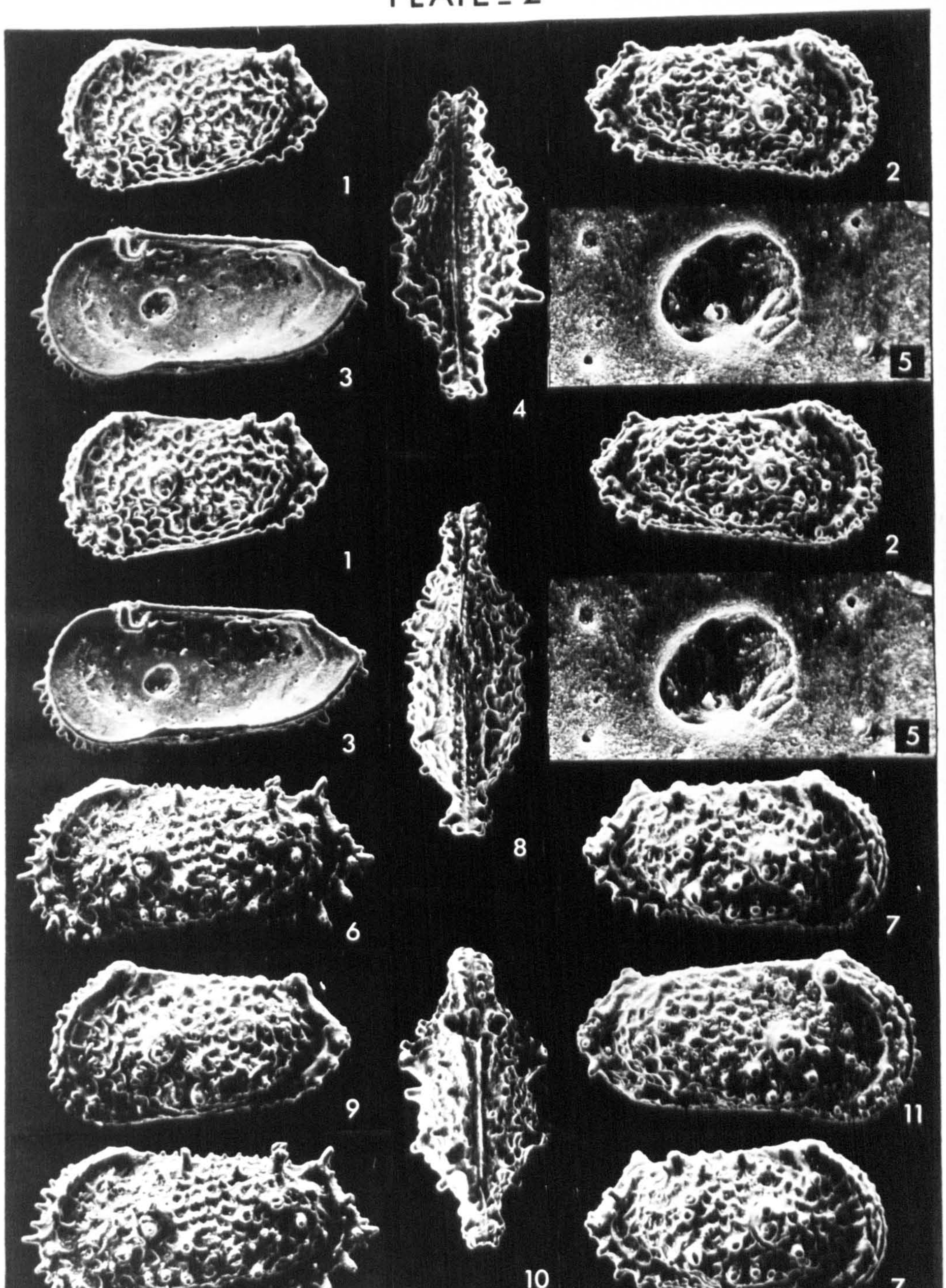


PLATE - 3

Acanthocythereis (Canthylocythereis) taqiyaensis sp. nov.

Fig. 1 : OS 11223 (Paratype); female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X55.

Fig. 3 : OS 11225 (Paratype); female, stereoscopic paired photographs, right valve, internal view; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X55.

Fig. 6 : OS 11225 (Paratype); female, stereoscopic paired photographs, muscle scars, right valve; X200.

Fig. 9 : OS 11225 (Paratype); hinge, right valve; X90.

Acanthocythereis (Canthylocythereis) alacer (M.S.) Al-Furaih, 1976.

Fig. 2 : OS 11234; female, stereoscopic paired photographs, left valve; Chemchemal Well-2, Iraq, sample 53, drilling depth 3124' - 3142'; Palaeocene/L. Eocene; X80.

Fig. 4 : OS 11237; female, dorsal view; Chemchemal Well-2, Iraq, sample 53, drilling depth 3124'- 3142'; Palaeocene/L. Eocene; X80.

Fig. 5 : OS 11235; male, stereoscopic paired photographs, right valve; Chemchemal Well-2, Iraq, sample 53, drilling depth 3124'-3142'; Palaeocene/L. Eocene; X80.

Fig. 8 : OS 11235; male, ventral view; X80.

Fig. 11: OS 11236; female, right valve; Chemchemal Well-2, Iraq, sample 53, drilling depth 3124'-3142'; Palaeocene/L. Eocene; X80.

Acanthocythereis (Canthylocythereis) bolispinosa sp. nov.

Fig. 7 : OS 11231 (Holotype); female?, stereoscopic paired photographs, left valve; Anah Well-2, Iraq, sample 15, drilling depth 2000'-2016'; Maastrichtian; X80.

Fig. 10: OS 11231 (Holotype); female?; dorsal view; X80.

PLATE - 3

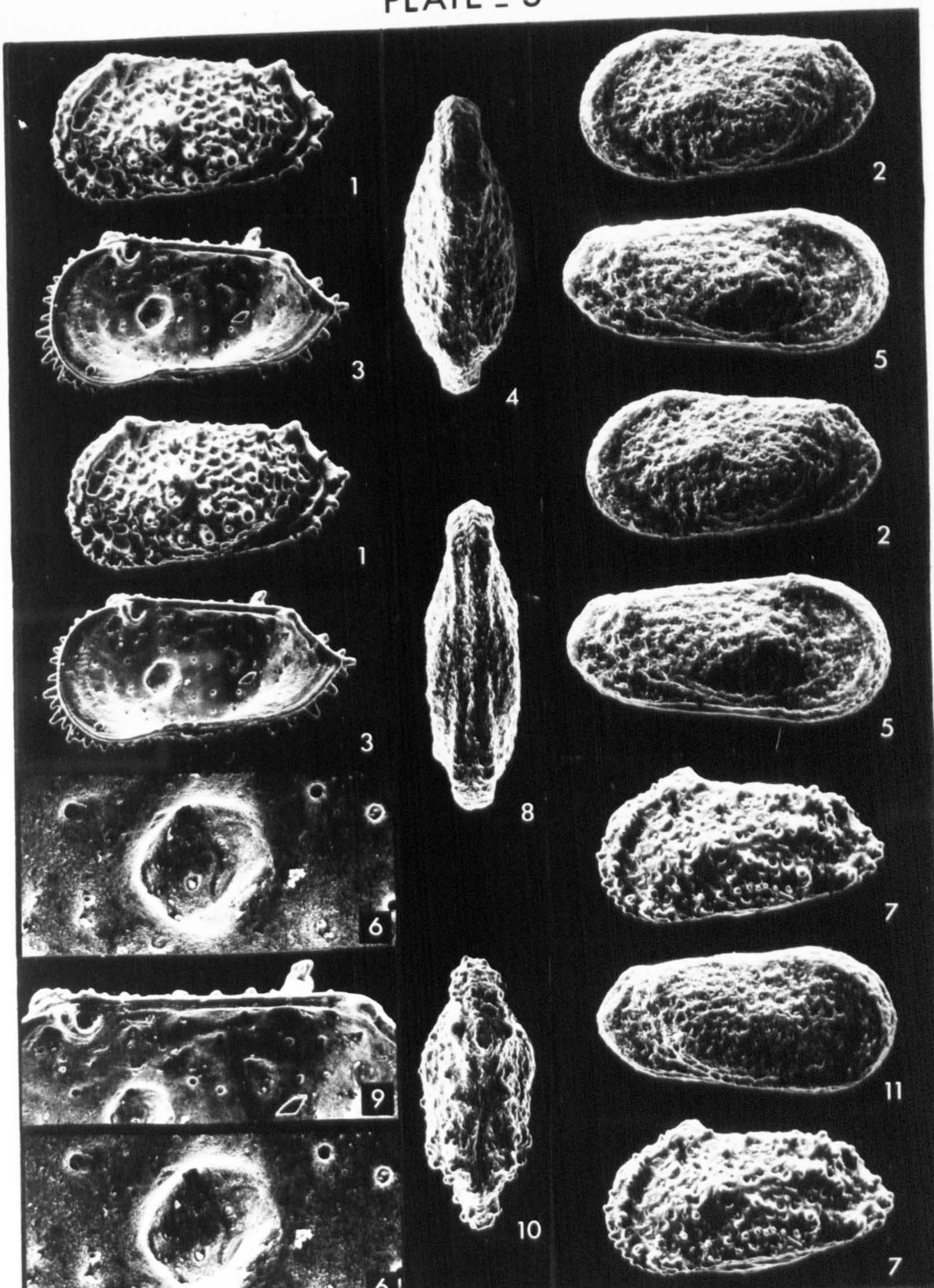


PLATE - 4

Acanthocythereis (Canthylocythereis) bolispinosa sp. nov.

Fig. 1 : OS 11232 (Paratype); female ?, stereoscopic paired photographs, right valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X80.

Fig. 2 : OS 11233 (Paratype); male?, stereoscopic paired photographs, left valve, internal view (broken); Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X80.

Fig. 4 : OS 11232 (Paratype); female?, ventral view; X80.

Acanthocythereis ? sp.

Fig. 3 : OS 11204; juvenile, stereoscopic paired photographs, left valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X80.

Fig. 5 : OS 11205; juvenile, stereoscopic paired photographs, right valve, internal view; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X80.

Fig. 11: OS 11206; juvenile, left valve, internal view; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X 80.

Cristaeleboris arabii Bassiouni, 1970

Fig. 6 : OS 11459; female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 7 : OS 11460; male, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 8 : OS 11461; female, dorsal view; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 9 : OS 11456; female, left valve; Tell-Burma, Jordan, sample BMJ 849; L. Palaeocene (U. Danian); X65.

Fig. 10: OS 11462; male, ventral view; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

PLATE - 4

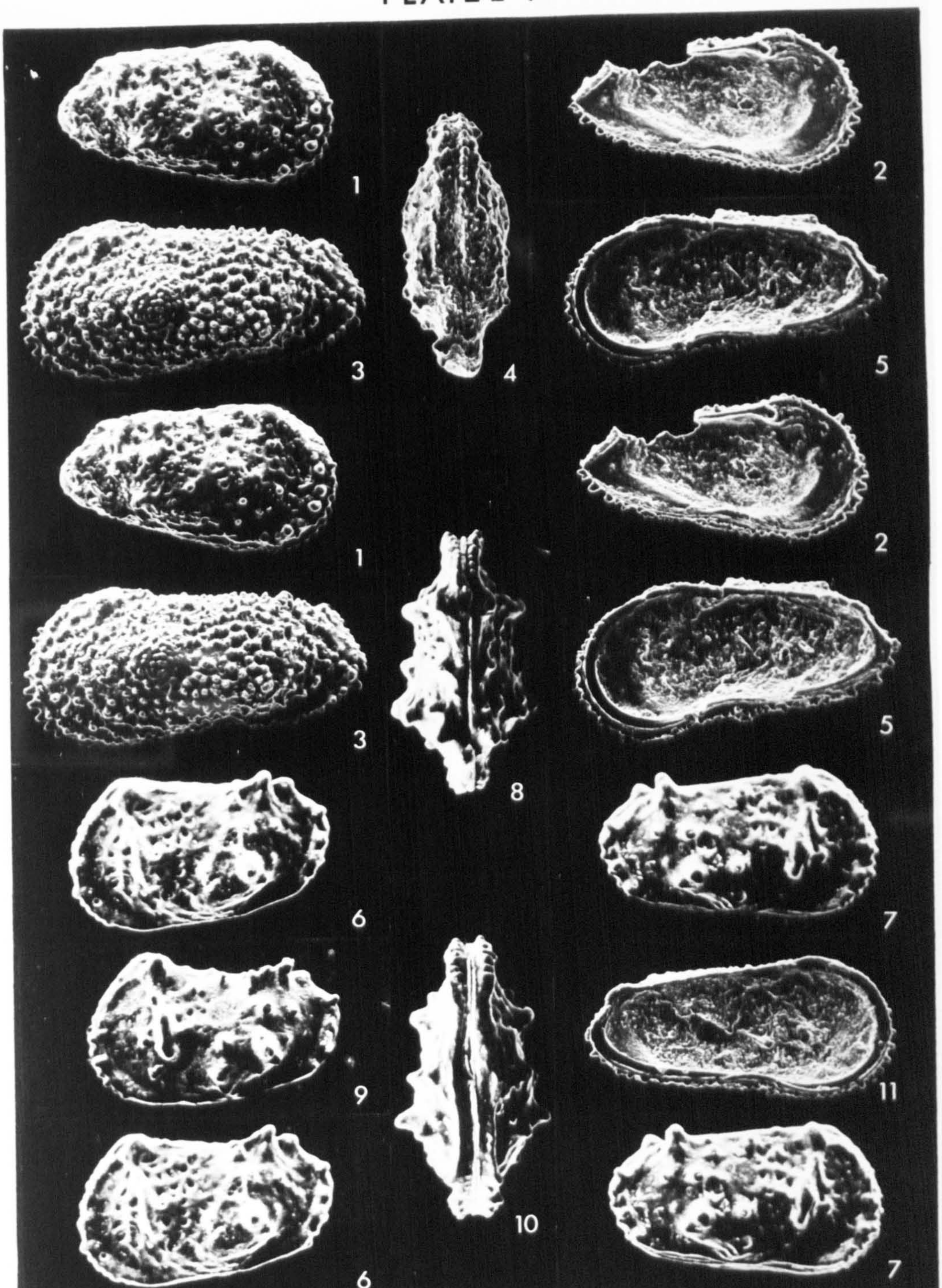


PLATE - 5

Cristaeloboris arabii Bassiouni, 1970

Fig. 1 : OS 11457; male, stereoscopic paired photographs, left valve, internal view; Tell-Burma, Jordan, sample BMJ 849; L. Palaeocene (U. Danian); X65.

Fig. 3 : OS 11453; female, stereoscopic paired photographs, right valve, internal view; Tell-Burma, Jordan, sample BMJ 849; L. Palaeocene (U. Danian); X65.

Fig. 6 : OS 11457; male, stereoscopic paired photographs, muscle scars, left valve; X350.

Fig. 9 : OS 11458; female, hinge, right valve; X100.

Cristaeleberis rotundonodosa Bassiouni, 1970.

Fig. 2 : TKH 11768 (Topotype); female, stereoscopic paired photographs, left valve; Yarmuk, Jordan, sample 40825; M. Palaeocene; X70.

Fig. 4 : TKH 11770 (Topotype); female, dorsal view; Yarmuk, Jordan, sample 40825; M. Palaeocene; X70.

Fig. 5 : TKH 11769 (Topotype); male, stereoscopic paired photographs, right valve; Yarmuk, Jordan, sample 40825; M. Palaeocene; X70.

Fig. 8 : TKH 11771 (Topotype); male, ventral view; Yarmuk, Jordan, sample 40825; M. Palaeocene; X70.

Fig. 11: TKH 11768 (Topotype); selvo-type pore canal; X3250.

Cristaeloberis fornicata Bassiouni, 1970.

Fig. 7 : OS 11469; male, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 73; Maastrichtian; X65.

Fig. 10: OS 11467; female, dorsal view; Tell-Burma, Jordan, sample BMJ 66; Maastrichtian; X65.

PLATE - 5

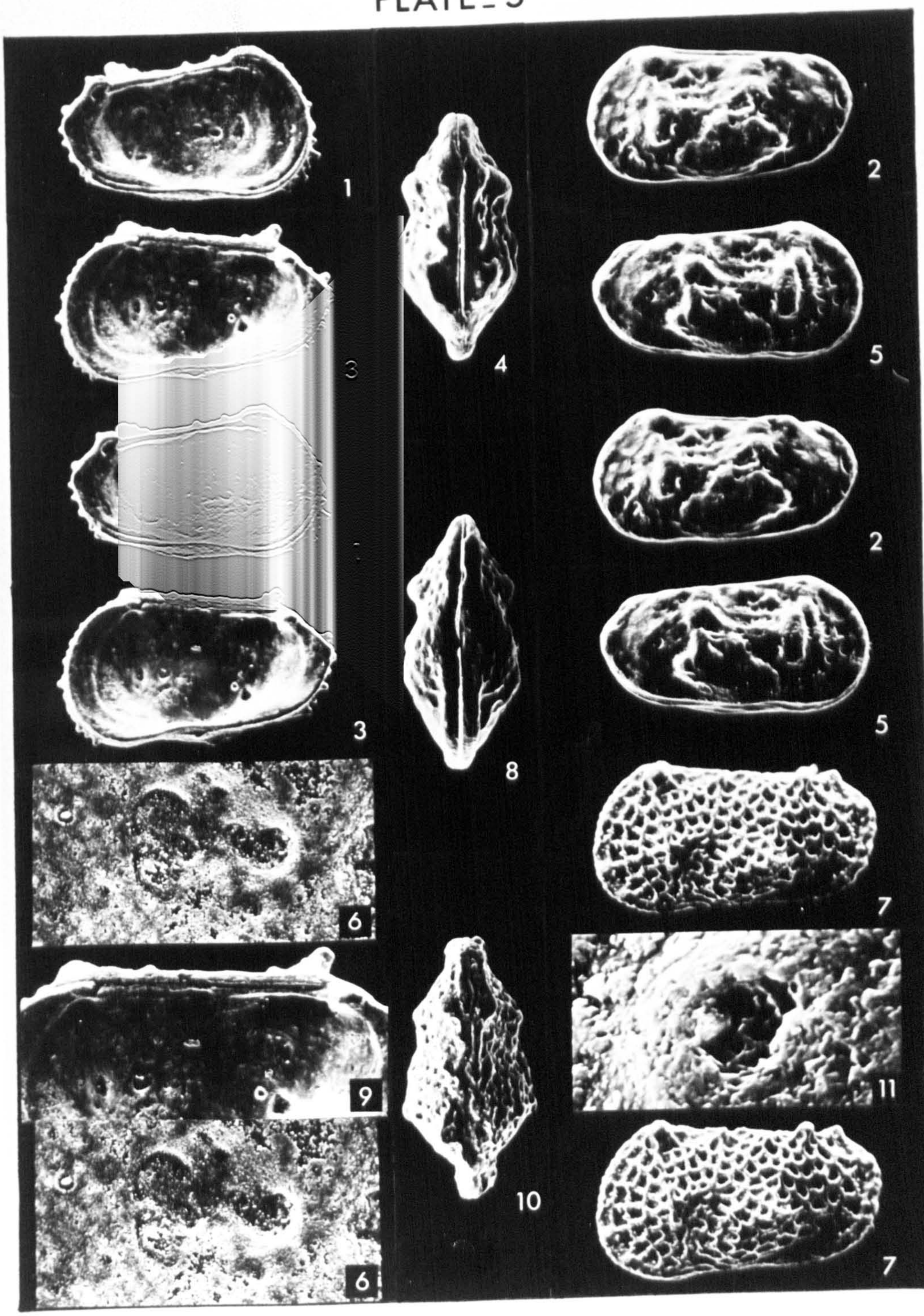


PLATE - 6

Cristaeloboris fornicata Bassiouni, 1970.

