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**LATE PALEOCENE-EARLY EOCENE OSTRACODE ASSEMBLAGES FROM CORE UAJ-1,  
METING-JHIMPIR COAL FIELD, SINDH PROVINCE, PAKISTAN**

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# LATE PALEOCENE-EARLY EOCENE OSTRACODE ASSEMBLAGES FROM CORE UAJ-1, METING-JHIMPIR COAL FIELD, SINDH PROVINCE, PAKISTAN

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## ABSTRACT

Sixty-two ostracode species were identified from late Paleocene and early Eocene sedimentary rocks recovered from core UAJ-1. The core was taken at Jhimpir, approximately 10 km northwest of Sonda, in the Meting-Jhimpir coal field, southern Sindh Province. The 120 m interval cored includes rocks of the Meting Limestone Member of the Laki Formation, the Sohnari Formation, and rocks questionably representing the Lakhra Formation. Based on the stratigraphic distribution of the ostracode species, three assemblage zones are recognized. The lowest assemblage zone ranges from 176 to 143 m in the Sohnari/Lakhra transition. The middle assemblage zone ranges from 143 to 88 m in the upper part of the Sohnari Formation and lower part of the Meting Limestone. The highest assemblage zone ranges from 88 to 50 m, and incorporates all of the Meting Limestone present in the core. Taxa that occur in the Sohnari Formation are different from those that were used to characterize the Lakhra Formation in core UAK-5, indicating that the Sohnari in core UAJ-1 represents younger deposition.

## INTRODUCTION

Drillhole UAJ-1 is located in the Meting-Jhimpir Coal Field (fig. 1), Thatta District, Sindh Province, approximately 2.5 km northeast of the Jhimpir railway station, topographic sheet 40 C/4, at 25°02'10" N. latitude and 68°01'55" E. longitude. The total depth was 177.60 m, of which the upper 50 m was rotary drilled and the lower 127.6 m was cored.

Core UAJ-1 is from the western-most site drilled in the Meting-Jhimpir coal field under the auspices of the U.S. Geological Survey-Geological Survey of Pakistan Coal Resource Evaluation and Assessment Program (USGS-GSP COALREAP) (fig. 2). Sedimentary rocks recovered include, in descending order, the lower part of the Meting Limestone Member of the Laki Formation, the Sohnari Formation, and possibly part of the Lakhra Formation. The lowest rocks recovered in the core are marine and represent a shallow-marine facies of either the Sohnari Formation or the underlying Lakhra Formation. The Meting Limestone recovered from the core is typical of the unit, consisting predominantly of soft limestone with abundant larger benthic foraminifers that are visible in hand section. The Meting Limestone changes lithology downcore, with the appearance of interbedded siltstones and associated changes in the composition and abundance of the larger foraminifer assemblage. The upper part of the Sohnari Formation is typical of the unit. Small, delicate bivalves and gastropods are common in rocks thought to be Sohnari or Lakhra, at about 138 m. A limestone bed was encountered between 141 and 143 m. By convention, the highest occurrence of a limestone bed below the coal beds has been used to identify the top of the Lakhra Formation. In core UAJ-1, however, a coal bed occurs below this first highest limestone, suggesting that the underlying marine rocks should be placed in the Sohnari Formation. The siltstones that occur between

Figure 1.--Map showing location of coal fields in Pakistan.

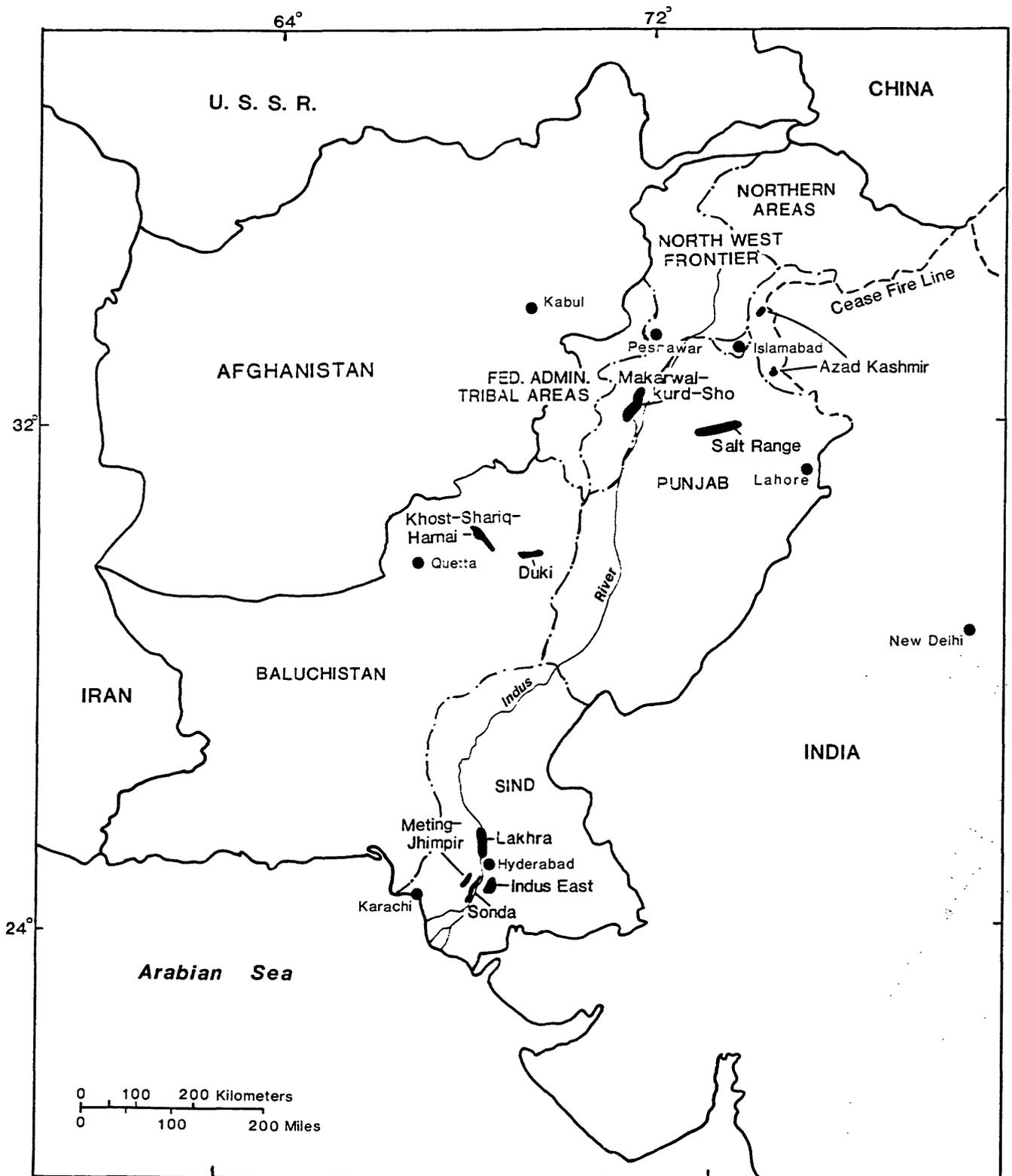
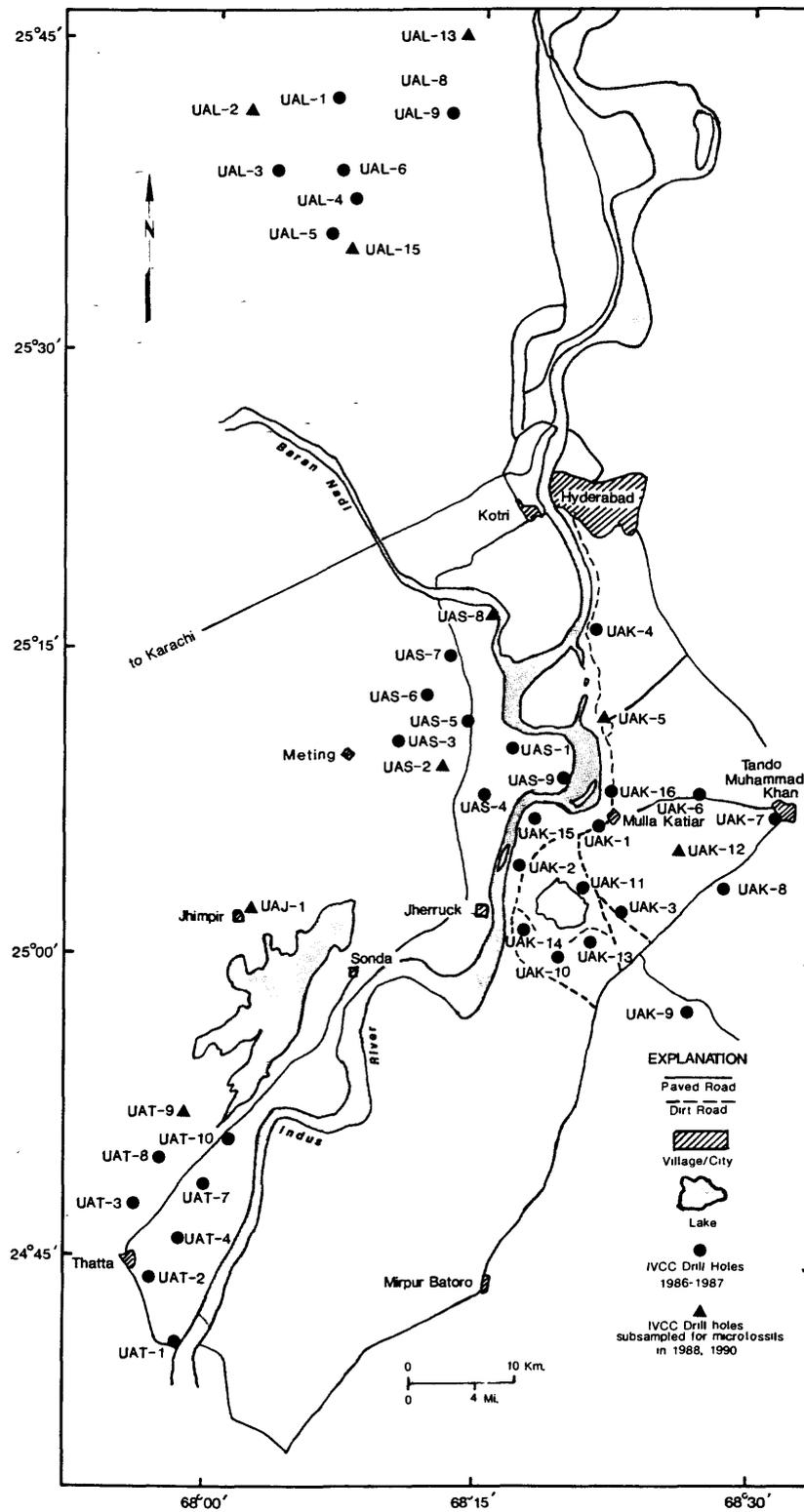


Figure 2.--Map showing location of drill holes in the Lakhra (UAL), Meting-Jhimpir (UAS, UAK, UAJ), and Sonda-Thatta (UAT) tracts. Solid triangles mark cores sampled for ostracodes.



138 m and the base of the core probably represent a marine facies in the Sohnari. A series of subsamples were taken from core UAJ-1 in 1990 for ostracode analysis in order to determine whether the ostracode assemblage is comparable to that in the Lakhra Formation, as typified in the Lakhra region, or whether the assemblage represents another fauna altogether, perhaps one unique to a marine facies of the Sohnari Formation. It was hoped that facies control could be separated from time, and thus be used to determine whether the Sohnari Formation in UAJ-1 represents a different age from that of the Lakhra Formation or whether it represents the same age as the Sohnari Formation in other boreholes.

## GEOLOGICAL SETTING

Based on the Hunting Survey Corporation (1961), sedimentary rocks underlying most of Sindh are mildly deformed into broad, gently dipping (usually less than 20 degrees) folds, and their sinuous and branching axial traces are often difficult to define. On the western side of the province, however, folds are better developed in a zone transitional to the intense deformation farther to the west. The area west of the Indus River contains well-defined, long, narrow, doubly plunging folds that form groups of linear, subparallel hills and valleys (for example, the Lakhra anticline; fig. 3). Cretaceous to Quaternary rocks crop out west of the Indus River, but east of the river most exposures are covered by modern alluvium or eolian sand. At various times during the Paleocene, shallow-marine, marginal marine, or nonmarine conditions prevailed in the study area. In contrast, only marine conditions existed during the Eocene, as indicated by the nummulitic limestones and calcareous shales deposited during this epoch.

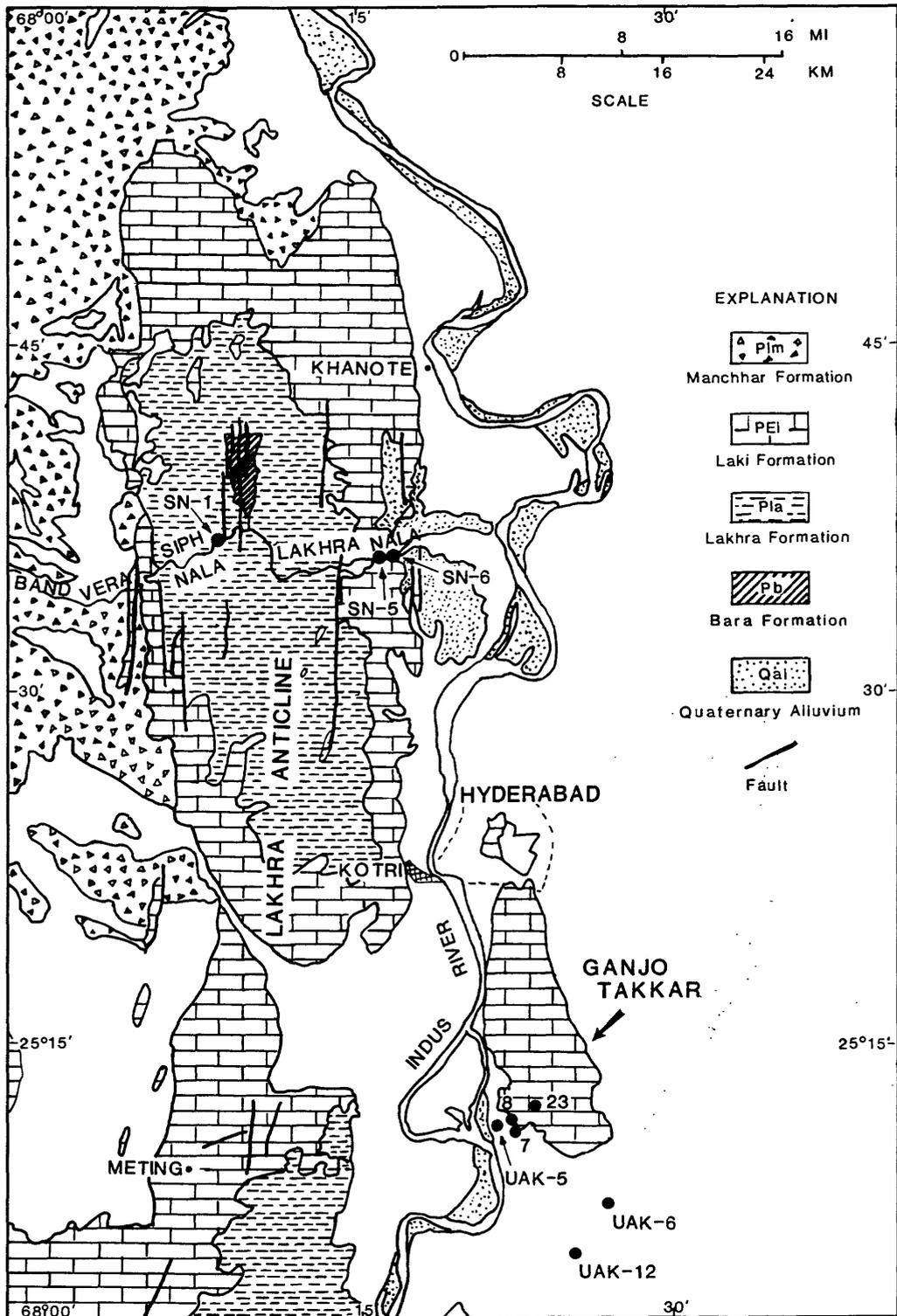
The Paleocene formations of the lower Indus Basin are placed in the Ranikot Group, which consists, in ascending stratigraphic order, of the Khadro Formation, the Bara Formation, and the Lakhra Formation. The Eocene formations include, in ascending stratigraphic order, the Sohnari Formation, the Laki Formation, the Tiyon Formation, and the Kirthar Formation.

The Lakhra Formation consists of interbedded limestone, sandstone, and shale (Hunting Survey Corporation, 1961; Shah, 1977). Sandstone predominates in the lower part of the formation, and interbedded sandstone and shale occur in the upper part. Based on larger benthic foraminifers, the Lakhra Formation has been correlated with the Lockhart Limestone and Patala Formation of Punjab Province and with the Dungan Formation of Balochistan Province.

The Sohnari Formation contains sandstone, siltstone, claystone, coal, underclay, and conglomerate (Outerbridge and others, 1991). The Sohnari Formation was known as the "Basal Laki Laterite" by some workers, who interpreted the Sohnari to be a laterite based on field observations of the red-weathering siltstones. However, the deep red color seen in outcrop is caused by impregnation of the clastic sediment by hematite; the red color does not occur below the weathered zone and is never observed in cores. The Sohnari Formation includes lateritic facies, marginal marine facies, and shallow-marine facies.

The Laki Formation consists mostly of limestone, with secondary calcareous clays, calcareous shale, and sandstone. The Laki includes the Meting Limestone, Meting Shale, and Laki Members (Shah, 1977). The Meting Limestone consists of nodular, thin-bedded, arenaceous limestone. The Meting Shale consists of interbedded shale and limestone with subordinate sandstone in the upper part. The Laki Limestone consists of nodular, often recrystallized limestone. Based on larger benthic foraminifers, the Laki Formation has been correlated with the Kharan Formation and the lower Saindak and Nisai Formation of Balochistan Province and with the Chharat Formation of Punjab Province.

Figure 3.--Map showing surface geology of the Lakhra anticline and adjacent outcrops to the south.



## PALEOECOLOGY

### Sohnari Formation

Ostracode species diversity and abundance are moderate in the basal rocks of the Sohnari (?Lakhra) in core UAJ-1 (figs. 4, 5). Between 176 and 165 m, the lithology is siltstone. The associated ostracode species are highly ornamented, and the association is indicative of normal marine conditions, probably deeper parts of the inner shelf to middle shelf.

Ostracode abundance and species diversity decrease between 165 and 157 m. This interval consists of some carbonaceous siltstone with scattered bivalves and small gastropods. The probable environment is shallow water, normal marine, and nearshore, possibly in part marginal marine, with high terrestrial input of both sediment and organic debris.

Between 143 and 137 m, ostracode species diversity is high and abundance is moderate. This interval is very fossiliferous. The lithology consists of interbedded clay shale and limestone. The ostracode species are highly ornamented and indicate middle shelf water depths.

No samples were taken between 137 and 119 m. The lithology in this interval consists of claystone, mudstone, carbonaceous rocks, sandstone, and coal, and is believed to represent nonmarine deposition.

The sample at 119.74 m contains a single ostracode species, *Pakistanella prima*, in low numbers. This taxon is believed to represent marginal marine conditions.

Between 119 and 111 m, ostracode species diversity and abundance are high. The lithology in this interval consists of claystone and foraminiferal sandstone. The ostracodes include ornamented and phytal forms, and indicate deeper inner shelf depths.

### Meting Limestone Member of Laki Formation

No samples were taken between 111 and 91 m. Between 91 and 83 m, ostracode species diversity and abundance is high, indicating favorable bottom conditions. The lithology in this interval consists of calcarenite, calcilutite, and calcareous clay. The ostracode assemblage includes phytal forms and bairdiids, and indicates deep inner shelf water depths.

The sample at 81 m is a claystone containing some pyrite. The ostracode assemblage shows low species diversity and abundance that is probably related to the pyrite formation -- either low oxygen conditions during deposition or post-depositional diagenesis. The ostracode species include phytal forms and bairdiids, and are probably indicative of inner shelf water depths.

Between 81 and 56 m, the ostracode assemblage shows moderate to low species diversity and abundance. The lithology consists of bleached limestone. The ostracode taxa imply inner shelf water depths.

At 55 m, the species diversity and abundance reaches the greatest numbers in the core. The lithology is a calcareous mudstone with glauconite. Few larger benthic foraminifers and megafossils are present. The ostracodes are highly ornamented and indicate deeper inner shelf to middle shelf water depths.

At 50 m, the lithology changes to a limestone. The ostracode species diversity and abundance drops from the peak at 55 m. The ostracode taxa include bairdiids, *Paijenborchella*, and many ornamented species that imply middle shelf water depths.

Figure 4.--Ostracode species diversity of core UAJ-1.