Fig. 1 : OS 11465; female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 66; Maastrichtian; X65.

Fig. 3 : OS 11466; male, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 66; Maastrichtian; X65.

Fig. 4 : OS 11468; female, ventral view; Tell-Burma, Jordan, sample BMJ 66; Maastrichtian; X65.

Cristaeloboris reticulata Bassiouni, 1970.

Fig. 2 : OS 11470; female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X65.

Fig. 5 : OS 11472; male, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X65.

Fig. 6 : OS 11475; female, stereoscopic paired photographs, right valve, internal view; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X65.

Fig. 7 : OS 11475; female, stereoscopic paired photographs, hinge, right valve; X140.

Fig. 8 : OS 11473; female, dorsal view, Tell-Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X65.

Fig. 9 : OS 11476; female, left valve; internal view; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X65.

Fig. 10: OS 11474; male, ventral view; Tell-Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X65.

Fig. 11: OS 11476; female, hinge, left valve; X140.

PLATE - 6

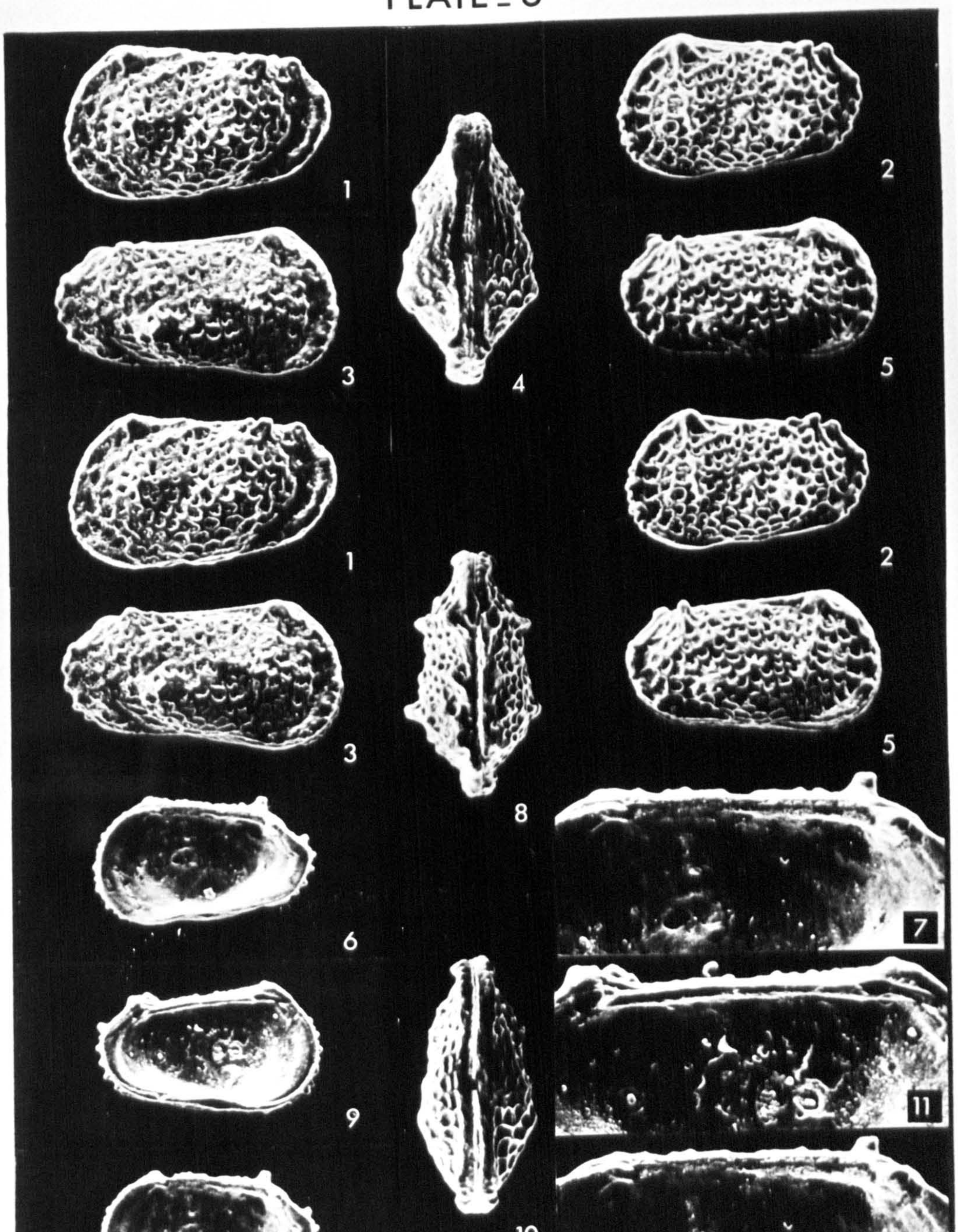


PLATE - 7

Cristaeloberis reticulata Bassiouni, 1970.

Fig. 1 : OS 11471; female, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X65.

Fig. 3 : OS 11477; stereoscopic paired photographs, muscle scars, left valve; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X350.

Cythereis ? ashurbanipali sp. nov.

Fig. 2 : OS 11435 (Holotype); female, stereoscopic paired photographs, left valve; Makhul Well-2, Iraq, sample 31, drilling depth 1475' - 1480'; Maastrichtian; X60.

Fig. 4 : OS 11438 (Paratype); female, dorsal view; Makhul Well-2, Iraq, sample 36, drilling depth 1540' - 1545'; Maastrichtian; X60.

Fig. 5 : OS 11436 (Paratype); male, stereoscopic paired photographs, right valve; Makhul Well-2, Iraq, sample 31, drilling depth 1475' - 1480'; Maastrichtian; X60.

Fig. 6 : OS 11442 (Paratype); male, stereoscopic paired photographs, right valve; Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X60.

Fig. 7 : OS 11440 (Paratype); female, stereoscopic paired photographs, right valve; Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X60.

Fig. 8 : OS 11437 (Paratype); female, ventral view; Makhul Well-2, Iraq, sample 32, drilling depth 1485' - 1490'; Maastrichtian; X60.

Fig. 9 : OS 11441 (Paratype); female, left valve; Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X60.

Fig. 10: OS 11439 (Paratype); male, ventral view; Makhul Well-2, Iraq, sample 36, drilling depth 1540' - 1545'; Maastrichtian; X60.

Fig. 11: OS 11436 (Paratype); surface ornamentation; X500.

PLATE_7

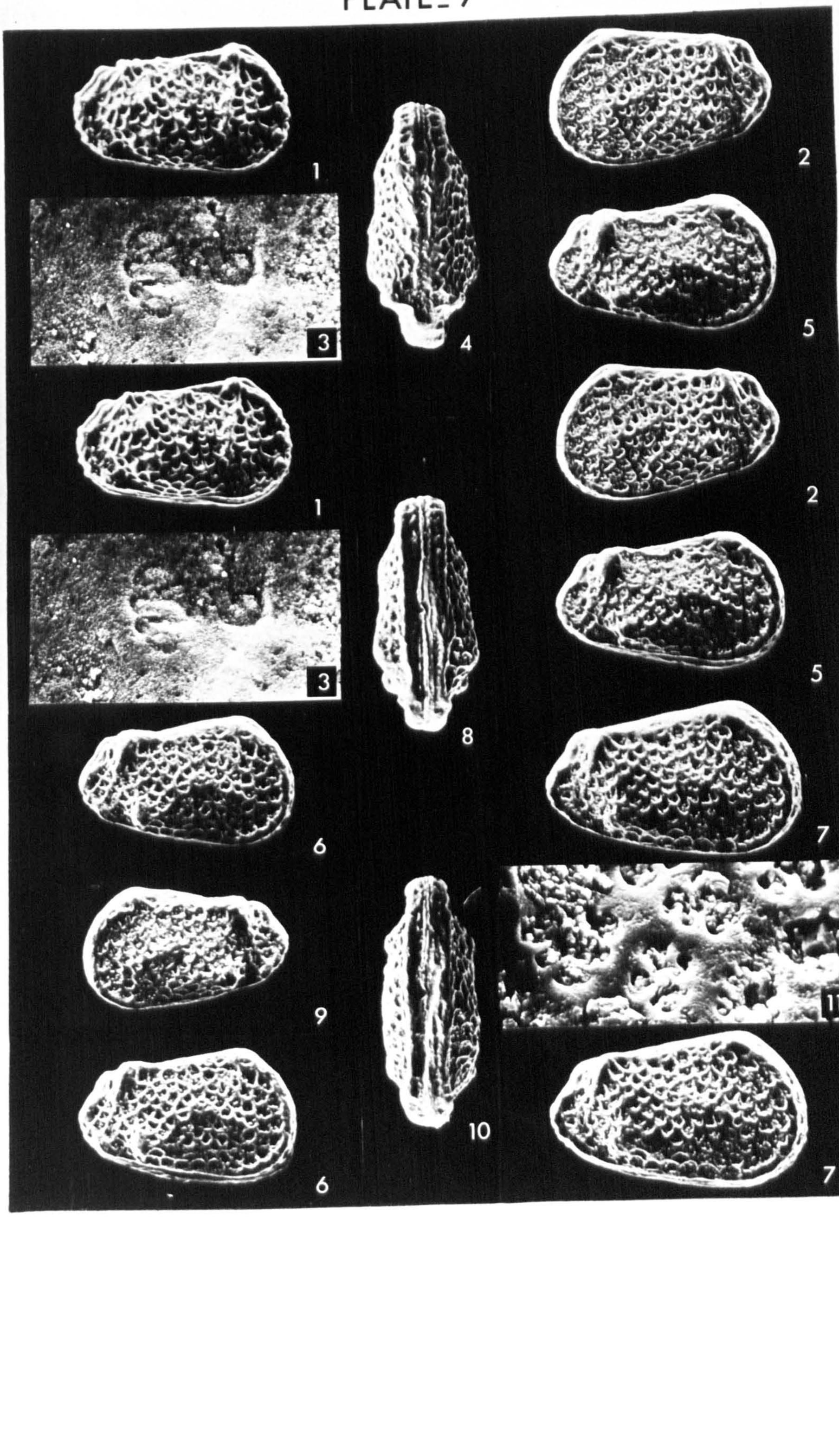


PLATE - 8

Cytherois esarhaddoni sp. nov.

Fig. 1 : OS 11449 (Holotype); female, stereoscopic paired photographs, right valve; Makhul Well-2, Iraq, sample 43, drilling depth 1645' - 1650'; Maastrichtian; X50.

Fig. 3 : OS 11450 (Paratype); male, stereoscopic paired photographs, left valve; Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X50.

Fig. 4 : OS 11449 (Holotype); female, dorsal view; X50.

Fig. 6 : OS 11451 (Paratype); male ?, stereoscopic paired photographs, right valve, internal view (broken); Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X50.

Fig. 8 : OS 11449 (Holotype); female, ventral view; X50.

Fig. 9 : OS 11451 (Paratype); male ?, anterior hinge tooth, right valve; X175.

Fig. 10: OS 11450 (Paratype); male, dorsal view; X50.

Cytherois sennacheribi sp. nov.

Fig. 2 : OS 11454 (Holotype); male ?, stereoscopic paired photographs, left valve; Makhul Well-2, Iraq, sample 34, drilling depth 1505' - 1510'; Maastrichtian; X45.

Fig. 5 : OS 11454 (Holotype); male ?, stereoscopic paired photographs, right valve; X45.

Cytherois sp. B

Fig. 7 : OS 11453; stereoscopic paired photographs, right valve; Makhul Well-2, Iraq, sample 30, drilling depth 1455' - 1460'; Maastrichtian; X45.

Fig. 11: OS 11453; left valve; X45.

PLATE_8

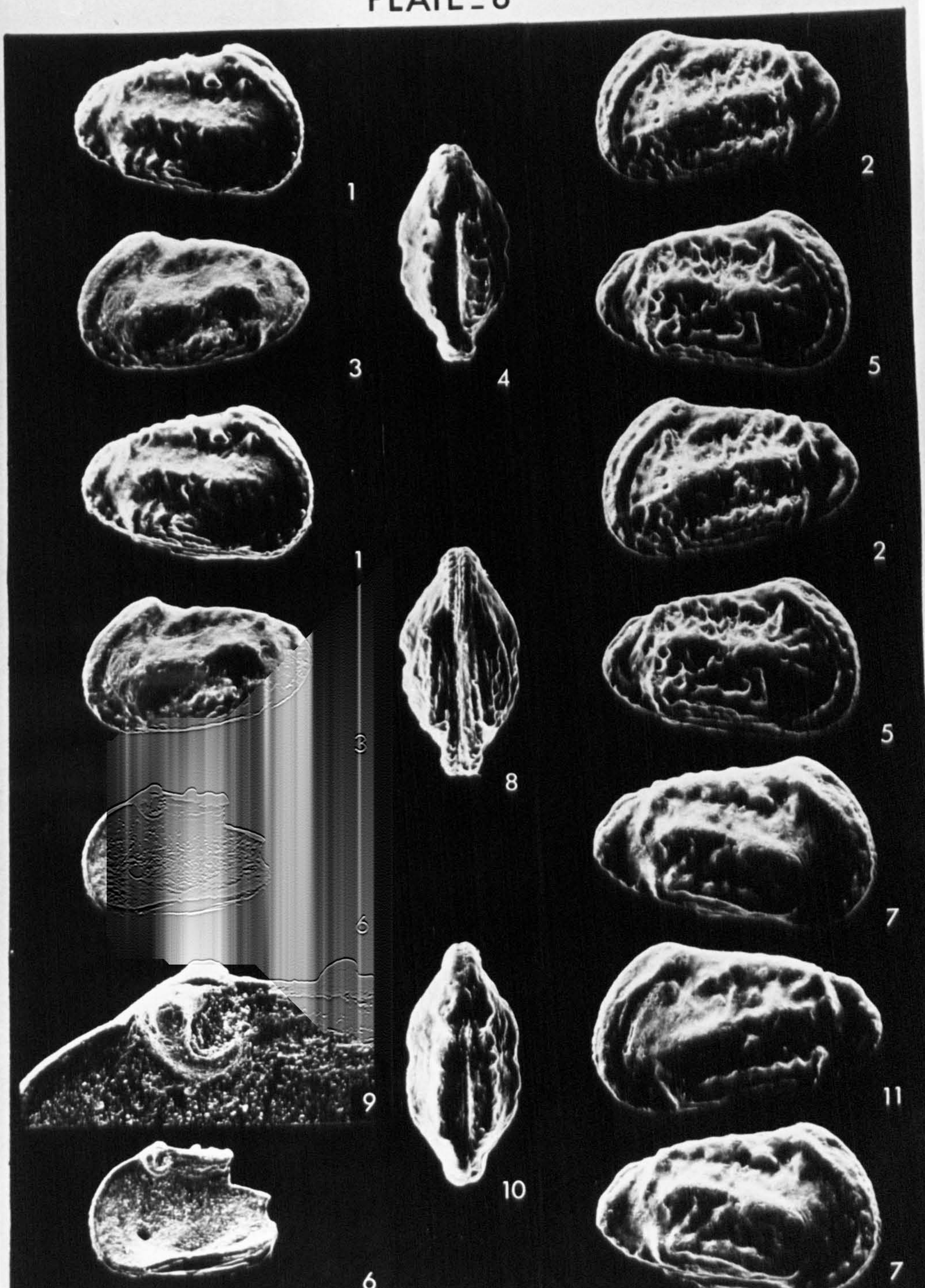


PLATE - 9

Cytherois sennacheribi sp. nov.

Fig. 1 : OS 11455 (Paratype); female?, dorsal view; Makhul Well-2, Iraq, sample 39, drilling depth 1570' - 1575'; Maastrichtian; X45.

Fig. 2 : OS 11454 (Holotype); male?, ventral view; Makhul Well-2, Iraq, sample 34, drilling depth 1505' - 1510'; Maastrichtian; X45.

Cythoreis sp. A

Fig. 3 : OS 11434; stereoscopic paired photographs, left valve; Makhul Well-2, Iraq, sample 28, drilling depth 1435' - 1440'; Maastrichtian; X60.

Fig. 4 : OS 11434; dorsal view; X60.

Fig. 5 : OS 11434; right valve; X60.

Fig. 8 : OS 11434; ventral view; X60.

Cythoreis sp. B

Fig. 6 : OS 11453; dorsal view; Makhul Well-2, Iraq, sample 30, drilling depth 1455' - 1460'; Maastrichtian; X45.

Fig. 7 : OS 11453; ventral view; X45.

Dumontina assyria sp. nov.

Fig. 9 : OS 11430 (Holotype); male, stereoscopic paired photographs, right valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X80.

Fig. 10 : OS 11430 (Holotype); male, ventral view; X30.

Fig. 11 : OS 11433 (Paratype); stereoscopic paired photographs, left valve, internal view (broken); Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X30.

Fig. 12 : OS 11431 (Paratype); female, stereoscopic paired photographs, left valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X80.

Fig. 13 : OS 11433 (Paratype); hinge, left valve (broken); X110.

Fig. 14 : OS 11432 (Paratype); female, dorsal view; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X80.

PLATE_9

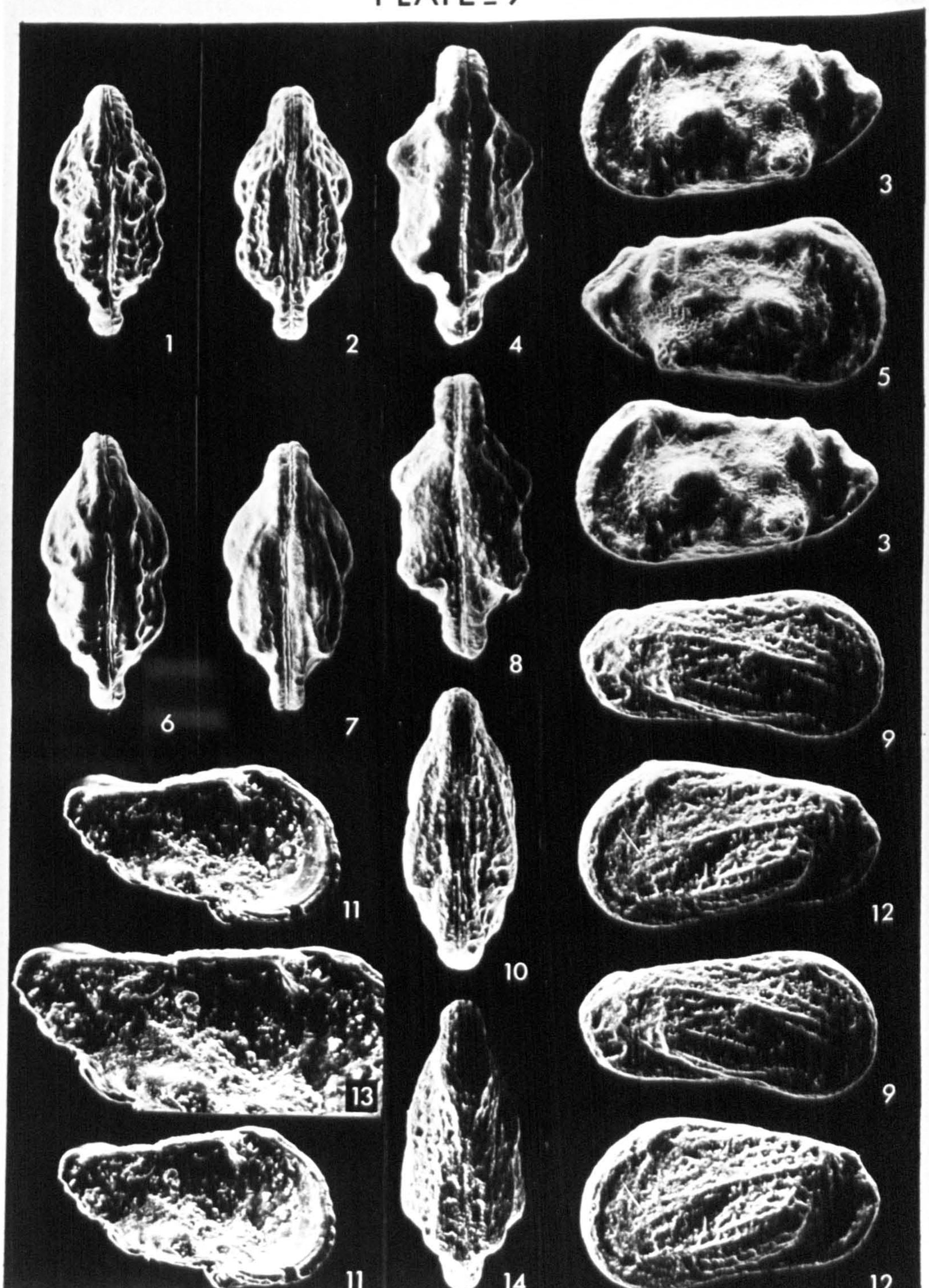


PLATE - 10

Occultocytherels babylonia sp. nov.

Fig. 1 : OS 11243 (Holotype); stereoscopic paired photographs, right valve; Jabel Sinjar Section, Iraq, sample S62; M. Eocene; X90.

Fig. 3 : OS 11245 (Paratype); stereoscopic paired photographs, left valve; Jabel Sinjar Section, Iraq, sample S45; Palaeocene?/L. Eocene; X90.

Fig. 4 : OS 11244 (Paratype); dorsal view; Jabel Sinjar Section, Iraq, sample S45; Palaeocene?/L. Eocene; X90.

Fig. 6 : OS 11245 (Paratype); ventral view; X90.

Fig. 7 : OS 11244 (Paratype); right valve; X90.

Occultocytherels elongata sp. nov.

Fig. 2 : OS 11247 (Holotype); female?, stereoscopic paired photographs, left valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 5 : OS 11248 (Paratype); male?, stereoscopic paired photographs, right valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 10 ; OS 11247 (Holotype); female?, dorsal view; X90.

Fig. 11 : OS 11248 (Paratype); male?, ventral view; X90.

Occultocytherels fordus sp. nov.

Fig. 8 : OS 11252 (Holotype); male, dorsal view; Jabel Sinjar Section, Iraq, sample S83; M./U. Eocene; X90.

Fig. 9 : OS 11252 (Holotype); male, stereoscopic paired photographs, left valve; X90.

Fig. 12 : OS 11252 (Holotype); male, ventral view; X90.

Fig. 13 : OS 11253 (Paratype); female, right valve; Jabel Sinjar Section, Iraq, sample S45; Palaeocene?/L. Eocene; X90.

PLATE - 10

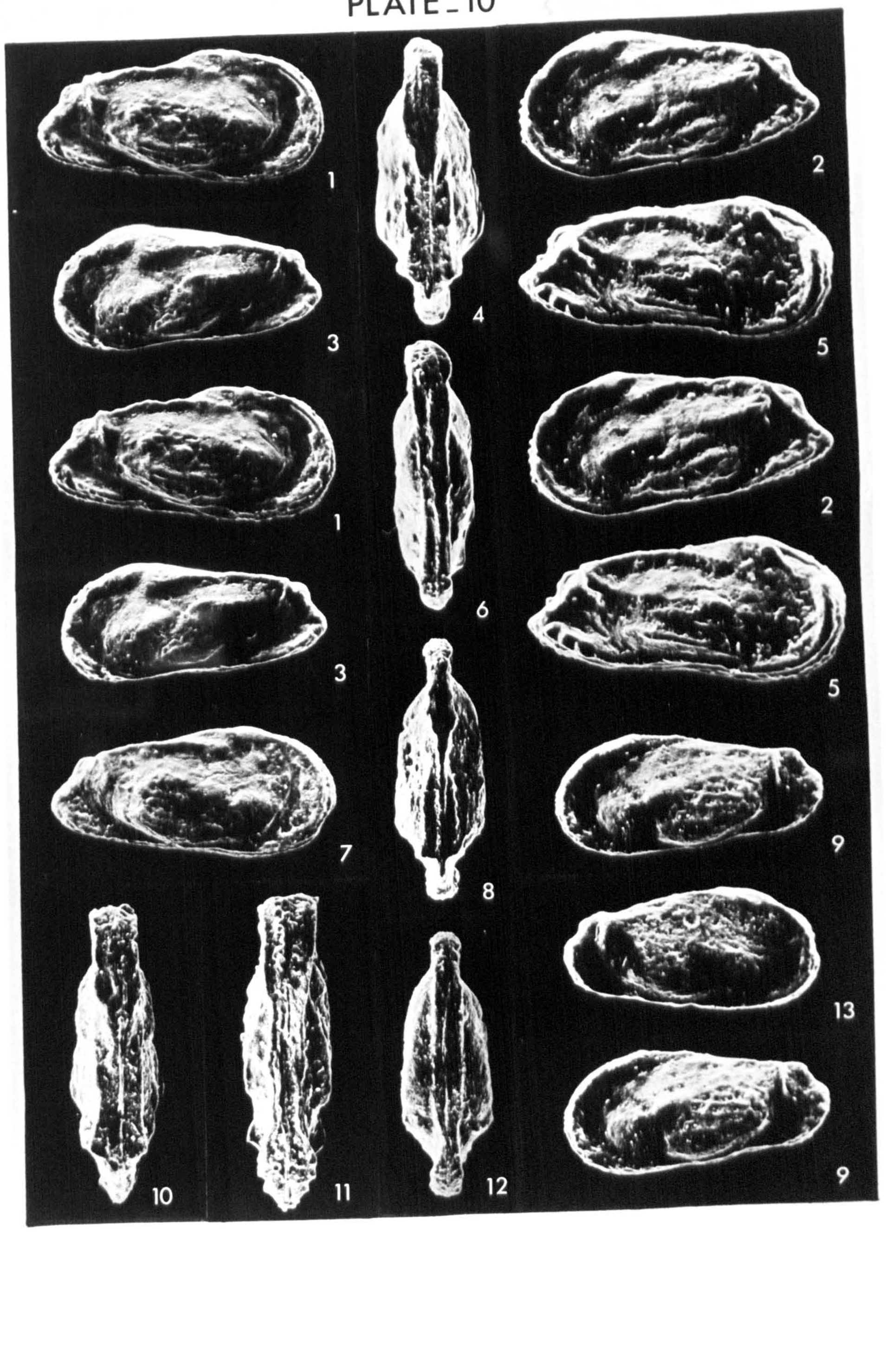


PLATE - 11

Occultocytherois fordus sp. nov.

Fig. 1 : OS 11256 (Paratype); female, stereoscopic paired photographs, right valve; Jabal Sinjar Section, Iraq, sample S87; U. Eocene; X90.

Occultocytherois harthaensis sp. nov.

Fig. 3 : OS 11259 (Paratype); male, right valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 4 : OS 11257 (Holotype); female, dorsal view; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 6 : OS 11257 (Holotype); female, stereoscopic paired photographs, left valve; X90.

Fig. 7 : OS 11258 (Paratype); male, stereoscopic paired photographs, right valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 8 : OS 11258 (Paratype); male, ventral view; X90.

Fig. 10 : OS 11259 (Paratype); male, ventral view; X90.

Occultocytherois hatraensis sp. nov.

Fig. 2 : OS 11261 (Holotype); female, stereoscopic paired photographs, left valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 5 : OS 11262 (Paratype); female, stereoscopic paired photographs, right valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 9 : OS 11263 (Paratype); female, right valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 11 : OS 11261 (Holotype); female, dorsal view; X90.

Fig. 12 : OS 11262 (Paratype); female, ventral view; X90.

PLATE _11

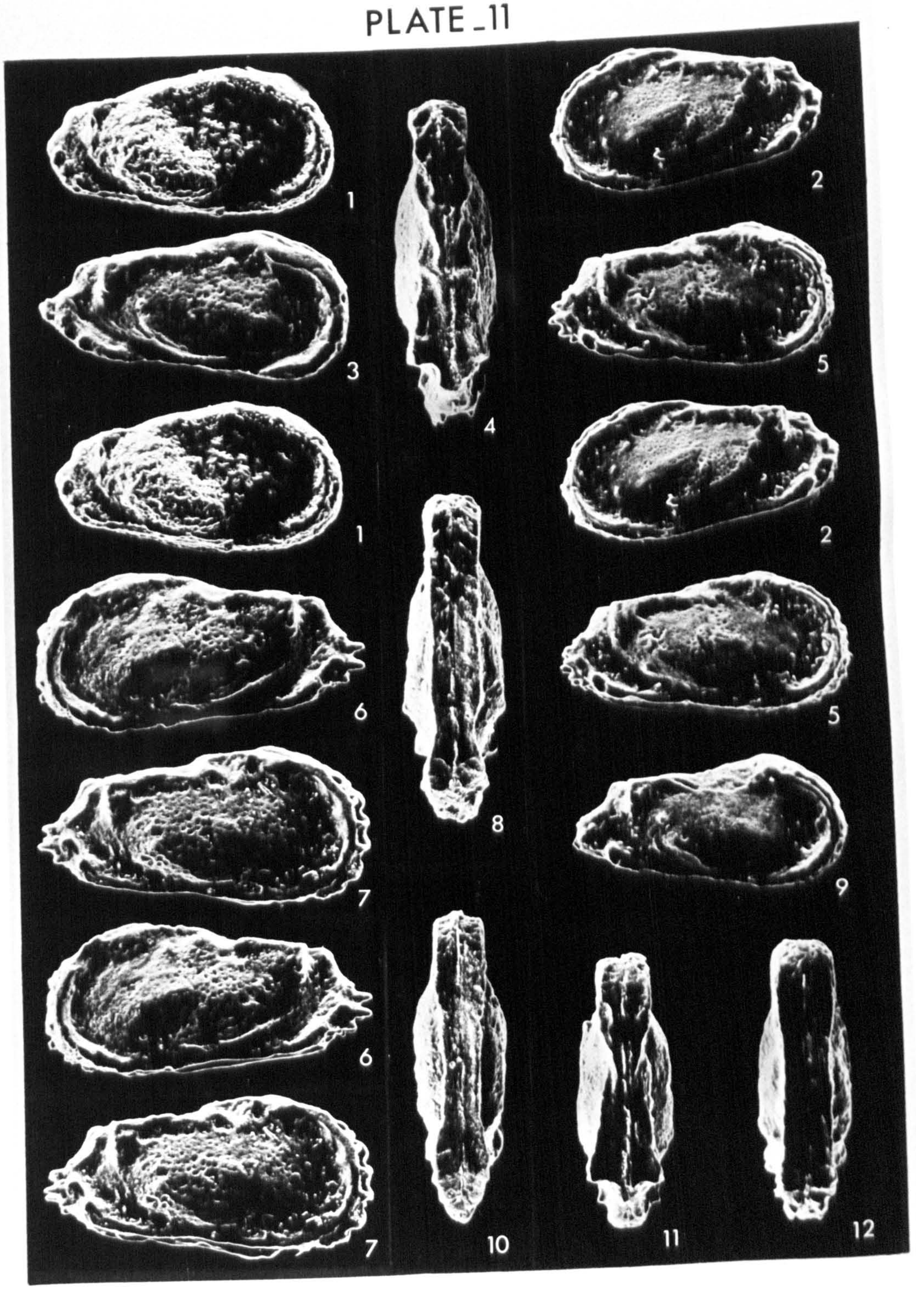


PLATE - 12

Occultocythereis ishtaria sp. nov.

Fig. 1 : OS 11265 (Holotype); female, stereoscopic paired photographs, right valve; Jabel Sinjar Section, Iraq, sample S82; M. Eocene; X90.

Fig. 3 : OS 11266 (Paratype); female, stereoscopic paired photographs, left valve (broken); Jabel Sinjar Section, Iraq, sample S83; M./U. Eocene; X90.

Fig. 4 : OS 11266 (Paratype); female, dorsal view; X90.

Fig. 6 : OS 11265 (Holotype); female, ventral view; X90.

Fig. 7 : OS 11267 (Paratype); male?, right valve; Jabel Sinjar Section, Iraq, sample S83; M./U. Eocene; X90.

Occultocythereis makhulaensis sp. nov.

Fig. 2 : OS 11269 (Holotype); stereoscopic paired photographs, left valve; Makhul Well-2, Iraq, sample 40, drilling depth 1605' - 1610'; Maastrichtian; X90.

Fig. 5 : OS 11270 (Paratype); right valve; Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X90.

Fig. 8 : OS 11270 (Paratype); dorsal view; X90.

Fig. 13 : OS 11269 (Holotype); ventral view; X90.

Occultocythereis namrudia sp. nov.

Fig. 9 : OS 11279 (Holotype); male, stereoscopic paired photographs, left valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 10 : OS 11230 (Paratype); female, stereoscopic paired photographs, right valve; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 11 : OS 11281 (Paratype); male, dorsal view; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

Fig. 12 : OS 11232 (Paratype); female, ventral view; Anah Well-2, Iraq, sample 15, drilling depth 2000' - 2016'; Maastrichtian; X90.

PLATE - 12

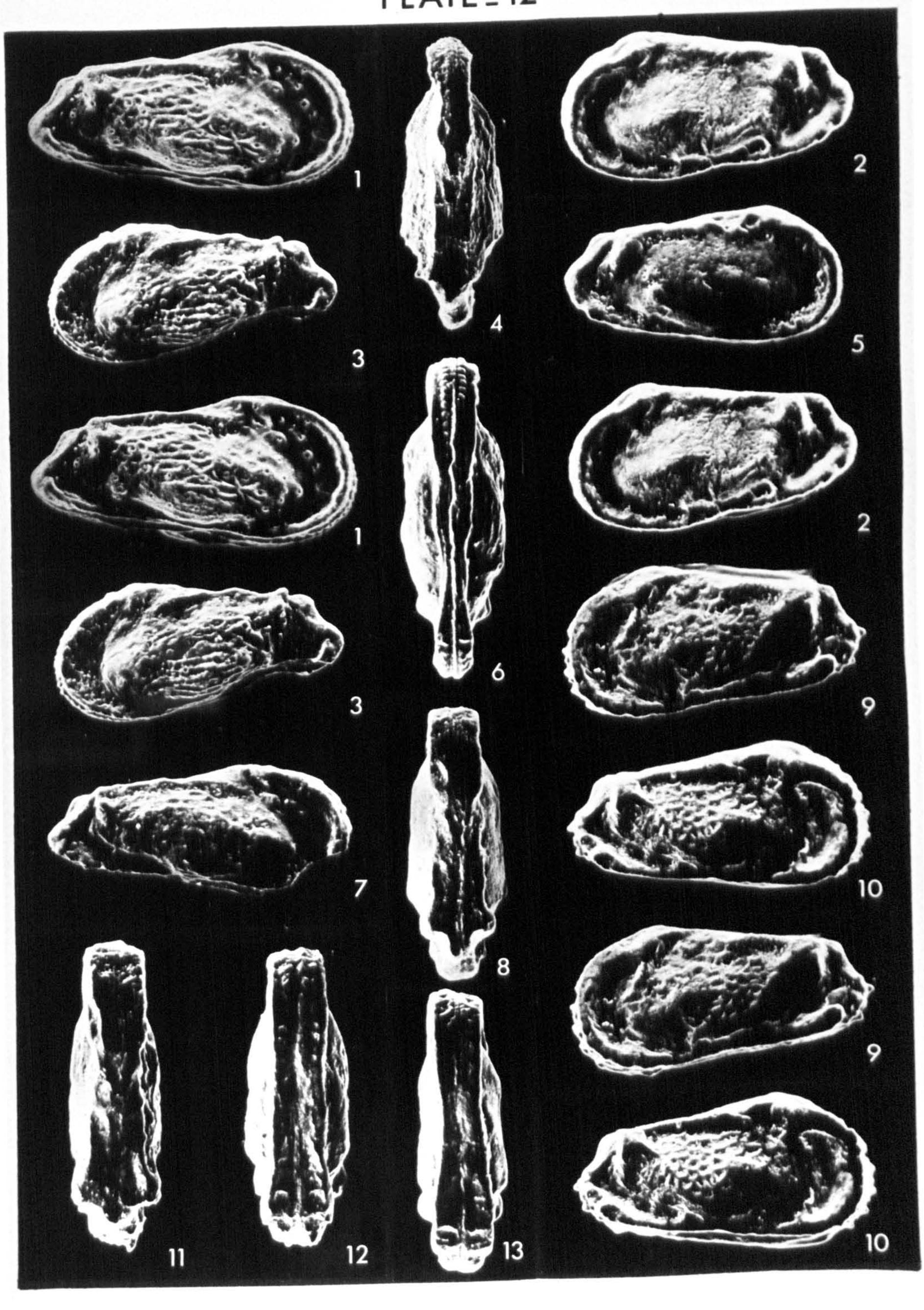


PLATE - 13

Ordoniya (Ordoniya) ordoniya (Bassiouni)

Fig. 1 : OS 11101; female, stereoscopic paired photographs (slightly distorted), left valve; Tell-Burma, Jordan, sample BMJ 847; L. Palaeocene (M. Danian); X 70.