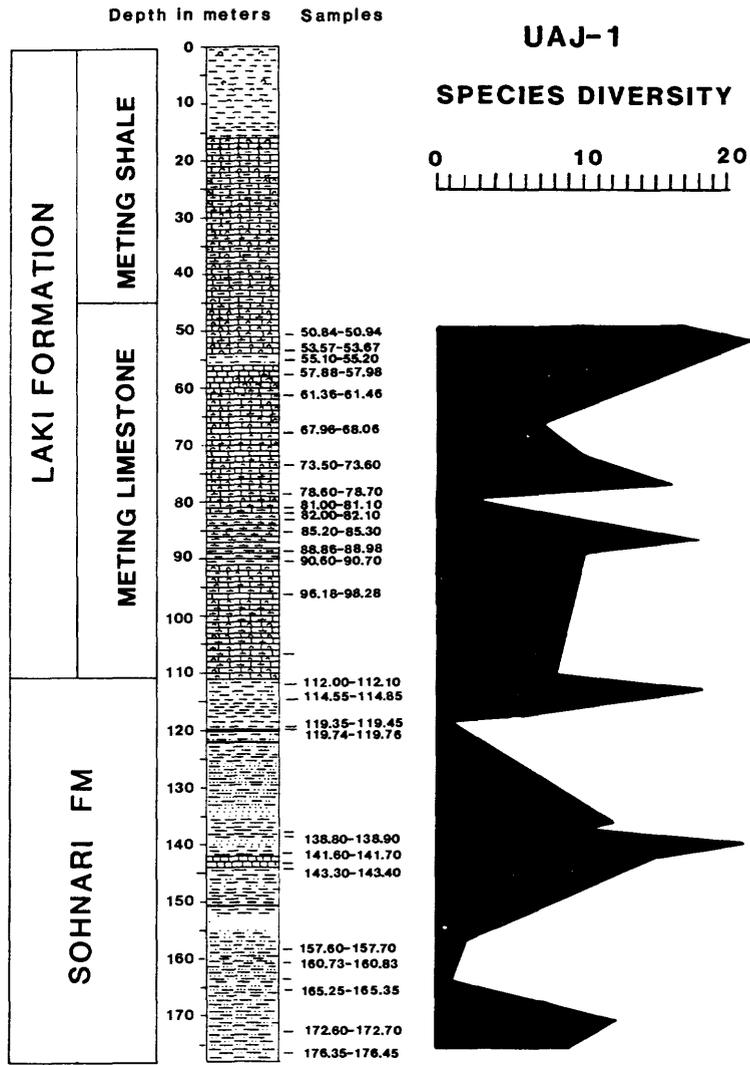
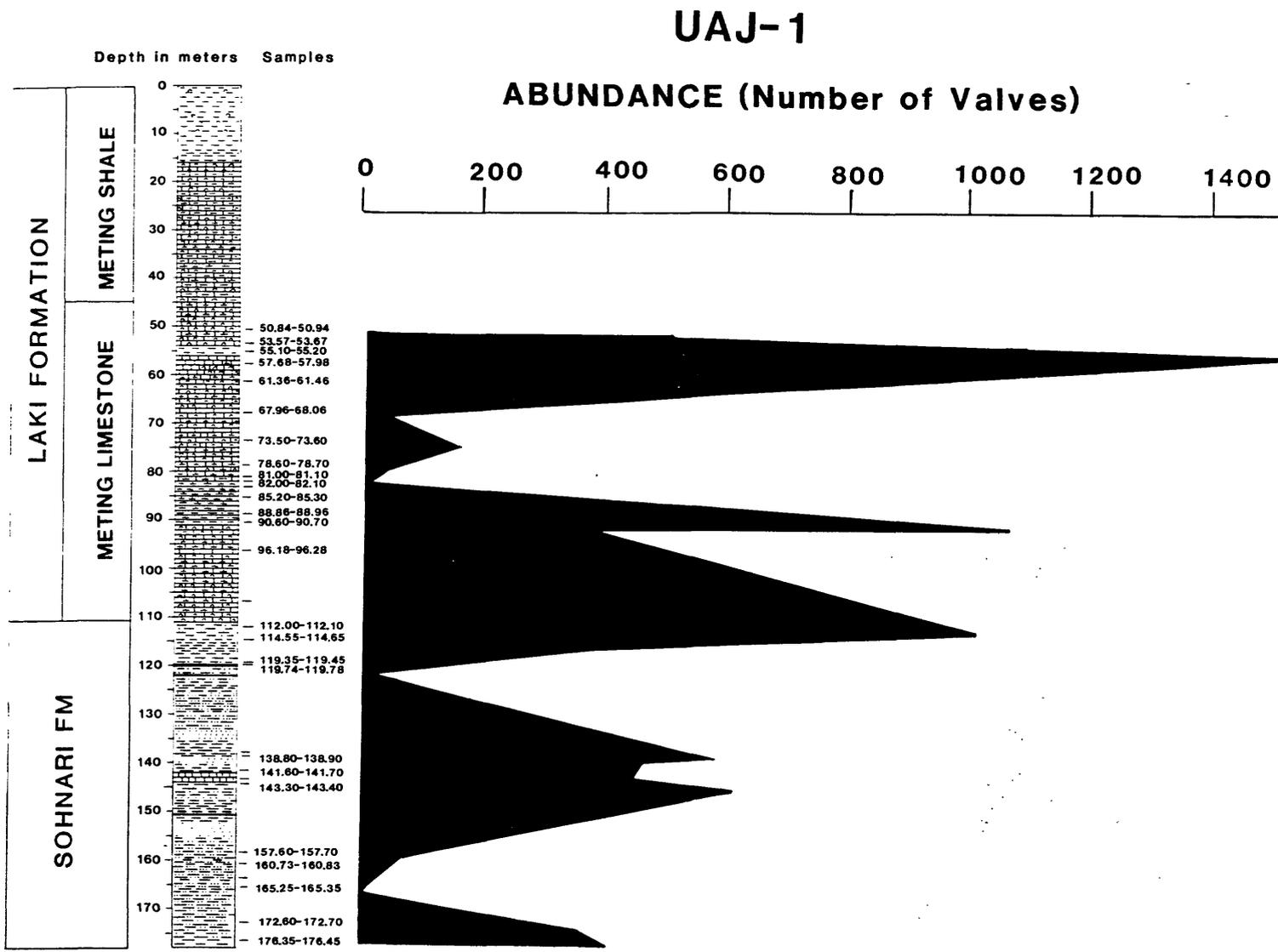


Figure 5.--Ostracode abundance of core UAJ-1.



## BIOSTRATIGRAPHY

A plot of the stratigraphic distribution of the 58 ostracode species that occur in core UAJ-1 is illustrated on figure 6. Based on the first appearance of a number of taxa, the ostracodes are subdivided into three distinct groups or assemblage zones. The first assemblage zone ranges from the base of the core to 143 m. This interval can be placed either into the Lakhra Formation or the Sohnari Formation, depending upon the lithologic definition used.

The second assemblage zone ranges from 143 m to 88.86 m. This interval is placed in the Sohnari Formation and the lower part of the Meting Limestone Member of the Laki Formation. Characteristic taxa include *Buntonia boldi*, *Anommatocythere* spp, and *Cytherura* sp. 1.

The third assemblage zone ranges from 88.86 m to the top of the core at 50.84 m. This interval is placed into the Meting Limestone. Characteristic taxa include *Paijenborchella* spp. and *Phlyctocythere* sp. 1.

Several species have been previously recognized, either in the published literature or in our collections from Pakistan. Taxa that can be used in correlations with Rajasthan, India, include the following: *Buntonia boldi*, which occurs in the Sohnari, Meting Limestone, Meting Shale, and Khuiala Formation; *Occultocythereis subspinellosa*, which occurs in the Sohnari, Meting Limestone, Meting Shale, Lakhra Formation, Lockhart Limestone, and Khuiala Formation; and *Schizocythere appendiculata*, which occurs in the Sohnari, Meting Limestone, Patala Formation, Nammal Formation, Khuiala Formation, and Bandah Formation.

Taxa that are believed to be temporally significant in UAJ-1 include *Argilloecia* sp. 1 (Sohnari Formation, Meting Limestone), *Stigmatocythere* sp. 2 (Sohnari Formation, Patala Formation, Nammal Formation), *Caudites* sp. 2 (Meting Limestone, Meting Shale), *Phlyctocythere* sp. 1 (Meting Limestone), and *Paijenborchella* sp. 2 (Meting Limestone, Meting Shale).

None of the diagnostic species that we use to define the Lakhra Formation in core UAK-5 are present in core UAJ-1, leading us to suggest that the Sohnari/Lakhra rocks in the basal part of UAJ-1 are younger than the rocks of the Lakhra Formation in core UAK-5. Pollen correlations suggest, however, that the lowermost cored Sohnari of core UAJ-1 is correlative with the upper part of the Lakhra Formation of core UAK-5 (Frederiksen, 1990).



## SYSTEMATICS

[Only the species that are illustrated on the plates are described in this report. The remaining undescribed species have notations on their stratigraphic occurrence in core UAJ-1. The undescribed taxa are either too rare or too poorly preserved to be illustrated and may be described later if more specimens are recovered from outcrop and/or other cores.]

Class OSTRACODA Latreille, 1806  
Order PODOPIDA Mueller, 1864  
Suborder PODOCOPINA Sars, 1866  
Superfamily BAIRDIACEA Sars, 1888  
Family BAIRDIIDAE Sars, 1888  
Genus BAIRDIA McCoy, 1844

*Type species.*--*Bairdia curtus* McCoy, 1844

*Bairdia sp. 1*  
Plate 3, figure 12

*Description.*--In lateral view, right valve is subtriangular in shape. Dorsal margin is arched, with straight anterodorsal and posterodorsal portions; anterior margin is rounded, with the greatest width developed dorsal of midline; ventral margin is nearly straight, with a shallow concavity; posterior margin has a wide, blunt caudal process located ventral of midline. No cardinal angles. Greatest length just ventral of valve midline; greatest height anterior of midline.

Valve surface is smooth; no external ornamentation. Numerous normal pores are scattered over the surface.

*Occurrence.*--Core UAJ-1: 172.6, 143.3, 141.60 114.55 m; Sohnari Formation.

*Bairdia sp. 2*  
Plate 3, figure 11

*Description.*--In lateral view, right valve forms an elongate, subtriangular to subtrapezoid shape. Dorsal margin is broadly arched; anterior margin with straight anterodorsal and anteroventral parts that incline sharply toward the middle of the margin, where a pronounced process dorsal of midline marks the greatest extent of the margin; ventral margin with a distinct, shallow concavity; posterior with a rounded, pronounced median caudal process; posterodorsal margin is straight and extends obliquely up to the dorsal margin. Greatest length through midline of valve; greatest height through middle of valve.

Ornamentation consists of small, shallow pits that cover the valve surface. Numerous normal pores occur between the ornament pits.

*Occurrence.*--Core UAJ-1: 143.3, 78.6 m; Sohnari Formation, Meting Limestone.

***Bairdia sp. 3***

*Occurrence*.--Core UAJ-1: 78.6, 73.5, 67.96, 50.84 m; Meting Limestone.

***Bairdia sp. 4***

*Occurrence*.--Core UAJ-1: 78.6, 50.84 m; Meting Limestone.

***Bairdia sp. 5***

*Occurrence*.--Core UAJ-1: 78.6, 73.5, 67.96, 55.1, 50.84 m; Meting Limestone.

**Superfamily CYPRIDACEA Baird, 1845  
Family PONTOCYPRIDIDAE G.W. Mueller, 1894  
Genus ARGILLOECIA Sars, 1866**

*Type species*.--*Argilloecia cylindrica* G.W. Mueller, 1894

***Argilloecia sp. 1*  
Plate 3, figure 19**

*Aglaioocypris sp.* Sohn, 1959, p. 61, pl. 1, figs. 7-9.

*Description*.--In lateral view, right valve is elongate, subcylindrical in shape. Dorsal margin is broadly arched; anterior and posterior margins are smoothly and evenly rounded; ventral margin is convex, with no concavity. No cardinal angles are developed. Greatest length is through valve midline; greatest height is just anterior of midline.

Valve surface is smooth.

*Occurrence*.--Core UAJ-1: 176.35, 172.6, 88.86, 73.5, 55.1, 50.84 m; Sohnari Formation, Meting Limestone. Meting Limestone at Meting Railway Station.

**Family PARACYPRIDIDAE Sars, 1923  
Subfamily PARACYPRIDINAE Sars, 1923  
Genus PARACYPRIS Sars, 1866**

*Type species*.--*Paracypris polita* Sars, 1866

***Paracypris sp. 1*  
Plate 3, figure 15**

*Paracypris sp. 1* Fatmi and Brouwers, in press, p. 11, pl. 5, figs. 12, 14.

*Description.*--In lateral view, left valve is elongate, subellipsoidal in shape. Dorsal margin is broadly arched, consisting of three straight sections; anterior margin is rounded, somewhat protracted; ventral margin is nearly straight, inclined slightly toward the posterior; posterior margin is drawn-out, terminating in a pointed caudal process. Greatest length ventral of midline, through caudal process; greatest height through valve midline.

No ornamentation; valve surface is smooth.