Fig. 2 : OS 11099; male, stereoscopic paired photographs (slightly distorted), left valve; Tell-Burma, Jordan, sample BMJ 851; L. Palaeocene (U. Danian); X 70.

Fig. 3 : OS 11097; female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X 70.

Fig. 4 : OS 11097; dorsal view; X 70.

Fig. 5 : OS 11104; female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X 70.

Fig. 6 : OS 11096; stereoscopic paired photographs, muscle scars, left valve; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X 550.

Fig. 7 : OS 11099; dorsal view; X 70.

Fig. 8 : OS 11098; female, right valve; Tell-Burma, Jordan, sample BMJ 851; L. Palaeocene (U. Danian); X 70.

Fig. 9 : OS 11096; male, left valve internal view; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X 70.

Fig. 10 : OS 11098; dorsal view; X 70.

Fig. 11 : OS 11103; male, right valve; Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X 70.

PLATE _13

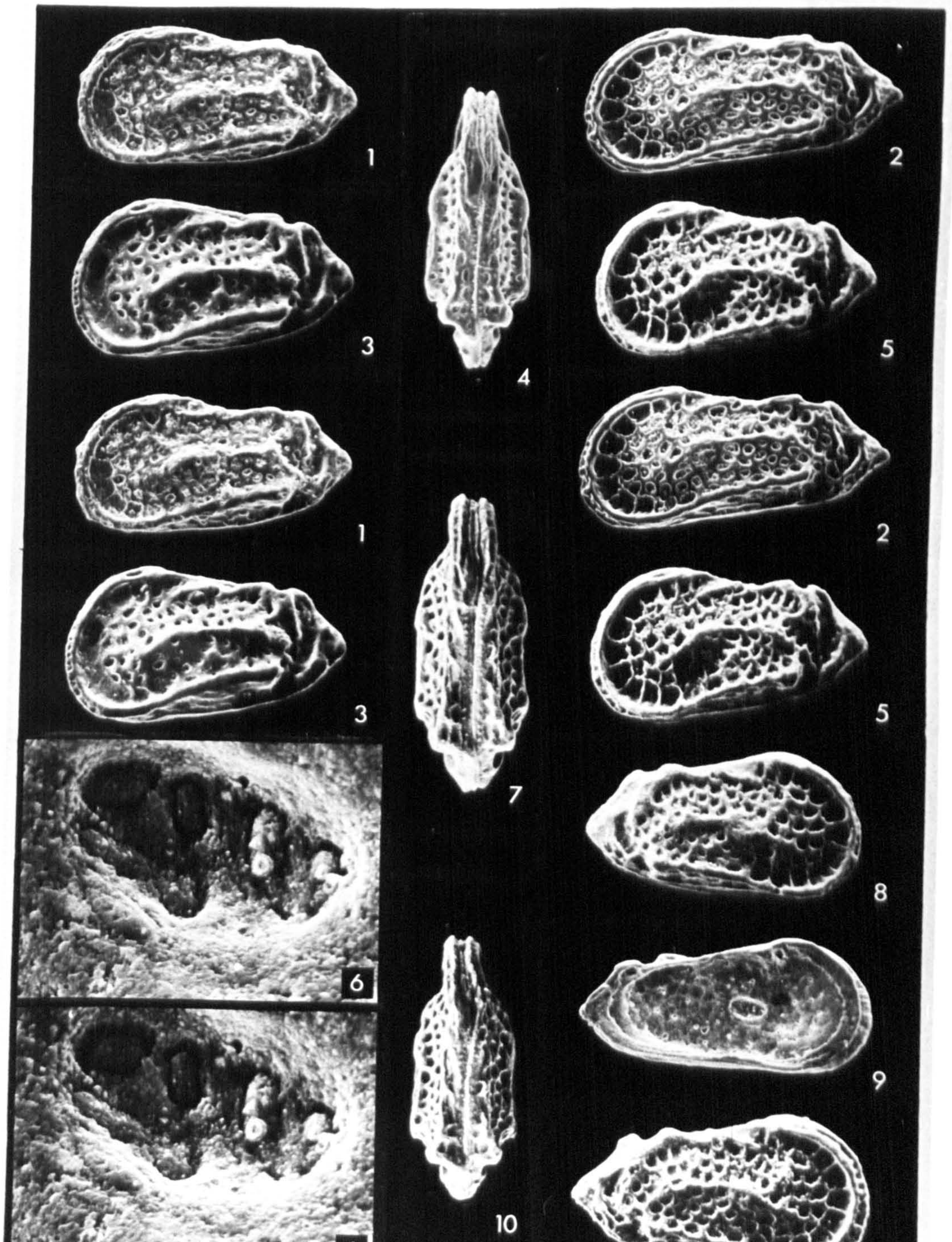


PLATE - 14

Ordoniya (Ordoniya) ordoniya (Bassiouni)

Fig. 1 : OS 11105; male, stereoscopic paired photographis, right valve internal view; Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X 70.

Fig. 3 : OS 11105; stereoscopic paired photographs, right valve hinge details; X 160.

Fig. 4 : OS 11103; male, dorsal view; Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X 70.

Ordoniya (Ordoniya) deroii (Bassiouni)

Fig. 2 : OS 11107; ?male, stereoscopic paired photographs (slightly distorted), left valve; Tell-Burma, Jordan, sample BMJ 849; L. Palaeocene (U. Danian); X 70.

Fig. 5 : OS 11106; ?female, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X 70.

Fig. 7 : OS 11106; dorsal view; X 70.

Fig. 11 : OS 11107; dorsal view; X 70.

Ordoniya (Ordoniya) burmaensis (Bassiouni)

Fig. 6 : OS 11111; female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X 70.

Fig. 8 : OS 11108; male, stereoscopic paired photographs (slightly distorted), left valve; Tell- Burma, Jordan, sample BMJ 851; L. Palaeocene (U. Danian); X 70.

Fig. 9 : OS 11110; male, left valve (slightly distorted photograph); Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X 70.

Fig. 10 : OS 11110; right valve; X 70.

PLATE_14

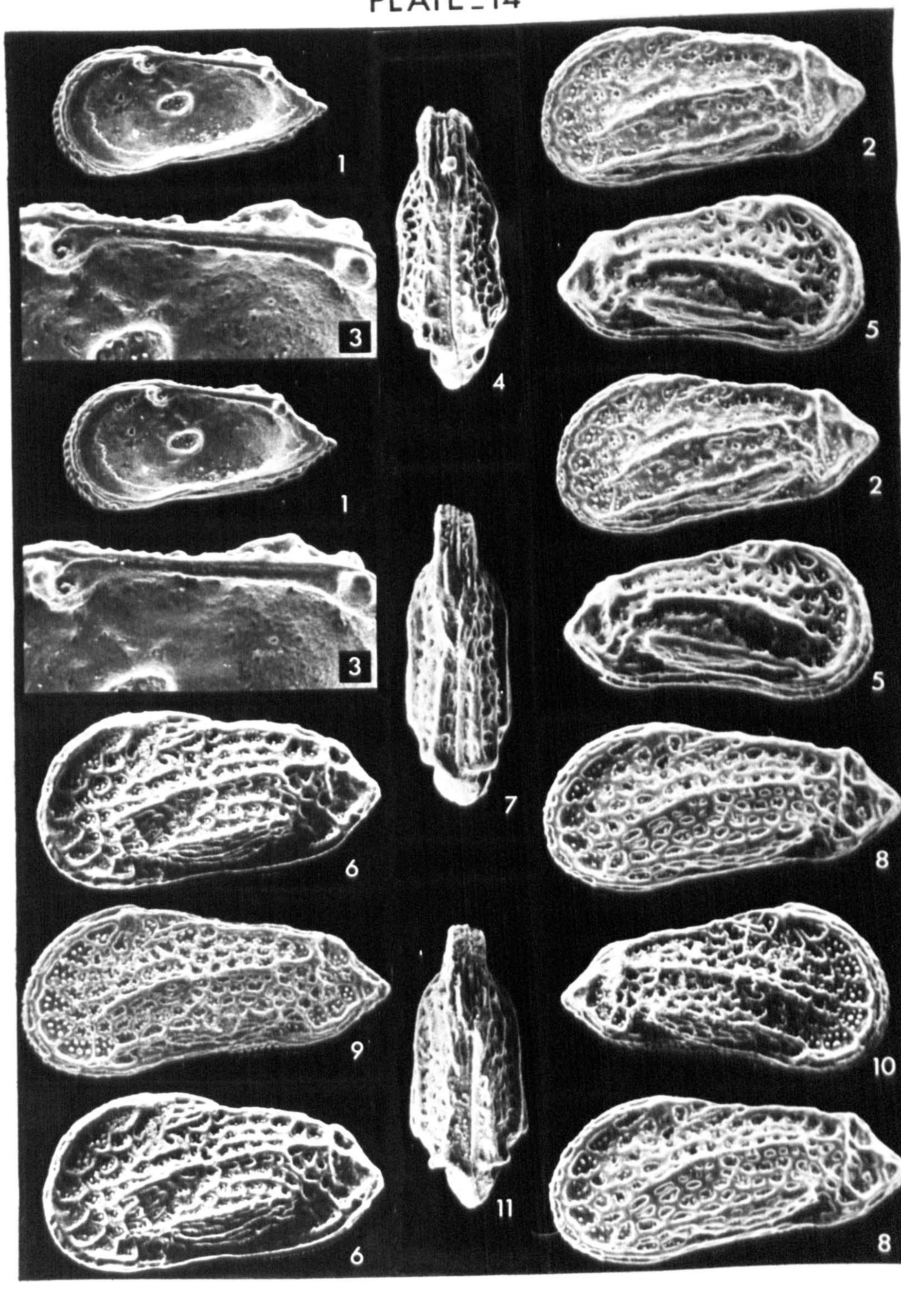


PLATE - 15

Ordoniya (Ordoniya) burmaensis (Bassiouni)

Fig. 1 : OS 11112; male, stereoscopic photographs, left valve internal view; Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X 70.

Fig. 3 : OS 11111; female, stereoscopic paired photographs (slightly distorted), right valve; Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X 70.

Fig. 4 : OS 11108; male, dorsal view; X 70.

Fig. 7 : OS 11110; male, dorsal view; X 70. (slightly distorted).

Ordoniya (Ordoniya) anahensis sp. nov.

Fig. 2 : OS 11119 (Holotype); female, stereoscopic paired photographs, right valve; Anah Well-2, Iraq, sample 5, drilling depth 920' - 925'; M.-U. Eocene; X 70.

Fig. 5 : OS 11120 (Paratype); stereoscopic paired photographs, "broken" left valve; Anah Well-2, Iraq, sample 5, drilling depth 920' - 925'; M.-U. Eocene; X 70.

Fig. 8 : OS 11120; stereoscopic paired photographs, surface ornamentation; X 700.

Ordoniya (Ordoniya) sinjariya sp. nov.

Fig. 6 : OS 11094 (Paratype); stereoscopic paired photographs, left valve; Anah Well-2, Iraq, sample 9, drilling depth 990' - 995'; M.-U. Eocene; X 70.

Fig. 9 : OS 11091 (Paratype); female, left valve; Jabel Sinjar section, Iraq, sample S85; M./U. Eocene; X 70.

Fig. 10 : OS 11094; dorsal view; X 70.

PLATE - 15

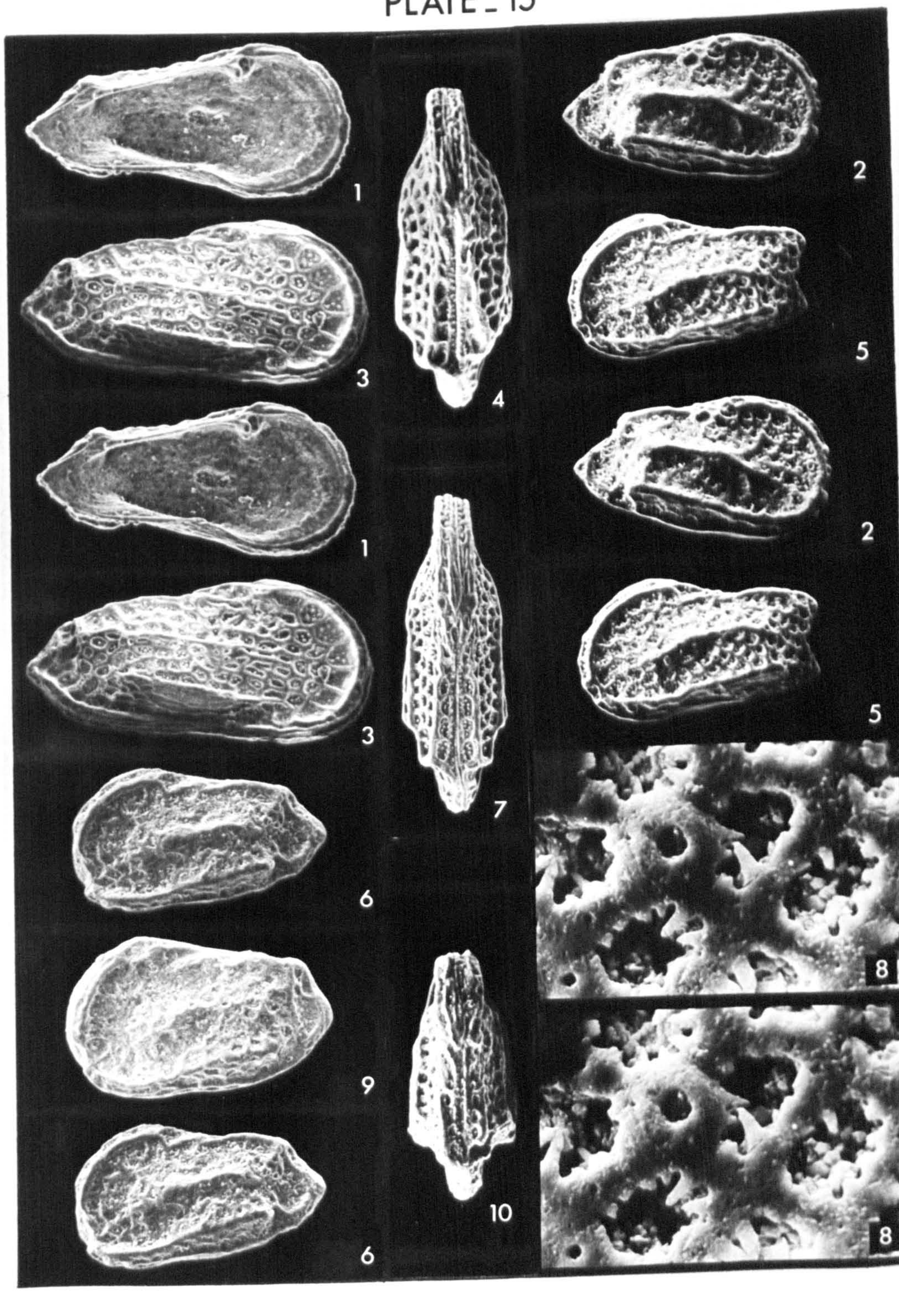


PLATE - 16

Ordoniya (Ordoniya) sinjariya sp. nov.

Fig. 1 : OS 11086 (Holotype); female, stereoscopic paired photographs, left valve; Jabel Sinjar section, Iraq, sample S77; M. Eocene; X 70.

Fig. 2 : OS 11089 (Paratype); female, stereoscopic paired photographs, right valve; Jabel Sinjar section, Iraq, sample S82; M. Eocene; X 70.

Fig. 3 : OS 11088 (Paratype); male, stereoscopic paired photographs, left valve; Jabel Sinjar section, Iraq, sample S82; M. Eocene; X 70.

Fig. 4 : OS 11086 (Holotype); dorsal view; X 70.

Fig. 5 : OS 11087 (Paratype); male, stereoscopic paired photographs, right valve; Jabel Sinjar section, Iraq, sample S77; M. Eocene; X 70.

Fig. 6 : OS 11088 (Paratype); dorsal view; X 70.

Fig. 8 : OS 11087 (Paratype); dorsal view; X 70.

Fig. 9 : OS 11092 (Paratype); male, stereoscopic paired photographs, right valve; Jabel Sinjar section, Iraq, sample S87; U. Eocene; X 70.

Fig. 11 : OS 11093 (Paratype); female, right valve; Jabel Sinjar section, Iraq, sample S87; U. Eocene; X 70.

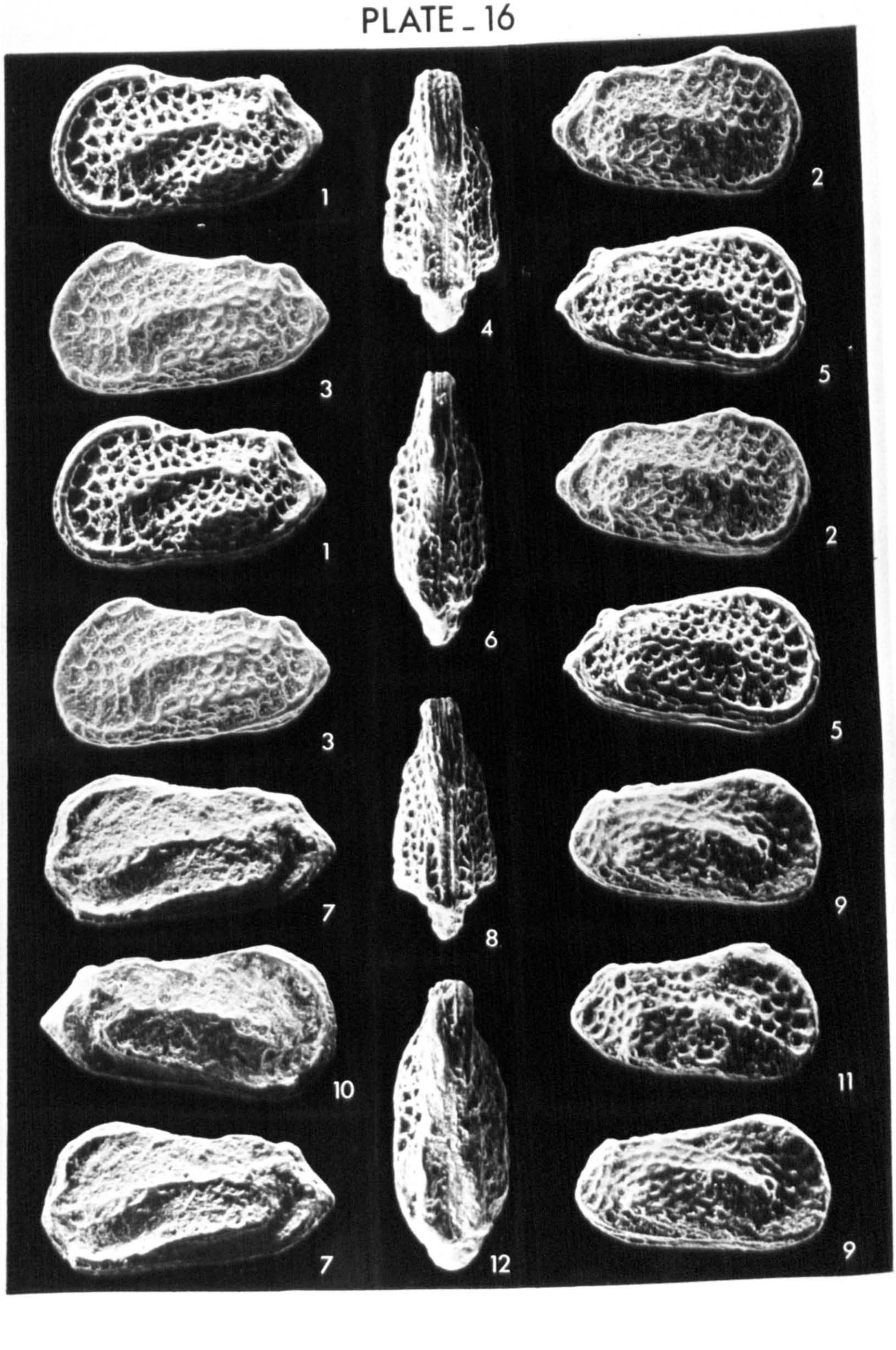
Ordoniya (Ordoniya) sp.

Fig. 7 : OS 11095; stereoscopic paired photographs, left valve; Jabel Sinjar section, Iraq, sample S96; U. Eocene; X 70.

Fig. 10 : OS 11095; right valve; X 70.

Fig. 12 : OS 11095; dorsal view; X 70.

PLATE - 16



Ordoniya (Pharkidata) bassiounii sp. nov.

Fig. 1 : OS 11113 (Holotype); male, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 848; L. Palaeocene (U. Danian); X 60.

Fig. 2 : OS 11113 (Holotype); male, stereoscopic paired photographs, (slightly distorted), right valve; X 60.

Fig. 4 : OS 11113; dorsal view; X 60.

Ordoniya (Pharkidata) aff. bilobatus sp. nov.

Fig. 2 : OS 11118; stereoscopic paired photographs, left valve; Jabel Sinjar section, Iraq, sample S43; Palaeocene; X 60.

Fig. 5 : OS 11118; stereoscopic paired photographs, right valve; X 60.

Fig. 6 : OS 11118; dorsal view; X 60.

Ordoniya (Pharkidata) bilobatus sp. nov.

Fig. 7 : OS 11115 (Holotype); ? male, stereoscopic paired photographis, left valve; Jabel Sinjar section, Iraq, sample S84; M./U. Eocene; X 60.

Fig. 8 : OS 11115 (Holotype); dorsal view; X 60.

Fig. 9 : OS 11115 (Holotype); stereoscopic paired photographs, right valve; X 60.

Fig. 10 : OS 11117 (Paratype); ? male, left valve; Jabel Sinjar section, Iraq, sample S83; M./U. Eocene; X 60.

Fig. 11 : OS 11116 (Paratype); ? female, right valve; Jabel Sinjar section, Iraq, sample S84; M./U. Eocene; X 60.

Fig. 12 : OS 11116 (Paratype); dorsal view; X 60.

PLATE_17

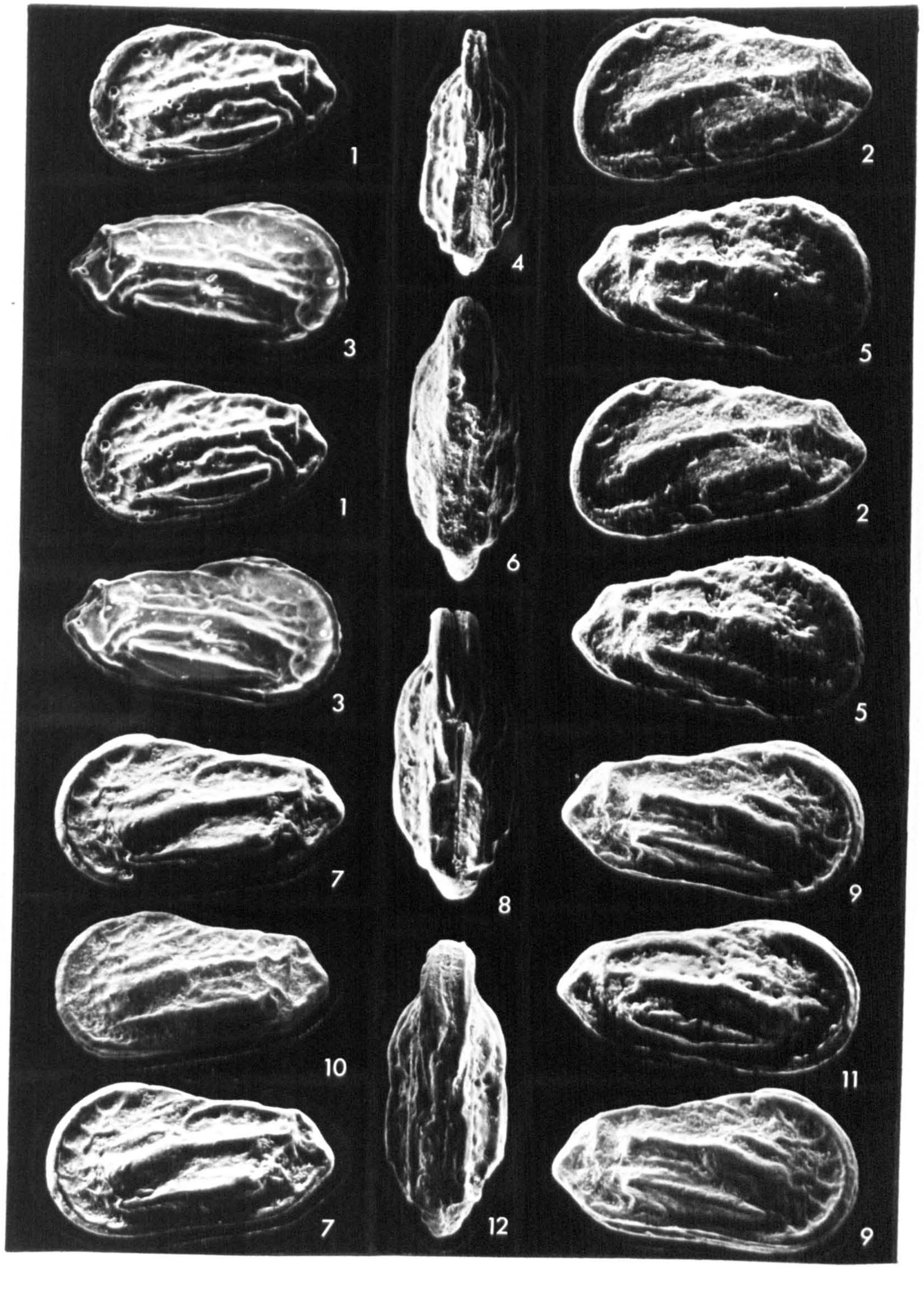


PLATE - 18

<u>Oertliella potraensis</u> sp. nov.

Fig. 1 : OS 11285 (Holotype); male, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 2 : OS 11286 (Paratype); male, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 3 : OS 11423 (Paratype); female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 4 : OS 11235 (Holotype); male, dorsal view; X65.

Fig. 5 : OS 11425 (Paratype); male, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 853; L. Palaeocene (U. Danian); X65.

Fig. 6 : OS 11287 (Paratype); female, dorsal view; Tell-Burma, Jordan, sample BMJ 843; L. Palaeocene (U. Danian); X65.

Fig. 7 : OS 11288 (Paratype); female, stereoscopic paired photographs, right valve, internal view; Tell-Burma, Jordan, sample BMJ 843; L. Palaeocene (U. Danian); X65.

Fig. 8 : OS 11423 (Paratype); female, dorsal view; X65.

Fig. 9 : OS 11289 (Paratype); female, left valve, internal view; Tell-Burma, Jordan, sample BMJ 843; L. Palaeocene (U. Danian); X65.

Fig. 10 : OS 11425 (Paratype); male, ventral view; X65.

Fig. 11 : OS 11423 (Paratype); sieve-type pore canals; X300.

PLATE_18

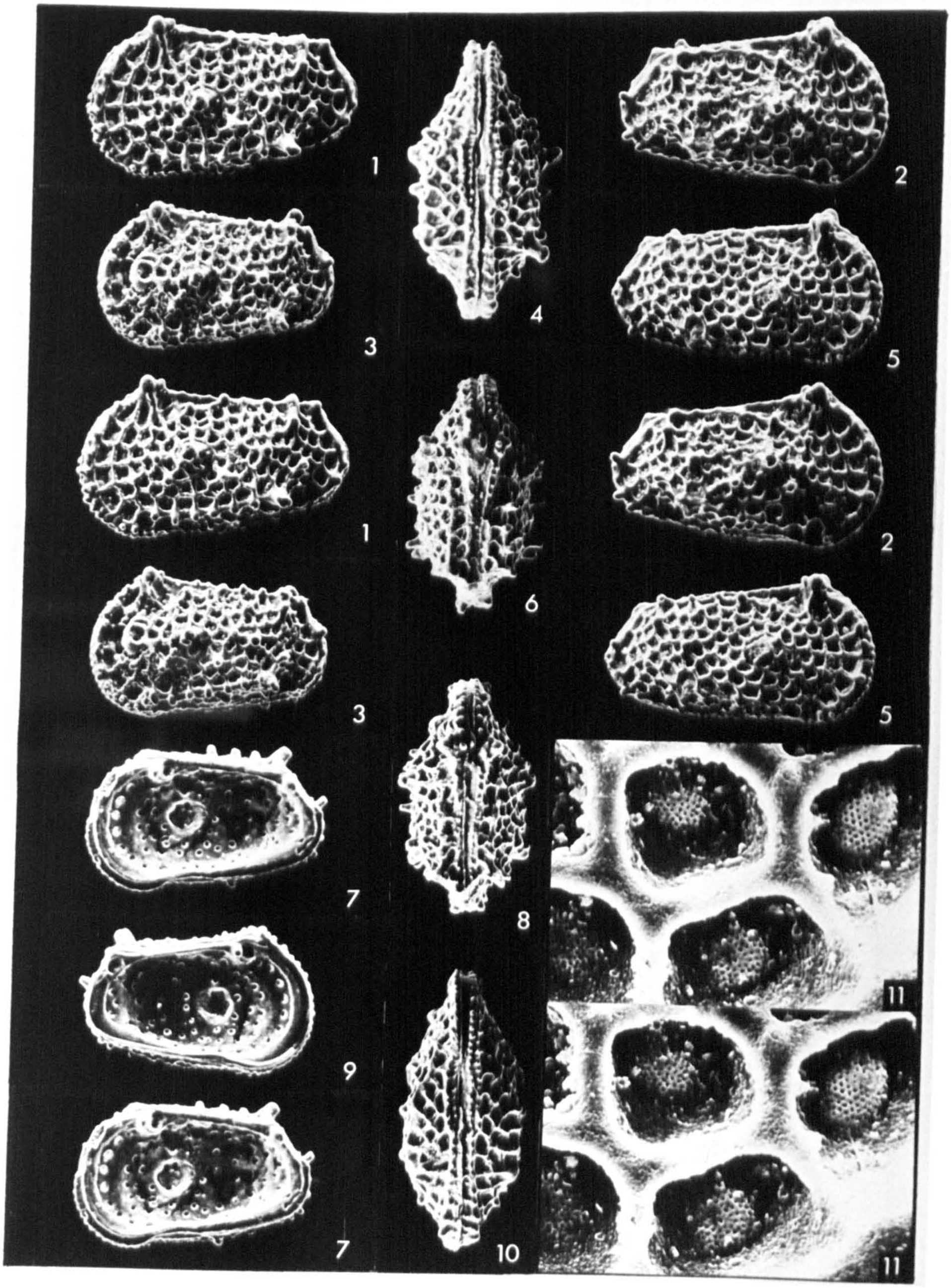


PLATE - 19

Oertliella petraensis sp. nov.

Fig. 1 : OS 11233 (Paratype); female, stereoscopic paired photographs, hinge, right valve; Tell-Burma, Jordan, sample BMJ 348; L. Palaeocene (U. Danian); X120.

Fig. 2 : OS 11239 (Paratype); female, stereoscopic paired photographs, hinge, left valve; Tell-Burma, Jordan, sample BMJ 843; L. Palaeocene (U. Danian); X120.

Fig. 4 : OS 11283 (Paratype); female, stereoscopic paired photographs, muscle scars, right valve; X300.

Paragrenocythere monilis sp. nov.

Fig. 3 : OS 11426 (Holotype); female, stereoscopic paired photographs, left valve; Jabol Sinjar Section, Iraq, sample S28; Maastrichtian; X50.

Fig. 5 : OS 11426 (Holotype); female, dorsal view; X50.

Fig. 6 : OS 11427 (Paratype); female, right valve; Jabol Sinjar Section, Iraq, sample S28; Maastrichtian; X50.

Fig. 7 : OS 11427 (Paratype); female, ventral view; X50.

Fig. 8 : OS 11428 (Paratype); male, stereoscopic paired photographhs, right valve; Jabol Sinjar Section, Iraq, sample S17; Maastrichtian; X50.

Fig. 12 : OS 11423 (Paratype); male, dorsal view; X50.

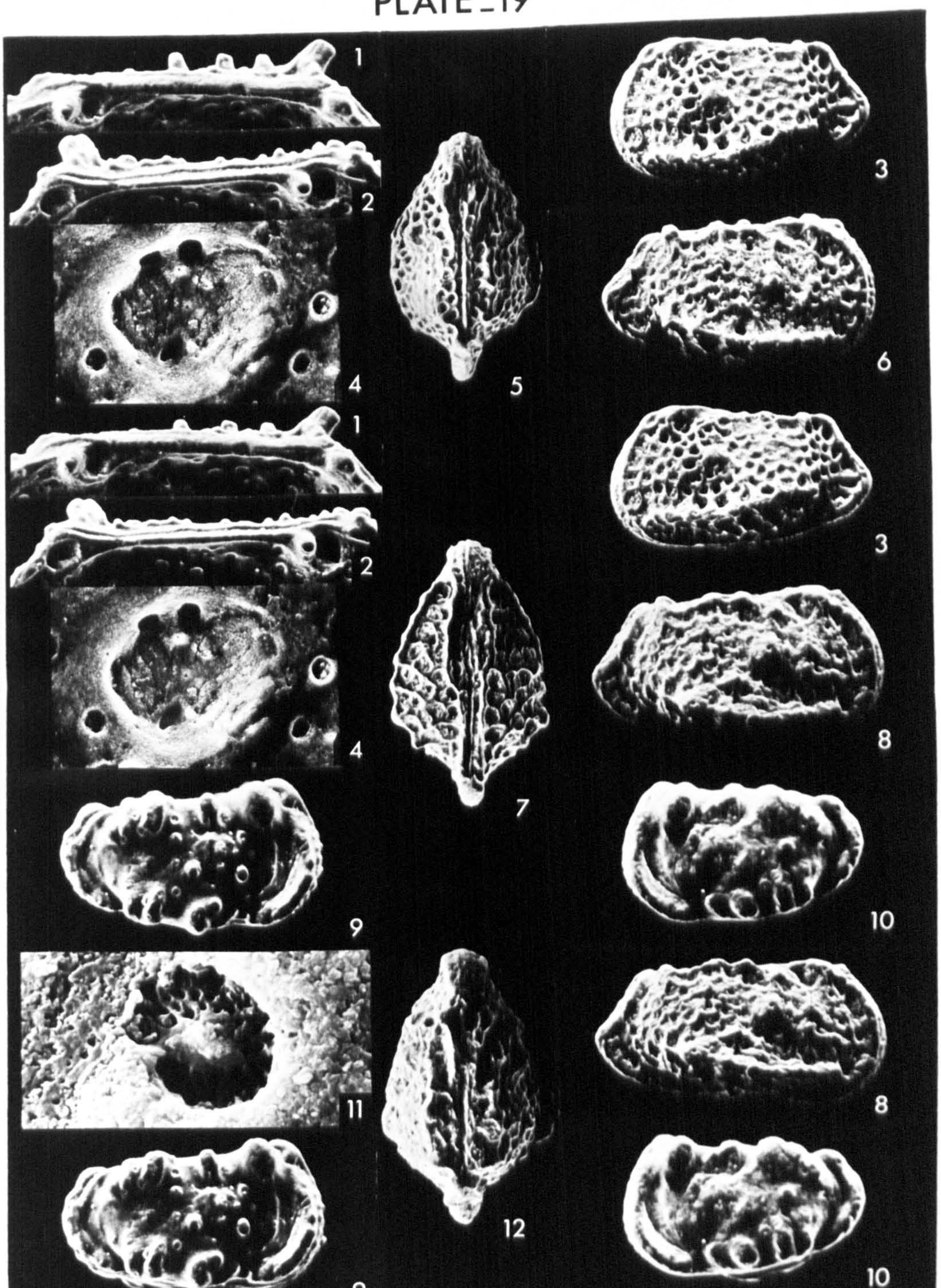
Poloriops lovisulcata sp. nov.

Fig. 9 : OS 11443 (Holotype); male, stereoscopic paired photographs, right valve; Makhul Well-2, Iraq, sample 41, drilling depth 1620' - 1625'; Maastrichtian; X60.

Fig. 10 : OS 11444 (Paratype); female, stereoscopic paired photographs, left valve; Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X60.

Fig. 11 : OS 11443 (Holotype); male, sieve-type pore canal; X2500.

PLATE_19



Peloriops levisulcata sp. nov.

Fig. 1 : OS 11445 (Paratype); male, stereoscopic paired photographs, left valve; Makhul Well-2, Iraq, sample 79, drilling depth 2095' - 2100'; Maastrichtian; X60.

Fig. 3 : OS 11446 (Paratype); female, stereoscopic paired photographs, right valve; Makhul Well-2, Iraq, sample 79, drilling depth 2095' - 2100'; Maastrichtian; X60.

Fig. 4 : OS 11443 (Holotype); male, dorsal view; Makhul Well-2, Iraq, sample 41, drilling depth 1620' - 1625'; Maastrichtian; X60.

Fig. 6 : OS 11447 (Paratype); stereoscopic paired photographs, right valve, internal view (broken); Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X70.