*Occurrence.*--Core UAJ-1: 176.35, 172.6, 141.6, 137.9, 78.6 m; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone, Lakhra Formation.

***Paracypris sp. 2***

*Occurrence.*--Core UAJ-1: 88.86 m; Meting Limestone.

Superfamily CYTHERACEA Baird, 1845  
Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948  
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948  
Genus SCHIZOPTOCYTHERE Siddiqui and Al-Furaih, 1981

*Type species.*--*Schizoptocythere circumspinososa* Siddiqui and Al-Furaih, 1981

***Schizoptocythere sp. 1***

Plate 2, figure 10

*Description.*--In lateral view, left valve is subtrapezoidal in shape. Dorsal margin is straight, angles down sharply toward posterior; anterior margin is rounded; ventral margin is sinuous, with a broad, well-developed concavity; posterior margin is drawn-out. Dorsal and ventral margins converge toward posterior. Posterodorsal corner is sharp, forming an obtuse angle. Greatest length is through midline of valve; greatest height is through anterior hinge element.

Ornamentation consists of spines and denticles. The valve surface is smooth. A subtle ridge or swelled area forms an arcuate shape along the ventral margin. Anterior margin with numerous even-spaced spines extending along the entire margin. Ventral margin with three large, long spines and several small denticles. Posterior margin with six large, long spines interspersed with several small denticles. Dorsal margin with two prominent spines in the middle of the margin. All of the spines contain a radial pore canal. Prominent, smooth, rounded eye tubercle.

*Occurrence.*--Core UAJ-1: 176.35, 172.6, 143.3, 141.6 m; Sohnari Formation.

***Schizoptocythere sp. 2***

Plate 2, figures 11, 12

*Schizoptocythere sp. 1* Brouwers and Fatmi, 1992, pl. 4, fig. 5.

*Description.*--In lateral view, left valve is elongate, subrectangular to subtriangular in shape. Dorsal margin is nearly straight, angling obliquely down toward the posterior; anterior margin is smoothly curved;

ventral margin broadly curved, trending obliquely up toward the posterior; posterior margin triangular in shape, somewhat protracted. Dorsal and ventral margins converge toward the posterior. Greatest length is through the valve midline; greatest height is through anterior hinge element. Males differ from females in being slightly less high and more tapered at the posterior.

Ornamentation consists of spines and denticles. The valve surface is smooth. Anterior margin with numerous long spines interspersed with smaller denticles. Ventral margin with three median spines grouped together; dorsal margin with a single median spine. Posterior margin with a single, large, long spine located at the posterodorsal corner and six long spines located at the posteroventral margin. A large, prominent eye tubercle extends well above the dorsal margin. Ventral area with a subtle swelling.

*Occurrence.*--Core UAJ-1: 55.1, 50.84 m; Meting Limestone.

Punjab Province--Nammal Gorge section: Hangu Formation, Lockhart Limestone. Dandot core 14: Patala Formation. Nilawan section: Lockhart Limestone.

Tribe ECHINOCYTHERIDEINAE Hazel, 1967  
Genus ALOCOPOCYTHERE Siddiqui, 1971

*Type species.*--*Alocopocythere transcendens* Siddiqui, 1971

*Alocopocythere transcendens* Siddiqui, 1971  
Plate 1, figure 3

*Description.*--In lateral view, left valve is elongate, subtriangular in shape. Dorsal margin is uneven, arched; anterior margin is smoothly curved; ventral margin is sinuous, with a pronounced median concavity and convexity at the anterior and posterior; posterior margin is acute, with a pointed caudal process. Dorsal and ventral margins converge posteriorly, forming an acute posterior end. No distinct cardinal angles. Greatest length at midline, through caudal process; greatest height just anterior of midline.

Ornamentation consists of reticulation, ridges, and denticles. The reticulation is strong and well-developed, forming subrounded and subrectangular pits. Reticulation covers nearly the entire valve; an arcuate region along the anterior and posterior margins is smooth. The reticulation pattern is chaotic except along the ventral and anterior margins, where a row of reticulation pits parallels the margins. An arcuate ridge, moderately developed, occurs near the ventral margin. A short dorsal ridge overhangs the margin and obscures the valve edge. Elongate, smooth, arcuate sulcus originates at the middle of the dorsal margin and trends obliquely toward the anteroventer. Short, blunt marginal denticles at caudal process; six short, blunt marginal denticles along anterior.

*Occurrence.*--Core UAJ-1: 112.0, 90.60, 88.86, 55.10 m; Meting Limestone.

*Alocopocythere sp. 1*  
Plate 1, figures 1, 5

*Alocopocythere sp. 3* Fatmi and Brouwers, in press, p. 13, pl. 1, figs. 2, 3.

*Description.*--In lateral view, left valve is subrectangular in shape. Dorsal margin is nearly straight, partly obscured by an overhanging ridge; anterior margin is smoothly curved; ventral margin is broadly sinuous, with a shallow concavity; posterior margin is somewhat drawn-out, with a subtle, small caudal process. Posterodorsal corner is rounded, weakly developed; anterodorsal corner is rounded, obtuse, extending

above the dorsal margin. Greatest length just dorsal of valve midline; greatest height through anterodorsal corner. Males differ from females in having a longer and lower valve shape.

Ornamentation consists of reticulation, tubercles, ridges, and denticles. Primary ornament is reticulation, which covers most of the valve surface. The reticulation is moderately developed, poorly organized into a radial and concentric pattern. The dorsal-most and ventral-most reticulation ridges are more strongly developed, with the dorsal ridge overhanging the margin and the ventral ridge angling obliquely up toward the posterior margin. The reticulation pits are ovoid to narrow ellipsoid in shape. Strong, deep, crescentic sulcus extends along the anterior side of the dorsal ridge, trending below the anterodorsal corner. The anterior and posterior margins have a smooth, flat area adjacent to the margin; the anterior margin has weak development of elongate pits oriented parallel to the margin. A smooth, narrow rim parallels the anterior margin. Smooth, ovoid eye spot. Anterior margin with nine small marginal denticles; posteroventer margin with a large spine extending beyond the margin.

*Occurrence.*--Core UAJ-1: 176.35, 141.6, 138.8, 137.9, 114.55 m; Sohnari Formation. Core UAK-5: Meting Shale.

***Alocopocythere sp. 2***

Plate 1, figure 4

*Description.*--In lateral view, left valve is elongate, subrectangular to subtrapezoid in shape. Dorsal margin is nearly straight, angling down toward posterior; anterior margin is rounded; ventral margin is sinuous, with a shallow, weak concavity anterior of mid-margin followed by a broad convex region from the middle of the margin to the posterior; posterior margin is drawn-out, with the greatest width dorsal of midline. Strong, protruding, rounded anterodorsal cardinal angle. Greatest length is through valve midline; greatest height is through anterodorsal corner.

Ornamentation consists of reticulation, ridges, and denticles. The reticulation is developed in the middle of the valve and is not well organized. A pattern of reticulation ridges trend obliquely from posterodorsum to anteroventrum. The reticulation forms rounded, ovoid, and ellipsoidal pits. The valve margins are not ornamented; the anterior and posterior margins have wide, flat, smooth regions. Normal pores are located on the reticulation ridges. A wide, shallow, smooth sulcus originates posterior of the anterodorsal cardinal angle, at the dorsal margin, trends obliquely toward the anteroventer, and terminates near the anterior margin. Weakly developed subcentral tubercle, covered with reticulation. Four to five weak, small marginal denticles at posterior; numerous small denticles at anterior margin, interspersed with a few longer marginal spines. Ovoid, smooth eye spot.

*Occurrence.*--Core UAJ-1: 119.35 m; Sohnari Formation.

***Alocopocythere sp. 4***

Plate 2, figure 1

*Buntoniid sp. 1* Fatmi and Brouwers, in press, p. 16, pl. 1, fig. 10.

*Description.*--In lateral view, left valve is subtriangular in shape. Dorsal and ventral margins curve sharply toward the posterior, forming a pointed posterior end. Dorsal margin unevenly curved; anterior margin rounded, with greatest curvature ventral of midline; ventral margin forms a convex shape, rounded upward at the posterior; posterior margin acute, with broad, truncated caudal process. Pronounced, rounded, obtuse anterodorsal corner. Greatest length anterior of midline, through caudal process; greatest height

through anterodorsal corner.

Ornamentation consists of reticulation, spines, and denticles. Primary ornament consists of reticulation, poorly organized, oriented in a spiral pattern from the middle of the valve outward. Pits are shallow and ovoid in shape, largest in the middle of the valve; small pits along the anterior margin. Posterior margin lacks reticulation pits. Short, weak sulcus trends obliquely from the dorsal margin anteroventrally. Weak, low subcentral muscle scar tubercle; pitting is weak in this region. Scattered short spines over valve surface, located on reticulation ridges between pits. Short spines along dorsal and ventral margins; posteroventral marginal denticles; overlapping rows of short mamillate spines along the anterior margin. Large, smooth, elongate eye tubercle.

*Occurrence.*--Core UAJ-1: 90.6 m; Meting Limestone. Core UAK-5: Meting Shale.

***Alocopocythere sp. 5***

Plate 1, figure 2

*Alocopocythere transcendens* Fatmi and Brouwers, in press, p. 13, pl. 1, fig. 4.

*Description.*--In lateral view, right valve is trapezoid in shape. Dorsal margin is nearly straight, angling down slightly toward the posterior; anterior margin is smoothly rounded; ventral margin is sinuous, with a moderate, narrow concavity; posterior margin is drawn-out, with a broad caudal process. No distinct cardinal angles. Greatest length through midline of valve; greatest height through anterodorsal corner.

Ornamentation consists of reticulation, tubercles, and denticles. Primary ornament is reticulation that covers most of the valve surface. The reticulation ridges form shallow, ovoid pits. The anterior, ventral, and posterior margins are smooth, with a broad, flattened rim. The reticulation is poorly organized at the anterior and radially arranged at the posterior. Weak subcentral muscle tubercle. The dorsal-most ridge overhangs the margin, forming an irregular appearance in lateral view. Prominent eye tubercle extends beyond the dorsal margin. Anterior with numerous small, sharp marginal denticles; posteroventral corner with a single spine.

*Occurrence.*--Core UAJ-1: 90.6, 88.86, 55.1 m; Meting Limestone. Core UAK-5: Meting Limestone.

***"Alocopocythere" sp. 1***

Plate 3, figures 1, 2

*Mosaeleberis sp. 3* Fatmi and Brouwers, in press, p. 38, pl. 7, figs. 1, 3.

*Phalcocythere sp. 2* Brouwers and Fatmi, 1992, pl. 3, fig. 8.

*Description.*--In lateral view, left valve is elongate, subrectangular in shape. Dorsal margin is straight; anterior margin is rounded, somewhat protracted; ventral margin is nearly straight, with a broad, very shallow concavity; posterior margin is truncated and nearly vertical. The posterodorsal corner is rounded, obtuse; the anterodorsal corner is broad, obtuse, and poorly defined. Greatest length is through midline of valve; greatest height is through anterior hinge element. Right valve is similar, but differs by having a concave dorsal margin and more pronounced concavity.

Ornamentation consists of reticulation, tubercles, denticles, and ridges. Primary ornament is reticulation, which covers most of the valve surface. The reticulation is moderately developed, with rounded ridges. Pits formed are rounded ovoid to triangular in shape. Crescentic region along the anterior margin is nearly free of reticulation, consisting of a flattened region with a radially-arranged series of pits. Weak,

arcuate ridge along the ventral margin. Short ridge extends from the anterodorsal corner nearly to the posterodorsal corner, overhanging the middle of the margin. Weak subcentral muscle tubercle, covered with reticulation. Short, triangular sulcus extends obliquely from the middle of the dorsal margin toward the anterior margin, occurring anterior and adjacent to the short dorsal ridge. Small, smooth eye spot. Posteroventral margin and entire anterior margin with small, sharp denticles.