Fig. 7 : OS 11443 (Paratype); stereoscopic paired photographs, left valve, internal view (broken); Makhul Well-2, Iraq, sample 56, drilling depth 1855' - 1860'; Maastrichtian; X70.

Fig. 8 : OS 11444 (Paratype); female, ventral view; Makhul Well-2, Iraq, sample 42, drilling depth 1635' - 1640'; Maastrichtian; X60.

Fig. 10 : OS 11447 (Paratype); anterior hinge tooth, right valve; X200.

Paracosta (Paracosta) rogeri (Sonmez-Gokcen)

Fig. 2 : OS 11240; male, stereoscopic paired photographs, left valve; SE Thrace, Turkey; U. Eocene - Oligocene; X50.

Fig. 5 : OS 11242; male, stereoscopic paired photographs, right valve; SE Thrace, Turkey; U. Eocene - Oligocene; X50.

Fig. 9 : OS 11241; female, stereoscopic paired photographs, left valve, internal view; SE Thrace, Turkey; U. Eocene - Oligocene; X50.

Fig. 11 : OS 11241; female, hinge, left valve; X70.

Fig. 12 : OS 11240; male, dorsal view; X50.

PLATE_20

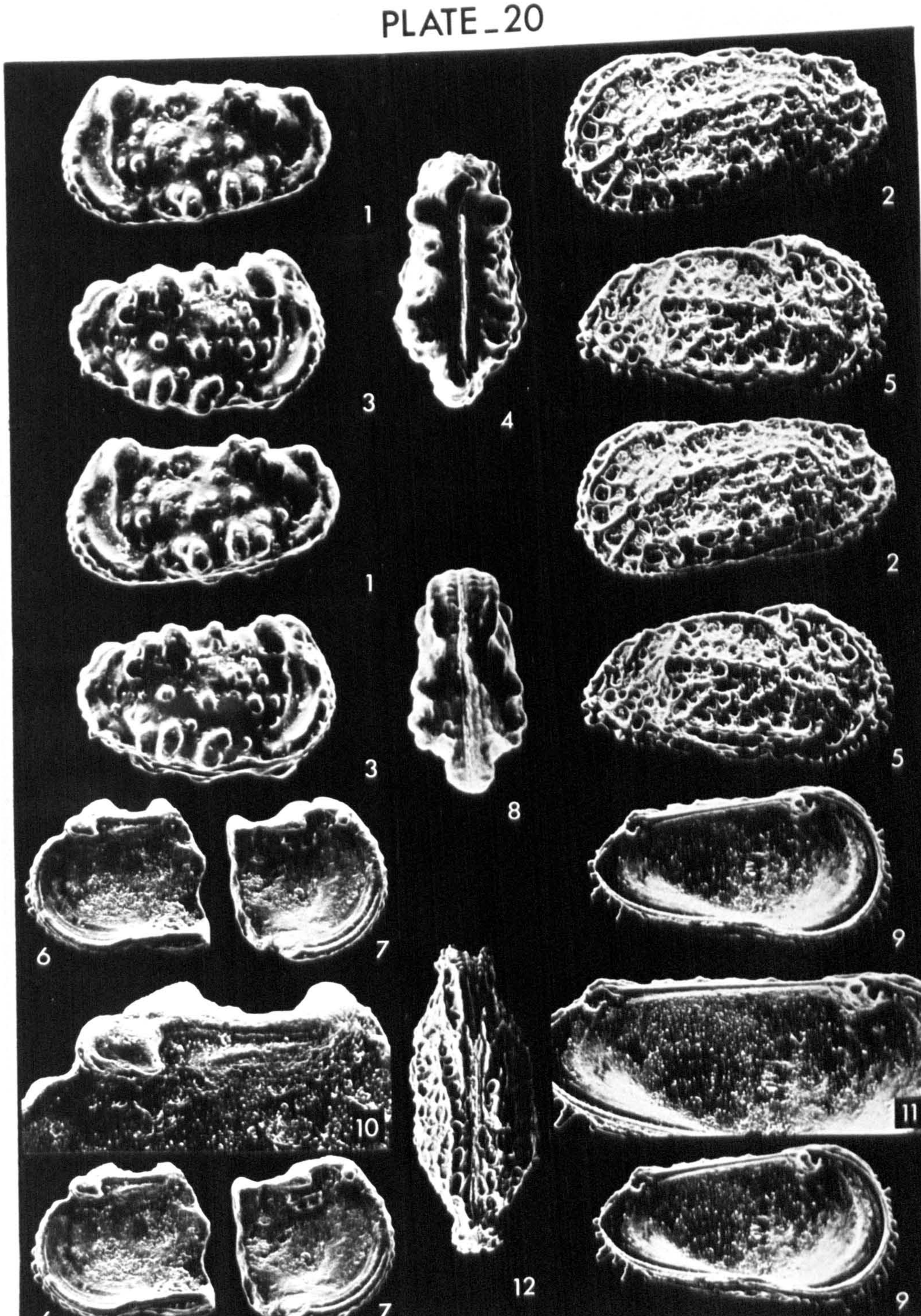


PLATE - 21

Paracosta (Paracosta) declivis Siddiqui, 1971

Fig. 1 : OS 11123 (Topotype); male, stereoscopic paired photographs, left valve; Rakhi Nala, Pakistan, sample 3662; Upper Eocene; X60.

Fig. 3 : OS 11124 (Topotype); female, stereoscopic paired photographs, right valve; Rakhi Nala, Pakistan, sample 3662; Upper Eocene; X60.

Fig. 4 : OS 11123 (Topotype); male, dorsal view; X60.

Fig. 6 : OS 11124 (Topotype); female, ventral view; X60.

Paracosta (Paracosta) arabica (Bassiouni)

Fig. 2 : TKH 11742; female, stereoscopic paired photographs, left valve; Yarmuk, Jordan, sample 42083; Lower (M?.) Palaeocene; X60.

Fig. 5 : (Lost specimen); female, stereoscopic paired photographs, right valve, internal view; Yarmuk, Jordan, sample 42083; Lower (M?.) Palaeocene; X60.

Fig. 7 : OS 11126; male, stereoscopic paired photographs, right valve; Tell-Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X60.

Fig. 8 : OS 11126; male, dorsal view; X60.

Fig. 9 : OS 11125; female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 842; L. Palaeocene (M. Danian); X60.

Fig. 10 : OS 11125; female, right valve; X60.

Fig. 11 : OS 11126; male, left valve; X60.

Fig. 12 : OS 11126; male, ventral view; X60.

PLATE_21

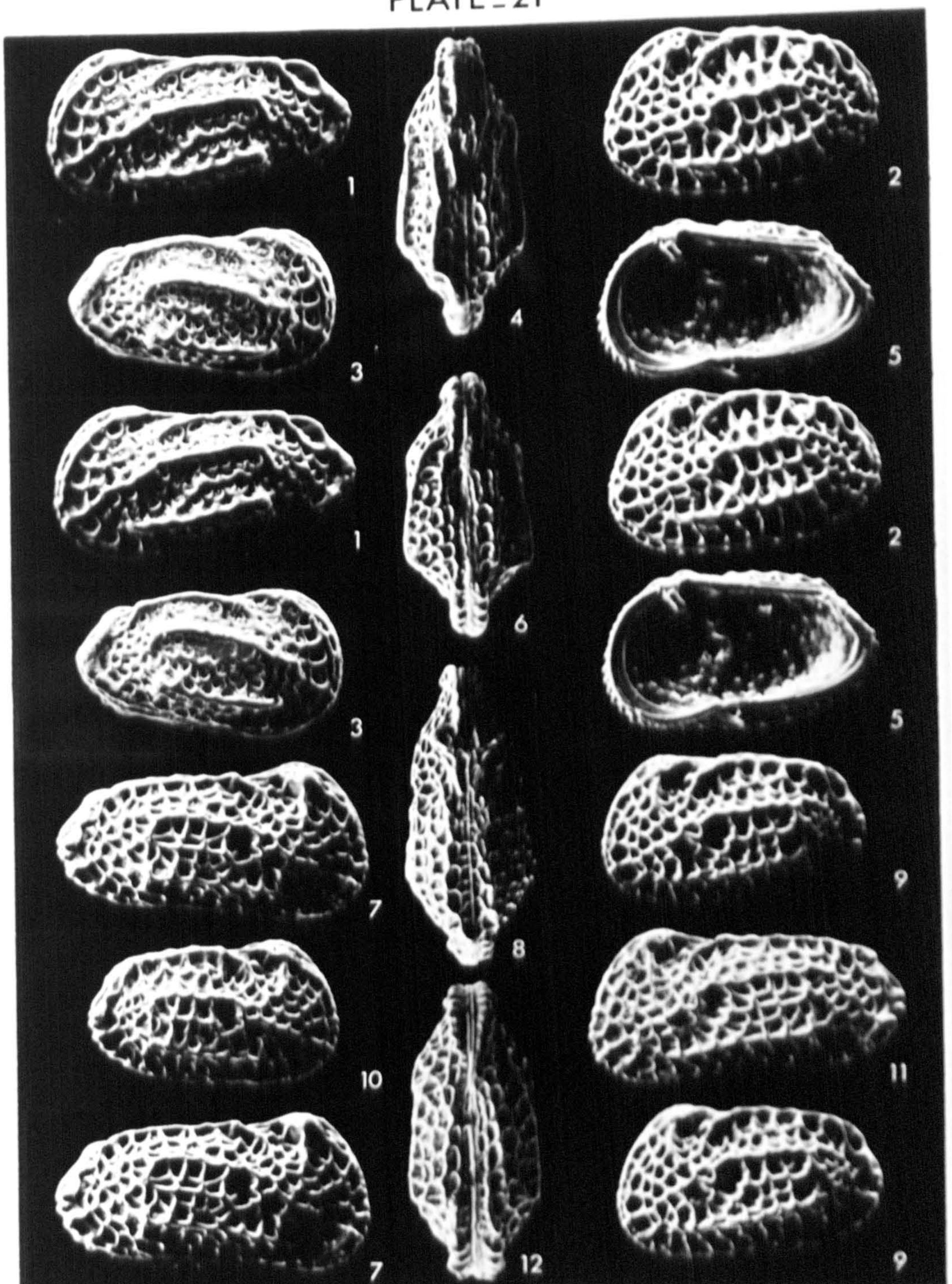


PLATE - 22

Paracosta (Paracosta) bicristata sp. nov.

Fig. 1 : OS 11139 (Holotype); female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X65.

Fig. 3 : OS 11140 (Paratype); female, stereoscopic paired photographs, hinge and muscle scars, right valve; Tell-Burma, Jordan, sample BMJ 850; L. Palaeocene (U. Danian); X110.

Fig. 4 : OS 11139 (Holotype); female, dorsal view; X65.

Fig. 6 : OS 11139 (Holotype); female, ventral view; X65.

Fig. 7 : OS 11140 (Paratype); female, right valve, internal view; X65.

Fig. 10 ; OS 11139 (Holotype); female, right valve; X65.

Paracosta (Paracosta) praecrassireticulata (Bassiouni)

Fig. 2 : TKH 11746 (Topotype); male, stereoscopic paired photographs, left valve; Jabel Thuleithuwat, Jordan, sample 45421; Middle (L.) Eocene; X50.

Fig. 5 : TKH 11747 (Topotype); female, stereoscopic paired photographs, right valve, internal view; Jabel Thuleithuwat, Jordan, sample 45421; Middle (L.) Eocene; X50.

Fig. 8 : OS 11142; female, dorsal view; Jabel Sinjar Section, Iraq, sample S71; M. Eocene; X50.

Fig. 9 : OS 11153; female, stereoscopic paired photographs, right valve; Syria, I.P.C. sample S/15732; Palaeocene; X50.

Fig. 11 : OS 11154; male, left valve; Syria, I.P.C. sample S/15732; Palaeocene; X50.

Fig. 12 : OS 11141; female, left valve; Rakhi Nala, Pakistan, sample 3604; M. Eocene; X50.

Fig. 13 : OS 11154; male, ventral view; X50.

PLATE _ 22

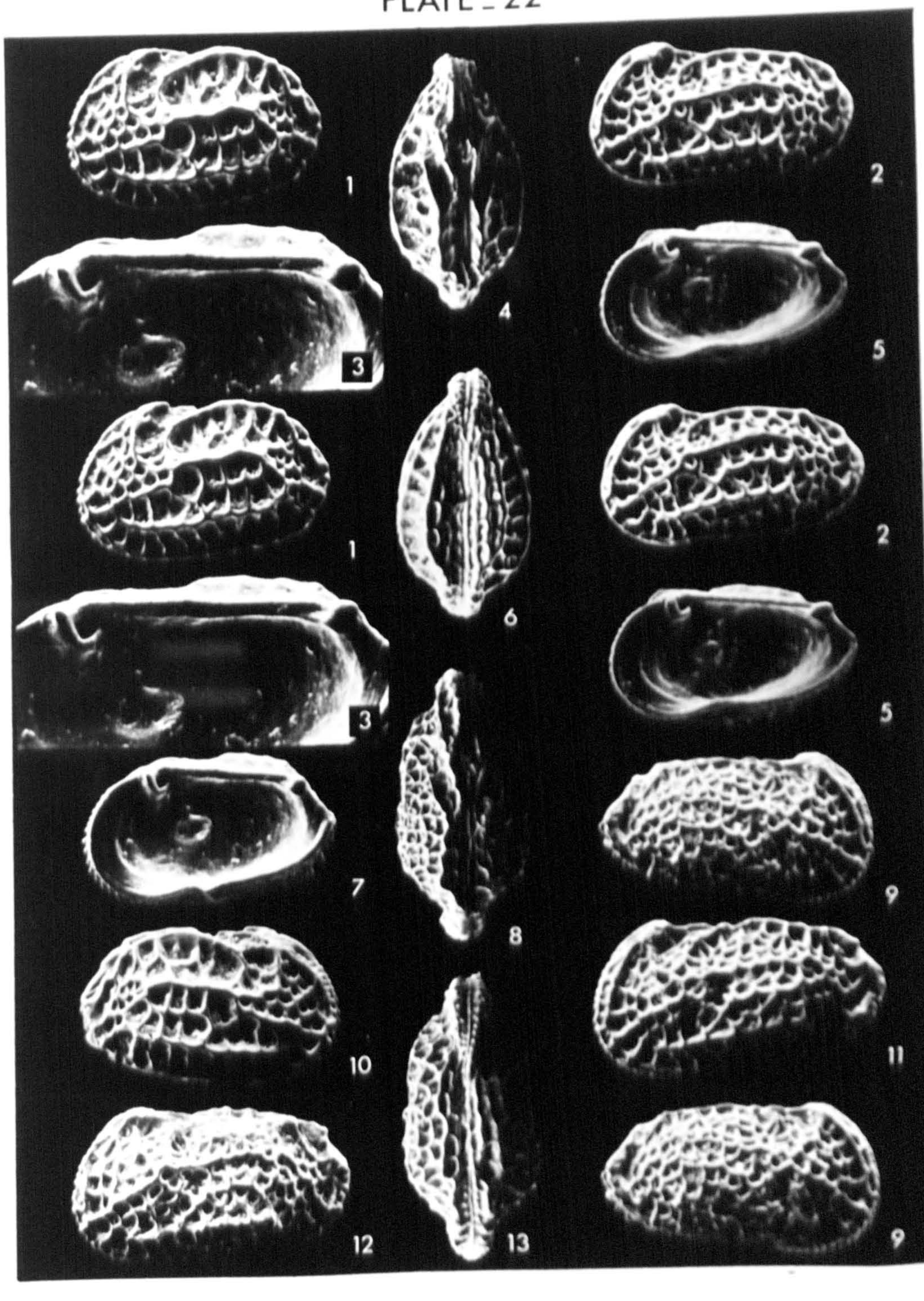


PLATE - 23

Paracosta (Paracosta) hammurabii sp. nov.

Fig. 1 : OS 11157 (Holotype); female, stereoscopic paired photographs, left valve; Maaloula, Syria, I.P.C. sample CA 2235; uppermost M. Eocene; X55.

Fig. 3 : OS 11158 (Paratype); male, right valve; Maaloula, Syria, I.P.C. sample CA2235; uppermost M. Eocene; X55.

Fig. 4 : OS 11157 (Holotype); female, dorsal view; X55.

Fig. 6 : OS 11157 (Holotype); female, ventral view; X55.

Fig. 7 : TKH 11753 (Paratype); female, hinge and muscle scars, right valve; Jabel Thuleithuwat, Jordan, sample 45421; M. Eocene; X90.

Paracosta (Paracosta) enlilia sp. nov.

Fig. 2 : OS 11175 (Holotype); male, stereoscopic paired photographs, left valve; Jabel Sinjar Section, Iraq, sample S88; U. Eocene; X60.

Fig. 5 : OS 11175 (Holotype); male, right valve; X60.

Fig. 8 : OS 11176 (Paratype); female, dorsal view; Jabel Sinjar Section, Iraq, sample S82; M.?-U. Eocene; X60.

Fig. 9 : OS 11176 (Paratype); female, stereoscopic paired photographs, left valve; X60.

Fig. 12 : OS 11176 (Paratype); female, ventral view; X60.

Paracosta (Paracosta) heluanensis (Bassiouni)

Fig. 10 : TKH 11756; male, stereoscopic paired photographs, left valve; Heluan, Egypt, sample J1; U. Eocene; X60.

Fig. 11 : TKH 11754; female, stereoscopic paired photographs, left valve; Heluan, Egypt, sample J1; U. Eocene; X60.

PLATE_23

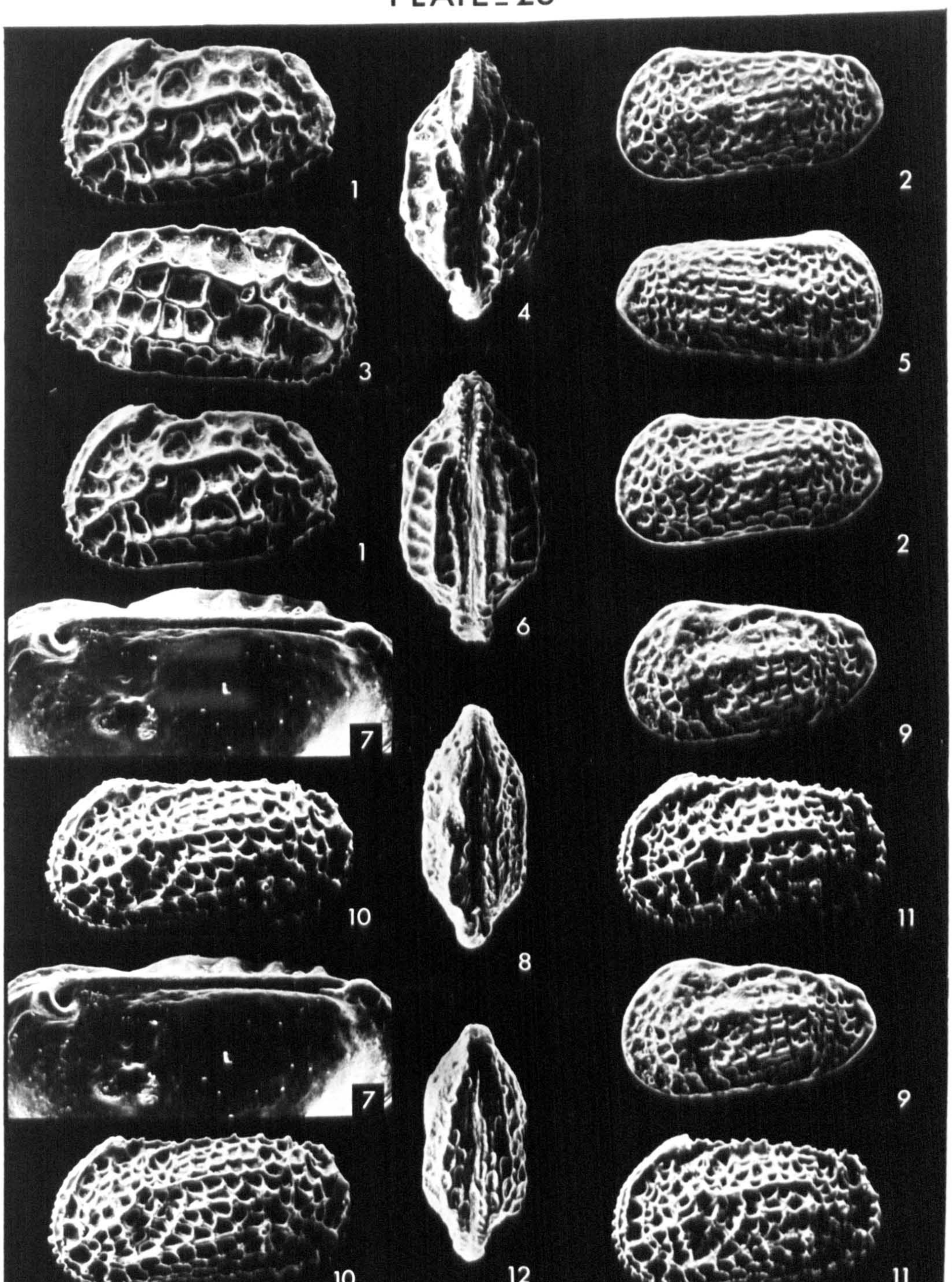


PLATE - 24

Paracosta (Paracosta) qdeimensis sp. nov.

Fig. 1 : OS 11163 (Holotype); male, stereoscopic paired photographs, left valve; Dolaa Camp, Bir Qdeim, Syria, I.P.C. sample Jd 743; L. Eocene; X60.

Fig. 3 : OS 11164 (Paratype); male, right valve; Dolaa Camp, Bir Qdeim, Syria, I.P.C. sample Jd 714; L. Eocene; X60.

Fig. 4 : OS 11163 (Holotype); male, dorsal view; X60.

Fig. 5 : OS 11166 (Paratype); female, right valve; Dolaa Camp, Bir Qdeim, Syria, I.P.C. sample Jd 743; L. Eocene; X60.

Fig. 7 : OS 11164 (Paratype); male, ventral view; X60.

Paracosta (Paracosta) aff. qdeimensis sp. nov.

Fig. 2 : OS 11167; male?, stereoscopic paired photographs, left valve; Jabel Sinjar Section, Iraq, sample S83; M. Eocene; X60.

Fig. 11 : OS 11167; male?, dorsal view; X60.

Paracosta (Paracosta) maaloulaensis sp. nov.

Fig. 6 : OS 11168 (Holotype); male, stereoscopic paired photographs, left valve; Maaloula, Syria, I.P.C. sample CA 2235; uppermost M. Eocene; X55.

Fig. 9 : OS 11168 (Holotype); male, stereoscopic paired photographs, left valve, internal view; X55.

Paracosta (Paleocosta) mokattamensis mokattamensis (Bassiouni)

Fig. 8 : TKH 11764; female, stereoscopic paired photographs, left valve; Mokattam, Egypt, sample VIII cm; U. Eocene; X55.

Paracosta (Paleocosta) enkii sp. nov.

Fig. 10 : OS 11179 (Holotype); stereoscopic paired photographs, left valve (broken); Anah Well-2, Iraq, sample 13, drilling depth 1220' - 1225'; uppermost M. Eocene; X60.

PLATE - 24

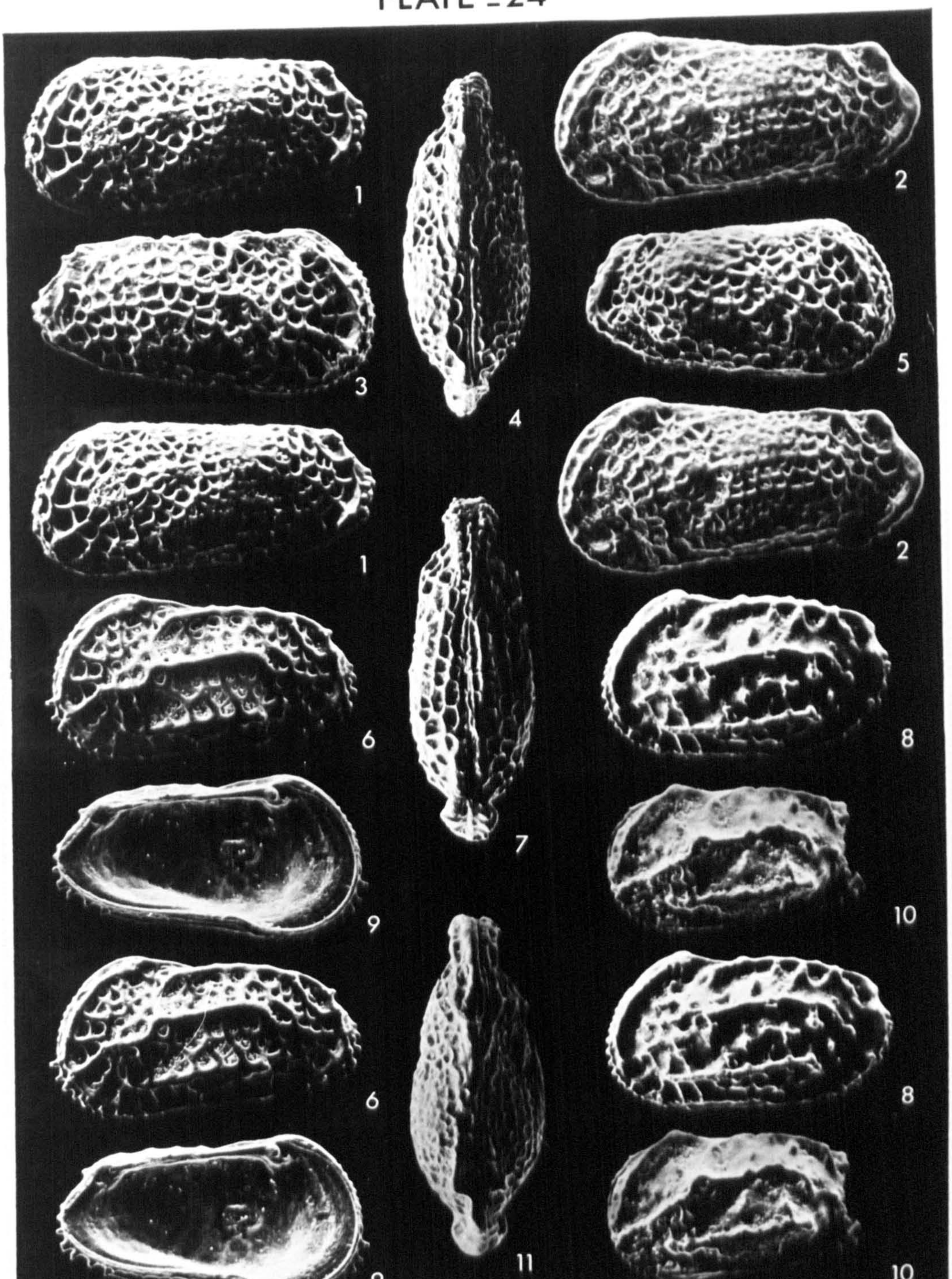


PLATE - 25

Paracosta (Paleocosta) crassireticulata (Bassiouni)

Fig. 1 : TKH 11759; female, stereoscopic paired photographs, left valve; Mokattam, Egypt, sample VIII cm; U. Eocene; X55.

Fig. 3 : OS 11172; female, stereoscopic paired photographs, right valve; Anah Well-2, Iraq, sample 1, drilling depth 800' - 805'; M./U. Eocene; X55.

Fig. 4 : OS 11172; female, dorsal view; X55.

Fig. 6 : OS 11172; female, ventral view; X55.

Paracosta (Paleocosta) aliena (Bassiouni)

Fig. 2 : OS 11181; stereoscopic paired photographs, left valve; Anah Well-2, Iraq, sample 1, drilling depth 800' - 805'; M./U. Eocene; X60.

Fig. 5 : TKH 11766; stereoscopic paired photographs, right valve; Mokattam, Egypt, sample VIII cm; U. Eocene; X60.

Fig. 8 : OS 11181; dorsal view; X60.

Fig. 12 : OS 11181; ventral view; X60.

Paracosta (Paleocosta) ansaryi (Bassiouni)

Fig. 7 : TKH 11761 (Topotype); female, stereoscopic paired photographs, left valve; Faydat ad Dahikiyah, Jordan, sample 45440; M./U. Eocene; X60.

Fig. 9 : OS 11173; female, stereoscopic paired photographs, right valve, internal view; Maaloula, Syria, I.P.C. sample CA 2235; uppermost M. Eocene; X60.

Fig. 10 : TKH 11762 (Topotype); male, right valve; Faydat ad Dahikiyah, Jordan, sample 45440: M./U. Eocene; X60.

Fig. 11 : OS 11173; female, right valve; X60.

PLATE - 25

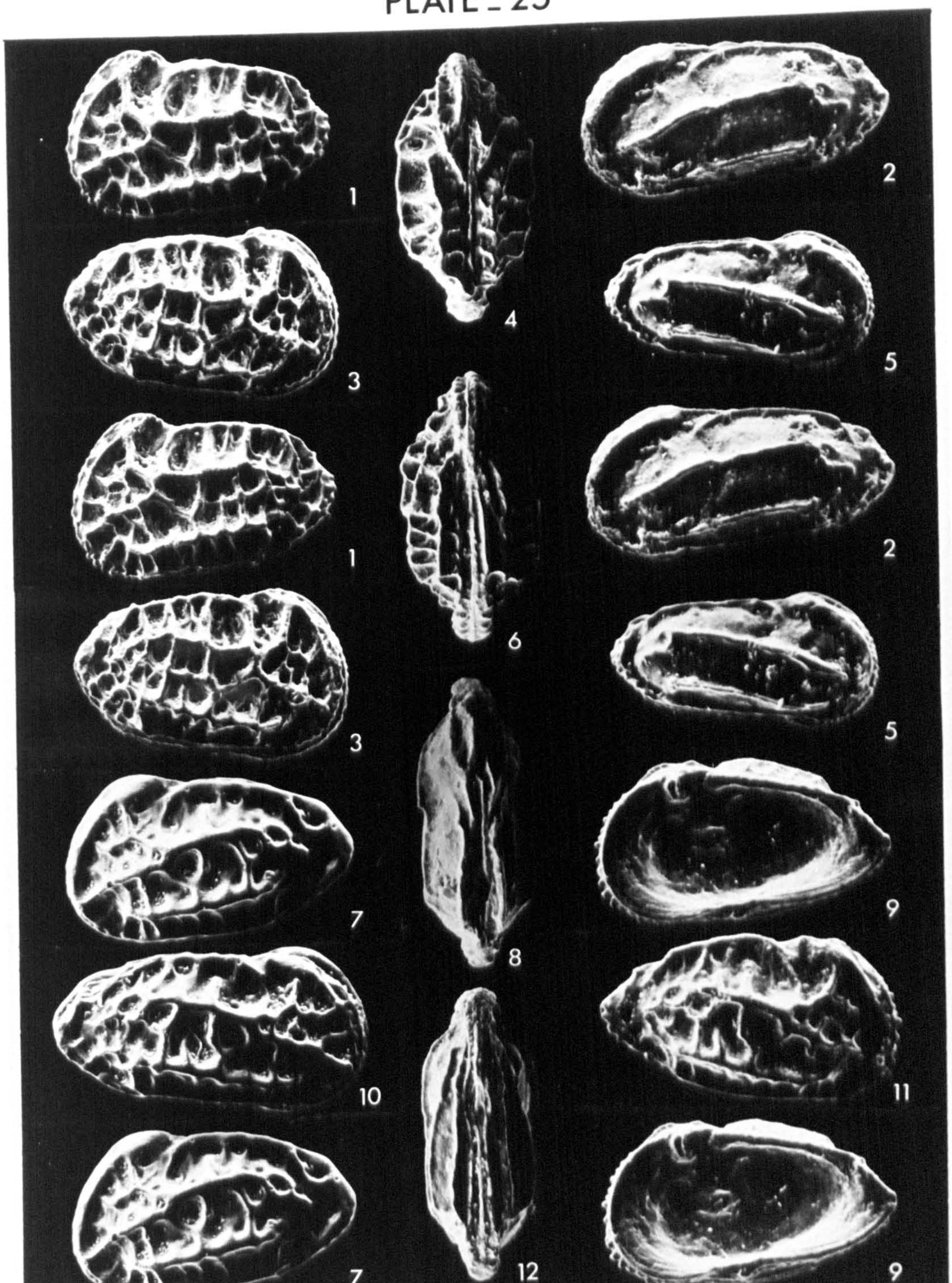


PLATE - 26

Allocosta proteros (Bassiouni)

Fig. 1 : OS 11182; female, stereoscopic paired photographs, left valve; Tell-Burma, Jordan, sample BMJ 851; L. Palaeocene (U. Danian); X55.

Fig. 2 : OS 11183; male, left valve; Tell-Burma, Jordan, sample BMJ 851; L. Palaeocene (U. Danian); X55.

Fig. 3 : OS 11183; male, stereoscopic paired photographs, right valve; X55.

Fig. 4 : OS 11184; female, dorsal view; Tell-Burma, Jordan, sample BMJ 851; L. Palaeocene (U. Danian); X55.

Fig. 6 : OS 11182; female, ventral view; X55.

Allocosta ninurta gen. et sp. nov.

Fig. 5 : OS 11185 (Holotype); male, stereoscopic paired photographs, left valve; Jabel Sinjar Section, Iraq, sample S77; uppermost M. Eocene; X55.

Fig. 7 : OS 11187 (Paratype); female, stereoscopic paired photographs, right valve; Jabel Sinjar Section, Iraq, sample S96; U. Eocene; X55.

Fig. 8 : OS 11185 (Holotype); male, dorsal view; X55.

Fig. 11 : OS 11185 (Holotype); male, ventral view; X55.

Allocosta syriaensis gen. et sp. nov.

Fig. 9 : OS 11190 (Holotype); male, stereoscopic paired photographs, left valve; Syria, I.P.C. sample S/15732 - 15737; Palaeocene; X55.

Fig. 10 : OS 11191 (Paratype); female, right valve; Syria, I.P.C. sample S/15732 - 15737; Palaeocene; X55.

Fig. 12 : OS 11190 (Holotype); male, ventral view; X55.

Fig. 13 : OS 11191 (Paratype); female, dorsal view; X55.

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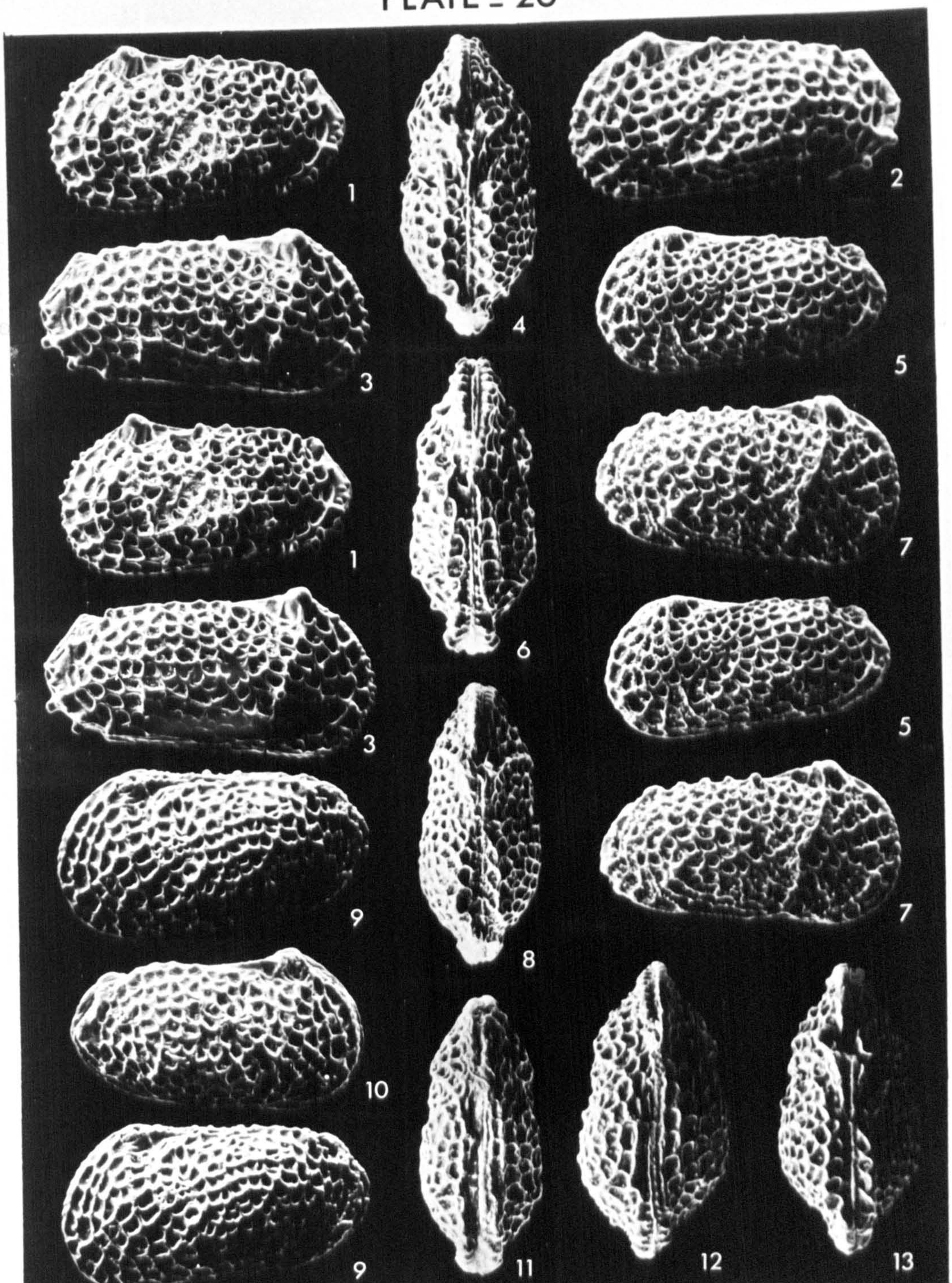
PLATE - 26