*Occurrence.*--Core UAJ-1: 176.35, 172.6, 165.25, 157.6, 141.6 m; Sohnari Formation. Core UAK-5: Meting Shale, Meting Limestone.

Punjab Province--Nammal Gorge section: Patala Formation. Dandot core 14: Patala Formation.

**Tribe MAURITSININI Deroo, 1962**  
**Genus ANOMMATOCY THERE Sohn, 1959**

*Type species.*--*Anommatocythere microreticulata* Sohn, 1959

***Anommatocythere sp. 1***  
Plate 2, figure 13

*Description.*--In lateral view, left valve is somewhat elongate, subrectangular in shape. Dorsal margin is nearly straight, angling down slightly toward the posterior; anterior margin is smoothly curved; ventral margin is sinuous, with a broad, shallow concavity; posterior margin with a wide, blunted caudal process. No distinct cardinal angles. Greatest length through caudal process; greatest height through anterior hinge element.

Ornamentation consists of reticulation and denticles. Reticulation covers nearly the entire valve. The anterior margin has a narrow, arcuate smooth area, and the posterior margin has a wider, triangular smooth area. The reticulation ridges are broad and high, and the pits are correspondingly deep. The reticulation pits are distinctive in outline, forming various shapes (e.g., U-, V-, W-, Y-shapes). Subtle, smooth eye spot. Arcuate ventral ridge extends nearly to the ventral margin. Evenly-spaced, small marginal denticles along caudal process and posteroventral margin; numerous, small, evenly-spaced marginal denticles along most of the anterior margin.

*Occurrence.*--Core UAJ-1: 143.3, 141.6 m; Sohnari Formation.

***Anommatocythere sp. 2***

*Occurrence.*--Core UAJ-1: 78.6 m; Meting Limestone.

**Tribe TRACHYLEBERINI Sylvester-Bradley, 1948**  
**Genus PHALCOCY THERE Siddiqui, 1971**

*Type species.*--*Cythere horrescens* Bosquet, 1852

***Phalcocythere sp. 1***

*Occurrence.*--Core UAJ-1: 143.3, 141.6 m; Sohnari Formation.

***Phalcoythere sp. 2***

Plate 3, figure 3

*Description.*--In lateral view, left valve is elongate, subrectangular in shape. Dorsal margin is nearly straight; anterior margin is evenly rounded; ventral margin is broadly concave, with a shallow, elongate concavity; posterior margin is truncated, nearly vertical. Dorsal and ventral margins are parallel. Anterodorsal cardinal angle is rounded, obtuse; posterodorsal cardinal angle is rounded and forms a right angle. Greatest length through midline of valve; greatest height through anterior hinge element.

Ornamentation consists of reticulation, tubercles, ridges, and denticles. Primary ornament is reticulation, which covers most of the valve. The reticulation is well-developed, moderate in scale, forming rounded, ovoid pits. The reticulation is not well organized. The posterior and anterior margins have a weaker reticulation, consisting of shallow pits parallel to the valve margin. Dorsal ridge proceeds from below the anterodorsal corner to the margin, overhanging the median portion. A sinuous, triangular-shaped sulcus parallels the anterior end of the dorsal ridge, extending to below the anterodorsal corner. Subtle subcentral muscle tubercle. Anterior and posterior margins with a narrow, smooth rim along the margin.

*Occurrence.*--Core UAJ-1: 88.86, 55.1 m; Meting Limestone.

***Phalcoythere sp. 3***

Plate 1, figures 13, 14

*Description.*--In lateral view, left valve is subquadrate in shape. Dorsal margin is broadly arched; anterior margin is smoothly and evenly curved; ventral margin is sinuous, with a well-developed selvage; posterior margin is somewhat drawn-out posteroventrally and curves obliquely posterodorsally. No distinct cardinal angles. Greatest length just ventral of midline; greatest height through anterodorsal corner. Males differ from females in having a longer, lower valve shape.

Ornamentation consists of reticulation, spines, and tubercles. Primary ornament is reticulation, which covers most of the valve surface. The reticulation is moderately developed, forming shallow, ovoid pits, most of comparable size. Reticulation is arranged concentrically at anterior and somewhat radially at posterior. Many of the ridge intersections have a short spine extending above the valve surface. Large, nearly smooth subcentral muscle tubercle. Anterior end with a smooth, flattened region and a thin raised ridge parallel to the valve edge. Narrow, smooth, flat flange extends along the ventral margin. Posteroventer with an arcuate smooth region. Subdued, smooth, ovoid eye spot. An L-shaped narrow ridge proceeds from the posterodorsal corner down to the posteroventral corner, then parallels the ventral margin. Short, overhanging dorsal ridge. Anterior margin with numerous short, angular denticles. Posteroventer with two rows of short spines.

*Occurrence.*--Core UAJ-1: 73.5, 50.84 m; Meting Limestone.

***Phalcoythere rete Siddiqui, 1971***

Plate 1, figure 18

*Phalcoythere rete Siddiqui, 1971, p. 59, pl. 31, figs. 5-12.*

*Description.*--In lateral view, right valve is elongate, subquadrate in shape. Dorsal margin is straight, angling slightly down toward the posterior; anterior margin smoothly rounded, with maximum extent slightly ventral of midline; ventral margin sinuous, with a broad, pronounced concavity; posterior margin drawn-out, with a sharp caudal process. Anterodorsal corner broadly rounded, indistinct; posterodorsal corner obtuse. Greatest length through midline of valve; greatest height through anterodorsal corner.

Ornamentation consists of reticulation, spines, and denticles. Primary ornament is reticulation, which covers the valve surface. The ridges are low and wide, forming shallow, ovoid pits. The reticulation is not well organized. Short spines are present at many of the ridge intersections, superimposed on the reticulation. Reticulation is weakly developed along the anterior and posterior margins, consisting of narrow radial ridges that are probably reflecting the trace of radial pore canals. Small spines or denticles occur along all of the margins, creating an irregular profile in lateral view. Anterior margin with a row of short spines along the rim, followed by numerous denticles that become more blunted at the anteroventral margin. Posteroventral margin with several rows of blunt spines interspersed with several small denticles.

*Occurrence.*--Core UAJ-1: 50.84 m; Meting Limestone.

Balochistan Province--Dungan Formation section, Sor Range (Upper Paleocene).

### Genus ACANTHOCYHEREIS Howe, 1963

*Type species.*--*Acanthocythereis araneosa* Howe, 1963

#### *Acanthocythereis* sp. 1

Plate 2, figures 6, 7, 9

*Description.*--In lateral view, left valve is elongate, subrectangular to subtrapezoid in shape. Dorsal margin is nearly straight, inclined slightly toward the posterior; anterior margin is smoothly curved; ventral margin with a pronounced concavity; posterior margin somewhat truncated, with a short, straight posterodorsal part and a rounded posteroventral part. Anterodorsal corner is rounded, obtuse, weakly developed; posterodorsal corner is sharp, forming an obtuse angle. Greatest length through midline of valve; greatest height through anterodorsal corner. Males differ from females by their longer, lower shape and a higher posterior end.

Ornamentation consists of reticulation, spines, tubercles, and denticles. Primary reticulation consists of a reticulation network that is radially and concentrically arranged. The reticulation forms rounded ovoid to ellipsoidal pits; the largest pits are arranged longitudinally along the valve margins. Superimposed on the reticulation ridges are numerous spines of various sizes, ranging from fairly prominent spines to very small denticles. Numerous spines of various sizes occur on the valve margins. The dorsal and ventral margins include several rows of small spines; the anterior and posterior margins include a mixture of small spines and long spines. Outstanding among the larger spines are spines at the four corners of the valve. Large, smooth eye tubercle extends well above the dorsal margin. Weak subcentral muscle tubercle, covered with reticulation.

*Occurrence.*--Core UAJ-1: 176.35, 172.6, 143.3, 141.6, 138.8, 137.9 m; Sohnari Formation.

#### *Acanthocythereis* sp. 2

Plate 2, figures 4, 5

*Acanthocythereis* sp. 1 Fatmi and Brouwers, in press, p. 24, pl. 2, figs. 4, 5.

*Description.*--In lateral view, left valve is elongate, subrectangular in shape. Dorsal margin is nearly straight, inclined slightly toward the posterior; anterior margin is evenly rounded; ventral margin is broadly concave; posterior margin is truncated and rounded. Anterodorsal cardinal angle extends above the valve margin; posterodorsal cardinal angle is rounded and forms a right angle. Right valve differs from left by a more inclined dorsal margin, a weaker posterodorsal cardinal angle, and a more elongate valve shape. Greatest length through midline of valve; greatest height anterior, through cardinal angle.

Ornamentation consists of reticulation and spines. Primary ornament is a reticulation pattern that covers the entire valve surface. The reticulation is well-developed, but not massive, consisting of wide, smooth ridges. The pits formed are shallow, large, and ovoid in shape. The reticulation pattern is arranged in a radial and concentric pattern. Large sieve pores are visible in the ornament pits. Numerous spines of various lengths, both mammillate and elongate in shape, occur at the ridge intersections over the valve surface. Many of these spines include a normal pore canal. Dorsal and ventral margins are irregular in appearance in lateral view because of the numerous ornament spines. Anterior with several rows of spines along the entire margin. Posterior with several long spines at the middle of the margin and short spines along the remainder of the margin. Two distinctive spines occur at the middle and toward the posterior end of the dorsal margin, both extending well beyond the valve edge. Large, hemispherical eye tubercle at anterodorsal corner, extending well above and beyond the valve margin. Weakly developed subcentral muscle tubercle.

*Occurrence.*--Core UAJ-1: 114.55, 112.0, 90.6, 88.86, 67.96, 55.1; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone, Sohnari Formation.

### ***Acanthocytherels sp. 3***

Plate 2, figure 2

*Description.*--In lateral view, left valve is rectangular in shape. Dorsal margin is nearly straight, inclined downward toward posterior; rounded anterior margin; ventral margin nearly straight, with subtle concavity; posterior margin with steeply curved posteroventral part and truncated posterodorsal part. Strong, obtuse posterodorsal corner; pronounced anterodorsal cardinal angle. Greatest length through midline of valve; greatest height through anterodorsal corner.

Ornamentation consists of pitting, spines, and tubercles. Primary ornament consists of rounded, shallow pits oriented parallel to the valve margins. Pits become somewhat larger toward margins. A number of smooth, low tubercles dominate the center of the valve, with three prominent tubercles forming a triangle posterior and ventral of the muscle tubercle. Four smaller tubercles occur posterior and dorsal of the muscle tubercle. Broad, low subcentral muscle scar tubercle. Three mammillate spines along dorsal margin; a number of small denticles interspersed with somewhat longer spines occur along the anterior and posterior margins; few small denticles along the ventral margin. Prominent, rounded eye tubercle.

*Occurrence.*--Core UAJ-1: 114.55, 112.0, 90.6, 55.1 m; Sohnari Formation, Meting Limestone.

*Comments.*--This species is very similar to *Cythereis styendri* Singh and Misra, 1966.

Tribe COSTAINI Hartmann and Puri, 1974  
Genus STIGMATOCYHERE Siddiqui, 1971

*Type species.*--*Stigmatocythere obliqua* Siddiqui, 1971

***Stigmatocythere sp. 2***  
Plate 1, figure 6

*Stigmatocythere sp. 2* Brouwers and Fatmi, 1992, pl. 1, fig. 8.

**Description.**--In lateral view, left valve is trapezoidal to subrectangular in shape. Dorsal margin is straight; anterior margin is broadly rounded; anterior half of ventral margin is straight, posterior half curves obliquely up toward the posterior; posterior with a subtle caudal process; posterior margin somewhat drawn-out. Anterodorsal corner is nearly a right angle; posterodorsal corner is sharp, obtuse. Greatest length is through midline of valve; greatest height is through anterior hinge element.

Ornamentation consists of spines, ridges, tubercles, and denticles. The overall valve surface is smooth. The valve is dominated by a heavy, large, rounded subcentral muscle tubercle. A number of blunt, large spines or small tubercles surround the subcentral tubercle; twelve spines occur posterior and dorsal of the tubercle and three spines occur anterior and anteroventral of the tubercle. A prominent ridge extends from the anteroventral corner, curves along the ventral margin, and terminates at the middle of the posterior margin. The ventral ridge is undulatory, made up of coalescing small tubercles or spines. A broad, flattened flange extends along the ventral margin. A second ridge forms an arcuate shape that overhangs the dorsal margin; a number of spines extend from this ridge over the margin. A deep, elongate, ellipsoid-shaped sulcus extends from the middle of the dorsal margin and extends obliquely for a short distance toward the anteroventer. Small, circular, smooth eye spot. Posterior margin with about 10 short spines; anterior margin with numerous small spines or denticles along the entire margin length.

**Occurrence.**--Core UAJ-1: 176.35, 172.6, 114.55 m; Sohnari Formation.

Punjab Province--Khairpur core 9: Patala Formation, Nammal Formation. Dandot core 14: Patala Formation.

**Tribe VEENIINI Puri, 1973**  
**Genus VEENIA Butler and Jones, 1957**

**Type species.**--*Cythereis ozanana* Israelsky, 1929

***Veenia sp. 2***  
Plate 2, figures 7-9

*Veenia sp. 1* Fatmi and Brouwers, in press, p. 27, pl. 3, figs. 1, 2.

*Veenia sp. 3* Brouwers and Fatmi, 1992, pl. 1, fig. 2.

**Description.**--In lateral view, left valve is elongate, subrectangular in outline. Dorsal margin angles down slightly toward posterior; anterior margin rounded; ventral margin slightly curved, forming a broad convex shape; posterodorsal margin trends straight toward posteroventer; posteroventral margin forms a blunt caudal process. Subtle, rounded anterodorsal corner; obtuse, rounded posterodorsal corner. Right valve is bullet-shaped; differs from left valve at the posterior margin, which forms a sharp caudal process at the middle of the margin. Greatest length through midline of valve; greatest height through anterodorsal corner.

Ornamentation consists of nodes, ridges, denticles, and tubercles. Large, subcircular, smooth, prominent, subcentral muscle tubercle. Three elongate nodes or short ridges radiate from the subcentral tubercle toward the posterior margin. An arcuate ventral ridge trends from the anteroventral region, subparallel to the ventral margin, and sweeping up toward the posterodorsal region; the ridge occurs somewhat interior of the valve margin. The ventral ridge is undulatory in shape, related to the position of a number of normal pores. Dorsal margin uneven, with a small marginal ridge angling obliquely from the

anterodorsal region, overhanging the middle of the dorsal margin, and extending a short distance toward the posteroventer. Large, smooth, comma-shaped eye spot. Anterior and posterior with a distinct, narrow, smooth marginal ridge. Series of small denticles along the anterior and posterodorsal margins; small spines along posteroventral margin.

*Occurrence.*--Core UAJ-1: 172.6, 143.3, 141.6, 138.8, 137.9, 114.55, 90.6, 55.1 m; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone.  
Punjab Province--Nammal Gorge section: Patala Formation. Khairpur core 9: Patala Formation.

***Veenia sp. 3***

*Occurrence.*--Core UAJ-1: 88.86 m; Meting Limestone.

**Subfamily BUNTONIINAE Apostelescu, 1961  
Genus BUNTONIA Howe, 1935**

*Type species.*--*Buntonia shubataensis* Howe, 1935

***Buntonia boldi* Khosla, 1972  
Plate 3, figure 6**

*Buntonia boldi* Khosla, 1972, p. 488, pl. 2, figs. 13, 14; pl. 5, fig. 3.

*Buntonia sp. 1* Fatmi and Brouwers, in press, p. 15, pl. 1, fig. 8.

*Description.*--In lateral view, left valve is rounded, ellipsoidal in shape. Dorsal margin is broadly arched; anterior margin is smoothly and evenly rounded; ventral margin is convex, with no concavity; posterior margin is rounded. No distinctive cardinal angles. Greatest length through midline of valve; greatest height through midline of valve.

Ornamentation consists of pitting and a sulcus. The primary ornament is pitting, which covers the entire valve surface. The pits are ovoid, generally small, and shallow; the pits become more concentrically-arranged toward the valve margins. A prominent sulcus extends vertically from near the dorsal margin, down the median part of the valve to just below the muscle scar area. A short horizontal ridge extends across the sulcus near its ventral end.

*Occurrence.*--Core UAJ-1: 141.6, 138.8, 137.9, 119.35, 114.55, 112.0, 90.6, 82.0 m; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale.

Gray shales of the *Assilina granulosa* Zone, Khuiala Formation (Lower Eocene), Rajasthan, India.

**Genus SOUDANELLA Apostelescu, 1961**

*Type species.*--*Soudanella laciniosa laciniosa* Apostelescu, 1961

***Soudanella sp. 1***

*Occurrence.*--Core UAJ-1: 137.9; Sohnari Formation.

**Family HEMICYTHERIDAE Puri, 1953**  
**Genus CAUDITES Coryell and Fields, 1937**

*Type species.*--*Caudites medialis* Coryell and Fields, 1937

***Caudites sp. 1***

*Occurrence.*--Core UAJ-1: 141.6 m; Sohnari Formation.

***Caudites sp. 2***  
Plate 2, figures 16, 17

*Caudites sp. 1* Fatmi and Brouwers, in press, p. 31, pl. 4, fig. 10.

*Description.*--In lateral view, left valve is elongate, subtriangular in shape. The dorsal margin is nearly straight, angling obliquely down toward the posterior; anterior margin is smoothly rounded; ventral margin is nearly straight, with a shallow concavity; posterodorsal margin is straight, vertical in course; posteroventral margin forms a sharp, pronounced caudal process, located near the ventral margin. Anterodorsal corner is weak, rounded, and obtuse; posterodorsal corner is sharp and forms a right angle. Greatest length ventral of midline, through caudal process; greatest height through anterior hinge element.

Ornamentation consists of reticulation, ridges, spines and denticles, and tubercles. The primary ornament is reticulation which occurs over the middle of the valve. The reticulation is moderately developed, forming ovoid pits. The reticulation is arranged somewhat radially about the subcentral tubercle and a posterodorsal tubercle. The anterior and posterior margins have a broad, flattened, smooth area. The anterior smooth region is crescentic in shape, and the posterior smooth area is triangular in shape. A narrow, smooth rim occurs adjacent to the anterior margin. Large, smooth, comma-shaped eye tubercle. Large, smooth subcentral muscle tubercle. A large tubercle, covered with reticulation, is located at the posterodorsal corner; the tubercle marks the end of an oblique ridge that trends from the posterodorsal corner to the middle of the ventral margin. Pronounced spine extends from the posterodorsal corner well beyond the dorsal margin. Small, weak anterior marginal denticles; few small denticles at the posteroventral corner.

*Occurrence.*--Core UAJ-1: 78.6, 73.5, 50.84 m; Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone.

**Subfamily THAEROCYTHERINAE Hazel, 1967**  
**Tribe THAEROCYTHERINI Hazel, 1967**  
**Genus HERMANITES Puri, 1955**

*Type species.*--*Hermania reticulata* Puri, 1954

***Hermanites sp. 1***  
Plate 1, figure 17

*Trachyleberid sp. 4* Fatmi and Brouwers, in press, p. 30, pl. 3, figs. 13, 14.

*Description.*--In lateral view, left valve is elongate, subrectangular in shape. Dorsal margin is nearly straight, appears irregular due to an overhanging ridge; anterior margin is smoothly and evenly curved; ventral margin is nearly straight, angling weakly up toward the posterior; posterior margin is truncated, nearly vertical. Posterodorsal corner is sharp, forming a right angle; anterodorsal corner is rounded, obtuse, weakly developed. Greatest length through midline of valve; greatest height through anterodorsal corner.

Ornamentation consists of reticulation, ridges, spines, tubercles, and denticles. Primary ornament is reticulation, which is strongly developed. Reticulation ridges are high, forming deep pits. The pits are elongate and polygonal, forming ovoid, U-, and trapezoid-shapes. The reticulation is arranged radially and concentrically about a prominent subcentral muscle tubercle. Posterior with a lower, flattened surface adjacent to the margin. Arcuate ventral margin angles obliquely toward the posterior. Overhanging, irregular dorsal ridge. Smooth, ovoid eye spot. Anterior with numerous sharp marginal denticles; posterior with two posterodorsal denticles, four posteroventral denticles, and three adjacent spines at the posteroventral corner.

*Occurrence.*--Core UAJ-1: 172.6, 143.3, 141.6, 114.55 m; Sohnari Formation. Core UAK-5: Lakhra Formation.

#### *Hermanites sp. 2*

*Occurrence.*--Core UAJ-1: 141.6, 138.8 m; Sohnari Formation.

#### *Hermanites sp. 3*

Plate 1, figure 15

*Caudites sp. 2* Fatmi and Brouwers, in press, p. 31, pl. 4, fig. 11.

*Description.*--In lateral view, right valve is subtriangular to trapezoid in shape. Dorsal margin nearly straight, angles down toward the posterior; anterior margin is smoothly rounded, with the greatest extent slightly ventral of midline; ventral margin partly obscured by an overhanging ridge, but with a pronounced, broad concavity; posterior margin with a prominent caudal process located ventral of midline; posterodorsal margin is concave. Obtuse, well-defined posterodorsal cardinal angle. Greatest length slightly ventral of midline, through caudal process; greatest height anterior of midline, through anterodorsal corner.

Ornamentation consists of reticulation, ridges, tubercles, and denticles. Primary ornament is strongly developed reticulation with few, wide, massive reticulation ridges. Pits formed are rounded, generally ovoid to quadrate. Reticulation is distinctly concentric at the anterior, more chaotic at the posterior. Large, smooth subcentral muscle tubercle. Anterior with a high, smooth marginal rim. Posterior with a V-shaped smooth area adjacent to the margin. A strong ridge extends from the posterodorsal corner, slightly obliquely down the valve to the posteroventral corner, connecting with a ridge that overhangs the ventral margin. Smooth, ovoid eye spot. Numerous, small, sharp anterior marginal denticles; one short spine at the posteroventral corner. Normal pores located both on the reticulation ridges and in the pits.

*Occurrence.*--Core UAJ-1: 119.35, 114.55, 88.86, 55.1 m; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone.