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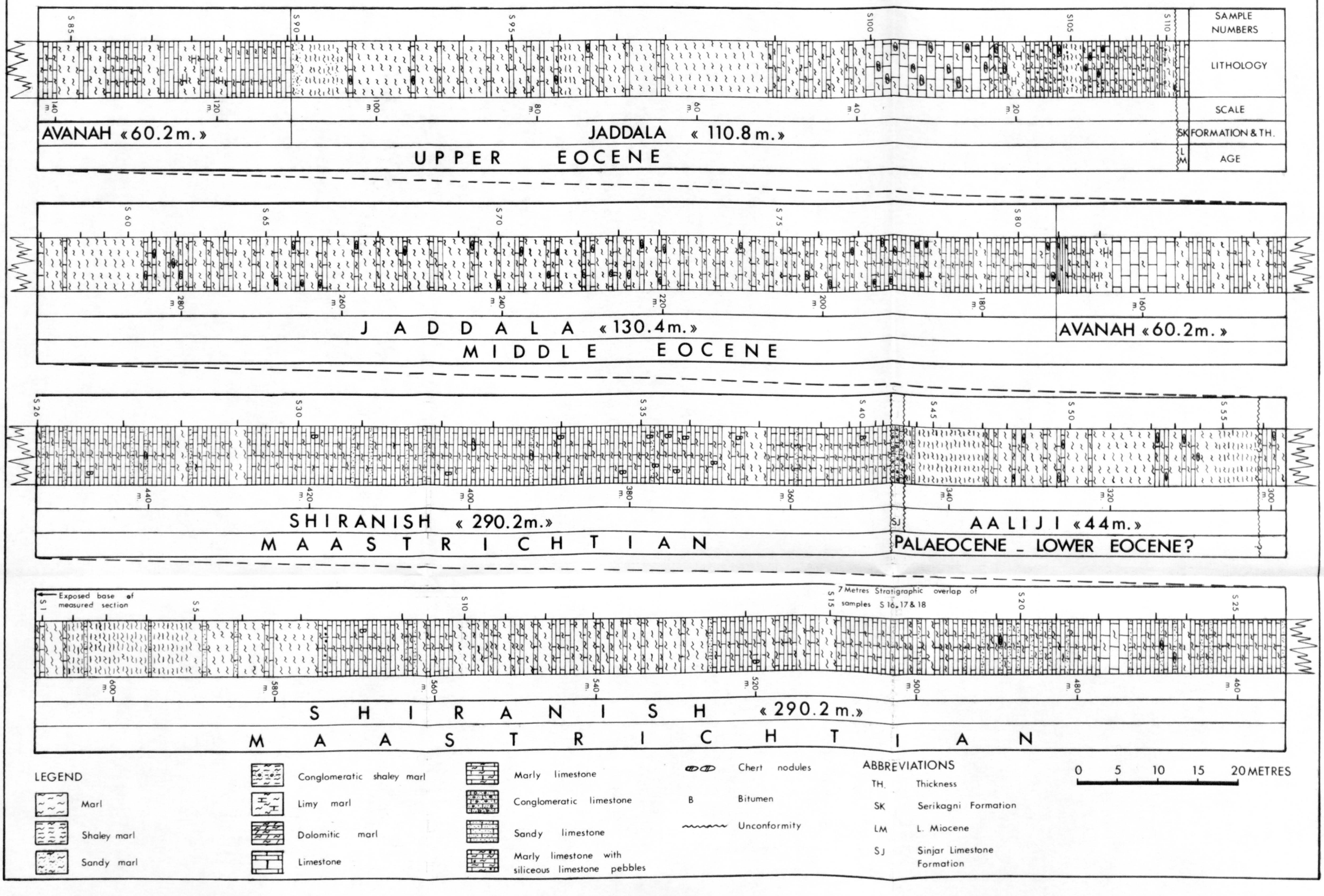
Jabel Sinjar Stratigraphic Section, measured and sampled by S.S.Al-Sheikhly, 1976.



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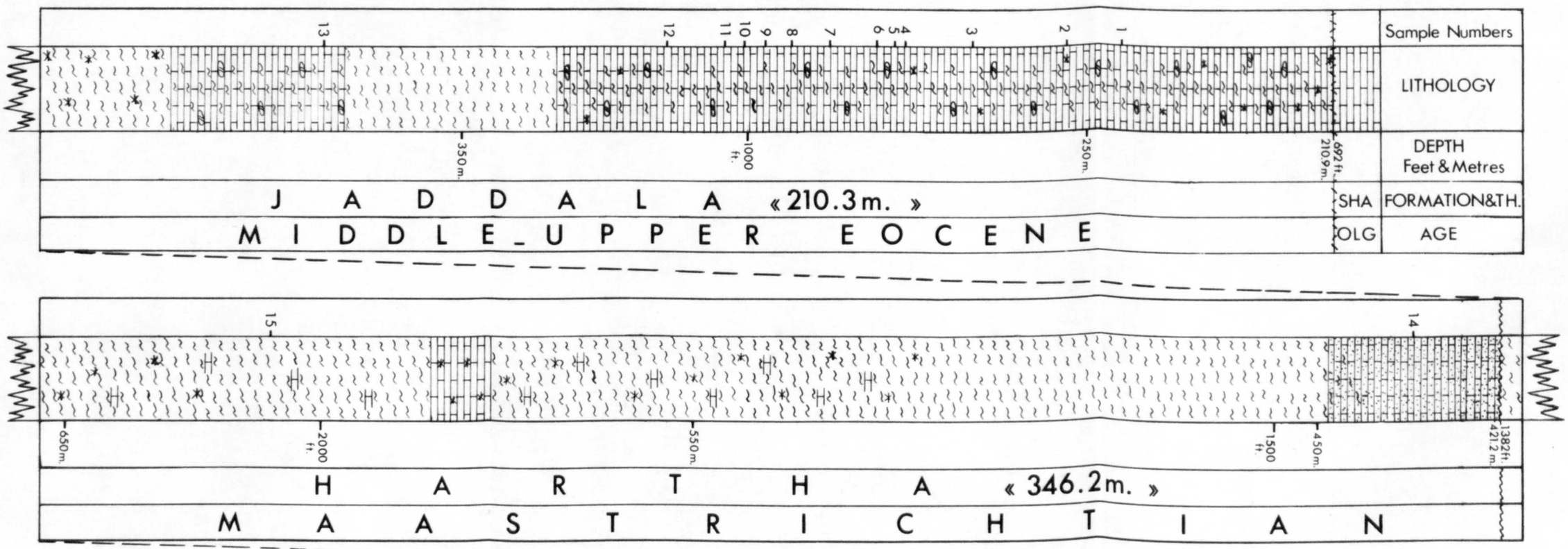
ANAH WELL _ 2 STRATIGRAPHIC SECTION, drilled & sampled by M.P.C., stored at I.N.O.C.



LEGEND

- Marl
- Limy marl
- Limestone
- Marly limestone
- Sandy marly limestone
- Sandy limestone
- Sandy limestone with pellets
- Chert nodules
- Glauconite
- B Bitumen
- Depositional break
- Unconformity

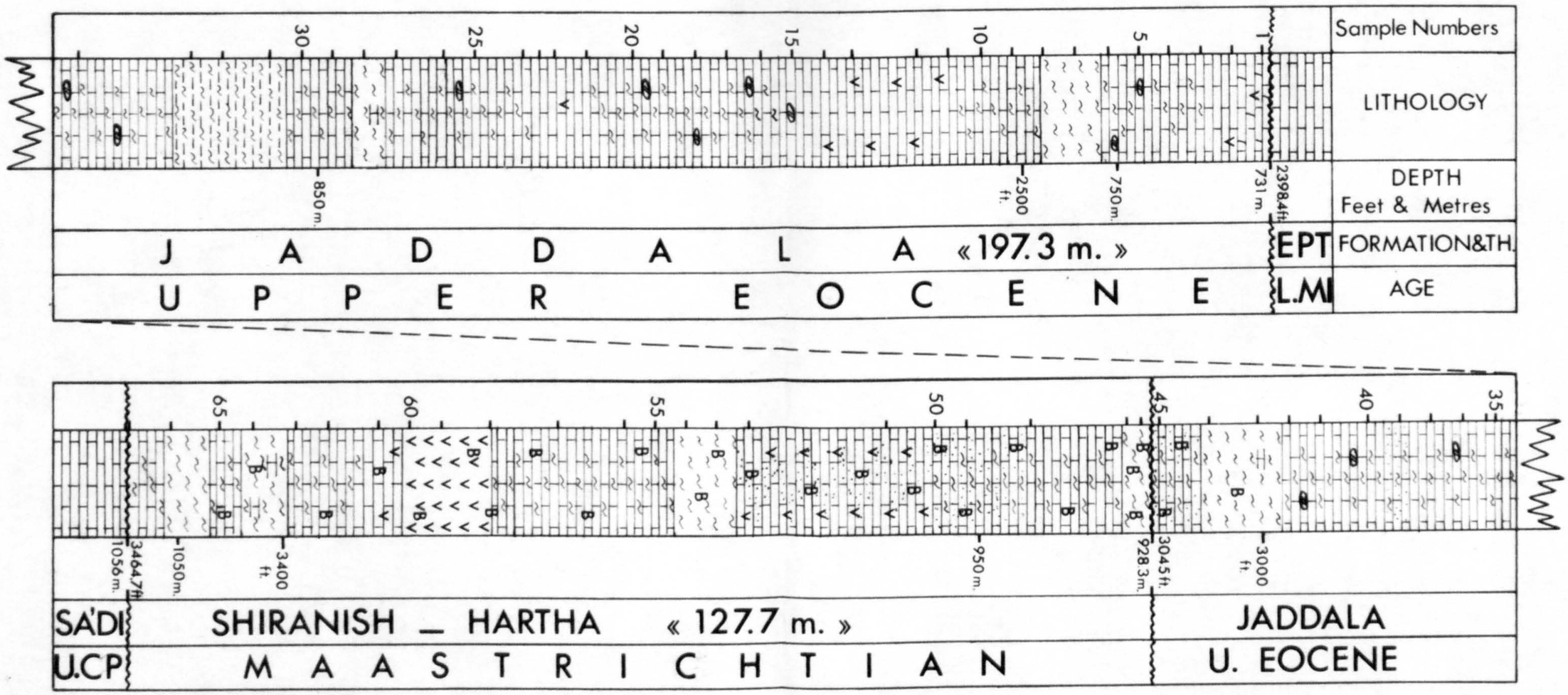
ABBREVIATIONS

M.P.C.	Mosul Petroleum Co.
I.N.O.C.	Iraq National Oil Co.
TH.	Thickness
SHA	Sheikh Alas limestone Formation
OLG	Oligocene
U.CMP.	Upper Campanian

0 25 50 75 100 FEET
0 10 20 30 METRES

GLASGOW UNIVERSITY LIBRARY

MITYAHA WELL_1 STRATIGRAPHIC SECTION, drilled, sampled & stored by I.N.O.C.



LEGEND

- Marl
- Limy marl
- Shaley marl
- Limestone
- Dolomitic limestone
- Marly limestone
- Sandy marly limestone
- Evaporitic limestone
- Evaporitic sandy limestone
- Evaporite
- Chert nodules
- B — Bitumen
- Unconformity

ABBREVIATIONS

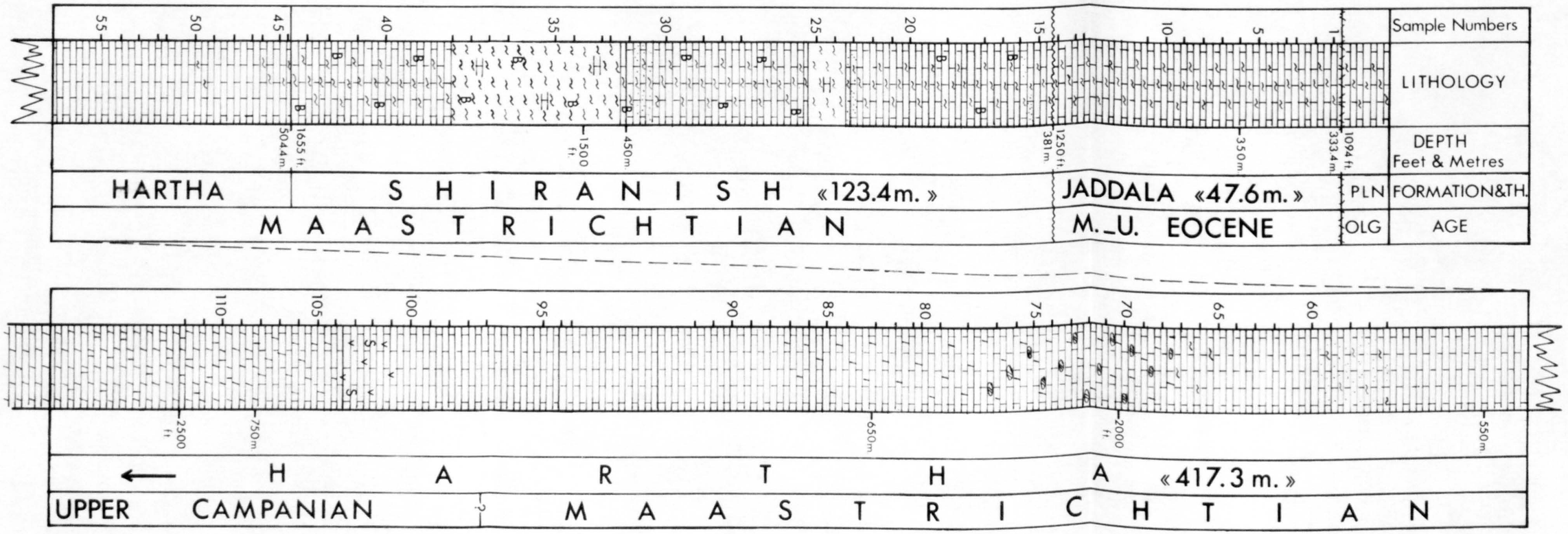
I.N.O.C.	Iraq National Oil Co.
TH.	Thickness
EPT	Euphrates limestone
L.MI	Lower Miocene
U.CP	Upper Campanian

0 25 50 75 100 FEET

0 10 20 30 METRES

GLASGOW UNIVERSITY LIBRARY

MAKHUL WELL _ 2 STRATIGRAPHIC SECTION, drilled & sampled by M.P.C., stored at I.N.O.C.



LEGEND

- Limey marl
- Limestone
- Marly limestone
- Sandy marly limestone
- Anhydritic limestone
- Dolomitic limestone
- Dolomite
- Calcitic dolomite
- Chert nodules
- B Bitumen
- S Sulfur
- Depositional break
- Unconformity

ABBREVIATIONS

M.P.C.	Mosul Petroleum Co.
I.N.O.C.	Iraq National Oil Co.
TH.	Thickness
PLN	Palani Formation
OLG	Oligocene

0 25 50 75 100 FEET
0 10 20 30 METRES

GLASGOW UNIVERSITY LIBRARY

CHEMCHEMAL WELL_2 STRATIGRAPHIC SECTION, drilled & sampled by I.P.C., stored at I.N.O.C.

LEGEND

- Marl
- Limey marl
- Red beds. (Shales, siltstones, sandy & gritty marls)
- Mudstone
- Shale
- Limey shale
- Siltstone
- Sandstone
- Basal conglomerate
- Anhydrite
- Limestone
- Muddy limestone
- Marly limestone
- Shaley limestone
- Sandy limestone
- Chert nodules
- Unconformity
- ⌖ 300 ft./90.1m. Stratigraphic overlap of samples 3 _ 19
- $ 700 ft./210.2 m. Stratigraphic overlap of samples 70 _ 86

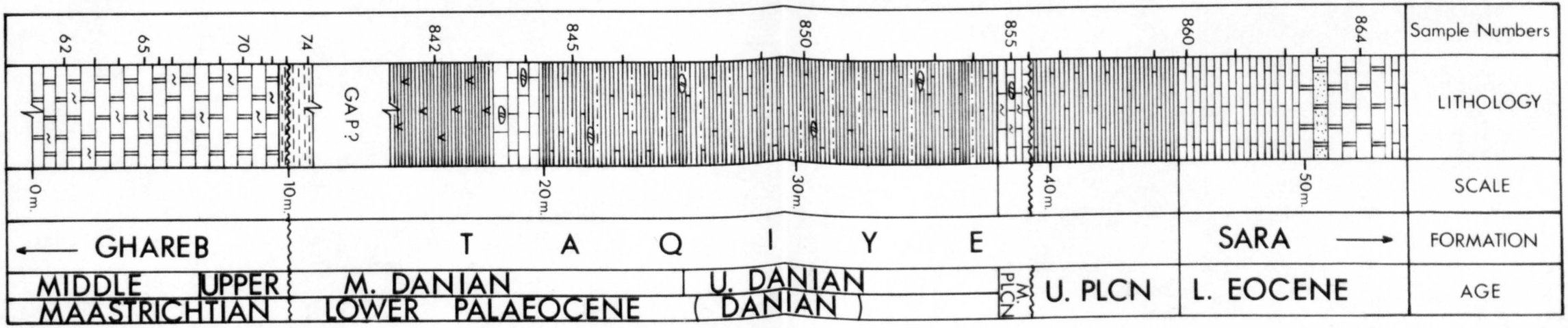
ABBREVIATIONS

I.P.C.	Iraq Petroleum Co.
I.N.O.C.	Iraq National Oil Co.
TH.	Thickness
L.FR	Lower Fars Formation
M.MI	Middle Miocene
KMT	Kometan Formation
TRN	Turonian

0 25 50 75 100 FEET
0 10 20 30 METRES

GLASGOW UNIVERSITY LIBRARY

TELL BURMA STRATIGRAPHIC SECTION, measured & sampled by A. R. FUTYAN, 1968; Stored at the British Museum (Natural History)



LEGEND

- Limestone
- Marly limestone
- Chalky limestone
- Sandy, chalky limestone
- Marly, chalky limestone
- Calcareous mudstone
- Calcareous, silty mudstone
- Gypsiferous mudstone
- Shale
- Nodules
- Unconformity

ABBREVIATIONS

- U. Upper
- M. Middle
- L. Lower
- PLCN Palaeocene

0 5 10 METRES