***Hermanites sp. 4***

Plate 1, figure 16

**Description.**--In lateral view, left valve is subtrapezoidal in outline. Dorsal margin is straight; anterior margin smoothly rounded; ventral margin sinuous, with a broad, shallow concavity, tapering up toward posterior; posterior margin with a pronounced caudal process located ventral of midline. Large, obtuse anterodorsal corner; sharp posterodorsal corner forms a right angle. Greatest length through caudal process; greatest height through anterodorsal corner.

Ornamentation consists of reticulation and ridges. Reticulation forms trapezoidal and subrounded ornament pits; reticulation covers valve, with no particular pattern. Prominent ridge originates at the posterodorsal corner, trends straight down, then angles obliquely toward the anteroventral corner. Posterior margin with weaker reticulation. Prominent, smooth eye tubercle.

**Occurrence.**--Core UAJ-1: 78.6, 55.1 m; Meting Limestone.

***Hermanites sp. 5***

**Occurrence.**--Core UAJ-1: 55.1, 50.84 m; Meting Limestone.

**Tribe BRADLEYINI Benson, 1972**  
**Genus QUADRACYTHERE Hornibrook, 1952**

**Type species.**--*Cythere truncula* Brady, 1898

***Quadracythere aspinosa* Sohn, 1959**  
Plate 1, figures 10, 11

*Quadracythere aspinosa* Sohn, 1959, p. 64, pl. 2, figs. 29-33.

*Quadracythere sp. 2* Fatmi and Brouwers, in press, p. 22, pl. 2, figs. 8, 12.

**Description.**--In lateral view, left valve is quadrate in shape. Dorsal margin is nearly straight; anterior margin is evenly rounded; ventral margin is sinuous, with a short, pronounced concavity; posterior margin is somewhat truncated, with smoothly curved posterodorsal and posteroventral portions. Posterodorsal and anterodorsal cardinal angles are rounded, obtuse, distinct. Greatest length through midline of valve; greatest height anterior of midline, through cardinal angle. Males differ from females by their longer, lower valve shape.

Ornamentation consists of reticulation, ridges, tubercles, spines, and denticles. Primary ornament is a well-developed reticulation network, which is organized roughly in a radial and concentric pattern. Ridges are heavily calcified, massive, and high, forming ovoid to quadrate pits. Pronounced, ornamented subcentral muscle tubercle, highlighted by a U-shaped ridge at the posterodorsal side. A dorsal ridge originates at the middle of the margin and proceeds to the posterodorsal corner, overhanging the valve edge. A second, stronger, arcuate ridge parallels most of the ventral margin. Smooth, ovoid eye spot. Anterior with numerous short, blunt spines along most of the margin. Posterior with two rows of blunt, mammillate spines at the middle of the margin. Normal pores occur at the intersection of the reticulation ridges.

*Occurrence*.--Core UAJ-1: 137.9, 114.55, 112.0, 55.1 m; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone. Meting Limestone.

***Quadracythere sp. 2***

*Occurrence*.--Core UAJ-1: 78.60, 73.50, 67.96 m; Meting Limestone.

**Subfamily ORIONINAE Puri, 1973**  
**Genus OCCULTOCYHEREIS Howe, 1951**

*Type species*.--*Occultocythereis delumbata* Howe, 1951

***Occultocythereis sp. 1***

*Occurrence*.--Core UAJ-1: 143.3 m; Sohnari Formation.

***Occultocythereis subspinelloa* Khosla, 1972**  
Plate 2, figure 15

*Occultocythereis subspinelloa* Khosla, 1972, p. 491, pl. 2, figs. 21-22; pl. 4, fig. 11; pl. 5, fig. 8.

*Occultocythereis sp. 3* Fatmi and Brouwers, in press, pl. 3, fig. 9; Brouwers and Fatmi, 1992, pl. 3, fig. 12.

*Description*.--In lateral view, right valve is subrectangular to subtrapezoidal in shape. Dorsal margin nearly straight, angles down toward posterior; anterior margin rounded; ventral margin sinuous, with broad, shallow concavity; posterior margin with truncated caudal process, straight posterodorsal part. No distinct cardinal angles. Greatest length through midline of valve; greatest height through anterodorsal corner. Carapace is laterally compressed.

Ornamentation consists of reticulation, spines, and denticles. Primary ornament consists of low reticulation pattern trending in an arcuate shape in the dorsal half of the valve and around the subcentral tubercle in the ventral half of the valve. Reticulation forms large, shallow ovoid ornament pits. Short spines cover valve surface, occurring on the reticulation ridges. The spines are generally simple, but a number of spines in the anterior region are bi- and trifurcate at the terminus. Arcuate ventral ridge occurs inward from the margin, originating just anteroventral of the subcentral tubercle, arching around the ventral margin, and angling obliquely toward the middle of the posterior margin. Subtle, low subcentral muscle tubercle. Smooth, large, squared eye spot. Arcuate region along anterior and posterior margins with no reticulation; both margins with a row of spines trending along the edge. Posteroventral margin with several long, strong spines; posterodorsal margin with somewhat shorter spines. Anterior with numerous, well-developed marginal spines. Short spines along ventral margin.

*Occurrence*.--Core UAJ-1: 143.3, 141.6, 55.1, 50.84 m; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone, Lakhra Formation.

Punjab Province--Khairpur core 9: Lockhart Limestone. Nilawan section: Lockhart Limestone.

Gray shales of the *Assilina granulosa* Zone, Khuiala Formation (Lower Eocene), Rajasthan, India.

***Occultocytherels sp. 3***

*Occurrence*--Core UAJ-1: 143.3, 78.6 m; Sohnari Formation, Meting Limestone.

***Occultocytherels sp. 4***

*Occurrence*--Core UAJ-1: 143.3, 141.6 m; Sohnari Formation.

***Occultocytherels sp. 5***

Plate 2, figure 14

*Description*--In lateral view, right valve is elongate, subrectangular in shape. Dorsal margin is straight, angling down slightly toward the posterior; anterior margin is evenly rounded; ventral margin is broadly concave, with a wide concavity; posterior margin is slightly protracted, with a weak, narrow caudal process. Posterodorsal corner is obtuse, rounded. Greatest length is through midline; greatest height is through anterodorsal corner; valves are laterally compressed.

Ornamentation consists of reticulation and spines. Reticulation consists of fine ridges over valve surface. Superimposed on the reticulation are numerous, close-spaced spines which cover most of the valve surface. The spines terminate as expanded bi-, tri-, and quadrafurcate shapes which nearly coalesce, giving the appearance of a solid surface. The anterior and posterior ends have crescentic- and arcuate-shaped smooth areas, respectively, adjacent to the margin. Smooth, ovoid eye spot. Anterior with numerous polyfurcate spines along the rim and long, narrow spines at the margin. Posterior with six polyfurcate spines along the rim and long polyfurcate spines interspersed with simple, long spines along the median and posteroventral margin. Dorsal and ventral margins with numerous short spines extending beyond the margin.

*Occurrence*--Core UAJ-1: 55.1 m; Meting Limestone.

**Family LOXOCONCHIDAE Sars, 1925  
Genus PHLYCTOCYHERE Keij, 1958**

*Type species*--*Phlyctocythere eocaenica* Keij, 1958

***Phlyctocythere sp. 1***

*Phlyctocythere sp. 1* Fatmi and Brouwers, in press, p. 33, pl. 5, fig. 8.

*Occurrence*--Core UAJ-1: 88.86 m; Meting Limestone. Core UAK-5: Meting Limestone.

**Family CYTHERINAE Baird, 1850  
Subfamily CYTHERINAE Baird, 1850  
Tribe SCHIZOCYTHERINI Mandelstam, 1960  
Genus SCHIZOCYTHERE Triebel, 1950**

*Type species.*--*Schizocythere hollandica* Triebel, 1950

***Schizocythere appendiculata* of Khosla, 1972**

Plate 1, figure 12; plate 3, figures 7, 8

*Schizocythere appendiculata* Khosla, 1972, p. 486, pl. 2, fig. 1.

*Schizocythere sp. 3* Fatmi and Brouwers, in press, p. 34, pl. 4, fig. 5; Brouwers and Fatmi, 1992, pl. 3, fig. 2.

*Description.*--In lateral view, left valve is ovoid in shape. Dorsal margin is nearly straight, somewhat irregular; anterior margin is smoothly and evenly curved; ventral margin is convex, broadly curved; posterior margin is truncated, with a short, blunt caudal process. Obtuse, rounded posterodorsal corner. Greatest length through valve midline; greatest height through anterior hinge element.

Ornamentation consists of reticulation, ridges, and denticles. Primary ornament is reticulation which is arranged in vertical rows at the posterior and radiate fan-like at the anterior. Ridges are low, forming shallow ovoid to subquadrate pits. Caudal process and anterior margin with a flat, smooth region adjacent to the valve edge. Dorsum with a horizontal ridge that overhangs the margin. Venter with an arcuate ridge that bifurcates at the anterior. Posteroventral corner with a blunt tuberculate structure that extends slightly beyond the valve margin. Normal pores occur at the ridge intersections. Few, scattered, small denticles at the middle of the anterior and posterior margins.

*Occurrence.*--Core UAJ-1: 143.3, 141.6, 138.8, 114.55, 78.6, 73.5, 67.96, 55.1, 50.84 m; Soharni Formation, Meting Limestone. Core UAK-5: Meting Limestone.

Punjab Province--Nammal Gorge section: Patala Formation. Khairpur core 9: Patala Formation, Nammal Formation. Dandot core 14: Patala Formation, Nammal Formation.

Gray shales of the *Assilina granulosa* Zone, Khuiala Formation, Palana (Lower Eocene); *Discocyclina dispansa* Zone, Bandah Formation, Middle Eocene, Rajasthan, India.

**Tribe PAIJENBORCHELLINI Deroo, 1960**  
**Genus PAIJENBORCHELLA Kingma, 1949**

*Type species.*--*Paijenborchella aurantia* Baird, 1838

***Paijenborchella sp. 1***

*Occurrence.*--Core UAJ-1: 88.86, 50.84 m; Meting Limestone.

***Paijenborchella sp. 2***

Plate 2, figure 18

*Paijenborchella sp. 1* Fatmi and Brouwers, in press, p. 35, pl. 4, fig. 7.

*Description.*--In lateral view, left valve is subtriangular, elongate in shape. Dorsal and ventral margins converge toward posterior end. Dorsal margin nearly straight, angling obliquely down toward the posterior; anterior margin smoothly curved, with greatest extent ventral of midline; ventral margin sinuous, forming a concave shape; posterior margin with an elongate, narrow, pronounced caudal process located considerably ventral of midline. Greatest length through caudal process; greatest height anterior, through

anterior hinge element.

Ornamentation consists of reticulation. Reticulation ridges are narrow and low, forming ovoid pits. Reticulation is weakly organized into a radial and concentric pattern. Smooth, crescentic region along anterior margin; caudal process with a smooth region. Small, ovoid, subtle eye spot.

*Occurrence.*--Core UAJ-1: 88.86 m; Meting Limestone. Core UAK-5: Meting Shale.

**Family XESTOLEBERIDIDAE Sars, 1928**  
**Genus XESTOLEBERIS Sars, 1928**

*Type species.*--*Cythere aurantia* Baird, 1838

***Xestoleberis sp. 1***

*Occurrence.*--Core UAJ-1: 143.3, 141.6, 137.9, 78.6, 73.5, 67.96, 55.1 m; Sohnari Formation, Meting Limestone.

**Genus FOVEOLEBERIS Malz, 1980**

*Type species.*--*Foveoleberis foveolata* (Brady, 1880)

***Foveoleberis sp. 1***

*Occurrence.*--Core UAJ-1: 114.55 m; Sohnari Formation.

**Genus UROLEBERIS Triebel, 1958**

*Type species.*--*Uroleberis pamensis* (Apostolescu, 1955)

***Uroleberis sp. 1***  
Plate 3, figure 9

*Description.*--In lateral view, right valve is ovoid to pear-shaped in outline. Dorsal margin is broadly arched; anterior margin is smoothly curved, with maximum extent ventral of midline; ventral margin is broadly convex; posterior smoothly curved at posteroventer, concave at posterodorsum, and with a small, distinct caudal process. No cardinal angles. Greatest length through valve midline; greatest height posterior of midline.

Ornamentation consists of pitting arranged over entire valve surface. Pits are ovoid, shallow, and small. Pits become more concentrically arranged toward the valve edge.

*Occurrence.*--Core UAJ-1: 88.86, 78.6, 73.5, 67.96, 55.1, 50.84 m; Meting Limestone.

Family LEPTOCYTHERIDAE Hanai, 1957  
Genus MOSALEBERIS Deroo, 1966

*Type species.*--*Mosaleberis interrupta* (Crane, 1965)

***Mosaleberis sp. 1***  
Plate 3, figure 4

*Description.*--In lateral view, left valve is trapezoid to subtriangular in shape. Dorsal margin is uneven, inclined sharply down toward the posterior; anterior margin is smoothly curved, rounded; ventral margin is nearly straight, inclined slightly up toward the posterior; posterior margin is truncated. Anterodorsal and posterodorsal corners are rounded, obtuse. Greatest length is through midline of valve; greatest height is anterior of midline, through anterodorsal corner.

Ornamentation consists of reticulation, ridges, spines, and denticles. Primary ornament is well-developed reticulation, poorly organized, covering the median part of the valve surface. The horizontally-oriented reticulation ridges are particularly prominent. Pits formed by the reticulation are relatively large, rounded, and subvoid. Anterior and posterior margins with broad, flat, smooth arcuate regions along margins. Parts of two reticulation ridges are prominent: one oblique ridge becomes wider and higher near the anterodorsal corner, and a second ridge, also oblique but more horizontally oriented, overhangs most of the dorsal margin and terminates at the posterodorsal corner as a spine. Subtle, low subcentral muscle tubercle. Numerous short, sharp denticles along the anterior margin; few short denticles along the posteroventral margin.

*Occurrence.*--Core UAJ-1: 176.35, 172.6, 143.3, 141.6, 138.8, 137.9, 114.55 m; Sohnari Formation.

***Mosaleberis sp. 2***  
Plate 3, figure 3

*Description.*--In lateral view, right valve is elongate, subquadrate in shape. Dorsal margin is nearly straight, angling obliquely toward posterior end; anterior margin is smoothly and evenly rounded; ventral margin is sinuous, with a broad, shallow concavity; posterior margin is pointed, with straight posteroventral and posterodorsal parts converging. No distinct cardinal angles. Greatest length through valve midline; greatest height through anterior hinge element.

Ornamentation consists of reticulation, tubercles, ridges, spines, and denticles. Primary ornament is reticulation, not organized in a discrete pattern. Reticulation ridges are narrow and low, forming ovoid to subquadrate shapes. Reticulation covers most of the valve surface. A wide, flat, smooth area defines the valve edge immediately along the anterior, ventral, posterior, and most of the dorsal margins. Anterior smooth region with a number of radiating lines that reflect the trace of radial pore canals. Dorsum with an oblique ridge that extends from just below the anterodorsal corner to the posterodorsal corner, overhanging the posterodorsal margin and terminating posteriorly as a spine. Anterior margin with a narrow, low ridge that occurs at the valve edge. Subtle subcentral muscle tubercle. Triangular-shaped, horizontally-oriented sulcus occurs at the anterodorsal margin. Anterior with numerous small marginal denticles; posteroventer with four blunt spines along the margin.

*Occurrence.*--Core UAJ-1: 88.86, 55.1 m; Meting Limestone.

**Family CYTHERIDEIDAE Sars, 1925**  
**Subfamily SCHULERIDEINAE Mandelstam, 1959**  
**Genus SCHULERIDEA Swartz and Swain, 1946**

*Type species.*--*Schuleridea acuminata* Swartz and Swain, 1946

***Schuleridea sp. 1***  
Plate 3, figure 5

*Schuleridea sp. 2* Fatmi and Brouwers, in press, p. 40, pl. 5, fig. 9.

*Description.*--In lateral view, left valve is ellipsoidal in shape. Dorsal margin is broadly arched; anterior margin is smoothly and evenly curved; ventral margin is broadly convex; posterior margin is smoothly curved. No cardinal angles. Greatest length is through valve midline; greatest height is through middle of valve.

Ornamentation consists of pitting that covers most of the valve surface. Pits are ovoid in shape, small, and shallow, becoming smaller marginally.

*Occurrence.*--Core UAJ-1: 112.0, 90.6, 88.86, 55.1 m; Meting Limestone. Core UAK-5: Meting Limestone, Lakhra Formation.

**Subfamily CUNEOCYTHERINAE Mandelstam, 1959**  
**Genus PAKISTANELLA Sohn, 1959**

*Type species.*--*Pakistanella prima* Sohn, 1959

***Pakistanella prima* Sohn, 1959**

*Pakistanella prima* Sohn, 1959, p. 61, pl. 1, figs. 20-27.

*Occurrence.*--Core UAJ-1: 119.74 m; Sohnari Formation. Meting Limestone at Meting Railway Station.

**Family KRITHIDAE Mandelstam, 1958**  
**Genus PARAKRITHELLA Hanai, 1959**

*Type species.*--*Neocyprideis pseudadonta* Hanai, 1959

***Parakrithella sp. 1***  
Plate 3, figures 13, 14

*Description.*--In lateral view, right valve is elongate, subcylindrical in shape. Dorsal margin is straight; anterior margin is smoothly curved, with the greatest extent slightly dorsal of midline; ventral margin is broadly concave, with a wide, shallow concavity; posterior margin is smoothly curved, with the greatest extent considerably ventral of midline, nearly at the ventral margin. No cardinal angles. Greatest length through valve midline; greatest height posterior of midline. Males differ from females in having a longer, lower valve outline.

No ornamentation; valve surface is smooth.

*Occurrence*.--Core UAJ-1: 141.6, 119.35, 114.55, 112.0, 90.6, 88.86, 78.6, 73.5, 55.1, 50.84 m; Sohnari Formation, Meting Limestone.

**Family CYTHERURIDAE G.W. Mueller, 1894**  
**Subfamily CYTHERURINAE G.W. Mueller, 1894**  
**Genus CYTHERURA Sars, 1866**

*Type species*.--*Cythere gibba* O.F. Mueller, 1785

*Cytherura sp. 1*  
Plate 3, figure 10

*Cytherura sp. 1* Fatmi and Brouwers, in press, p. 41, pl. 5, fig. 6.

*Description*.--In lateral view, left valve is elongate, trapezoidal to subtriangular in shape. Dorsal margin is broadly arched; anterior margin is smoothly curved, with the greatest extent ventral of midline; ventral margin is broadly concave; posterior margin with a pronounced, narrow, long caudal process located just dorsal of midline. No cardinal angles. Greatest length is anterior of midline; greatest height is posterior of midvalve.

Ornamentation consists of reticulation and ridges. The primary ornament is reticulation, which covers most of the valve surface. The reticulation is low, forming shallow pits. The reticulation is arranged horizontally in broadly arcuate rows along the ventral half of the valve. The pits change shape and size from venter to dorsum, consisting of elongate pits ventrally, groups of two to three pits medially, and small, isolated pits dorsally. The dorsal pitting is arranged roughly concentric to the valve edge. The caudal process and anterior margin are smooth. A distinct ridge originates at the posteroventral corner, overhangs most of the ventral margin, and terminates at the anteroventral corner. A small arcuate ridge forks off near the anterior terminus of the ventral ridge, ending near the median part of the anterior margin. Elongate, ellipsoidal, smooth eye spot located slightly ventral of the anterodorsal margin.

*Occurrence*.--Core UAJ-1: 141.6, 138.8, 137.9, 114.55, 88.86 m; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone, Lakhra Formation.

**Family PARACYTHERIDEIDAE Puri, 1957**  
**Genus PARACYTHERIDEA G.W. Mueller, 1894**

*Type species*.--*Paracytheridea depressa* G.W. Mueller, 1894

*Paracytheridea sp. 1*

*Occurrence*.--Core UAJ-1: 141.6 m; Sohnari Formation.

**Suborder PLATYCOPIDA Sars, 1866**  
**Family CYTHERELLIDAE Sars, 1866**  
**Genus CYTHERELLA Jones, 1849**

*Type species.*--*Cytherina ovata* Roemer, 1840

***Cytherella sp. 1***  
Plate 3, figure 18

*Cytherella sp. 2* Fatmi and Brouwers, in press, p. 44, pl. 6, fig. 3.

*Description.*--In lateral view, right valve is subovoid to ellipsoidal in shape. Dorsal margin is nearly straight; anterior margin is smoothly curved, with the greatest extent slightly dorsal of midline; ventral margin is broadly convex; posterior margin is smoothly curved, with a subtle caudal process. No cardinal angles. Greatest length through valve midline; greatest height located posterior of midline.

Ornamentation consists of fine pitting. The pits are small, ovoid, and are concentrated at the posterior and anterior margins, with some pits along the anteroventral margin and some arranged in an arcuate vertical row anterior of midline. Anterodorsal region with a triangular sulcus that originates slightly ventral of the dorsum and extends vertically to the median valve region, with the pointed part of the triangle toward the venter.

*Occurrence.*--Core UAJ-1: 176.35, 172.6, 143.3, 141.6, 138.8, 137.9, 119.35, 114.55, 112.0, 90.6 m; Sohnari Formation, Meting Limestone. Core UAK-5: Meting Shale, Meting Limestone, Sohnari Formation, Lakhra Formation.

***Cytherella sp. 2***  
Plate 3, figure 17

*Cytherella sp. 6* Fatmi and Brouwers, in press, p. 45, pl. 6, fig. 1.

*Description.*--In lateral view, left valve is ovoid to ellipsoidal in shape. Dorsal margin is nearly straight; anterior margin is smoothly curved; ventral margin is broadly convex; posterior margin is smoothly curved, with the greatest extent just dorsal of midline. No cardinal angles. Greatest length is through valve midline; greatest height is anterior of midline.

Ornamentation consists of pitting, which covers the valve periphery. The median part of the valve surface is smooth. Pits are small and ovoid, becoming finer marginally. Pits are arranged somewhat concentrically. The median dorsal area includes a broad depression that includes most of the dorsal margin.

*Occurrence.*--Core UAJ-1: 172.6, 138.8, 137.9, 114.55 m; Sohnari Formation. Core UAK-5: Lakhra Formation, Bara Formation.

***Cytherella barpatharensis* Neale and Singh, 1985**  
Plate 3, figure 16

*Cytherella barpatharensis* Neale and Singh, 1985, p. 360, pl. 40, figs. 10-12.

*Description.*--In lateral view, right valve is elongate, subcylindrical in shape. Dorsal margin is broadly arched; anterior margin is smoothly and evenly curved; ventral margin is slightly concave, with a subtle, shallow concavity; posterior margin is smoothly curved, with the greatest extent slightly dorsal of midline. No cardinal angles. Greatest length is through valve midline; greatest height anterior of midline.

Most of the valve surface is smooth. The valve edge is marked by a lower, flattened area, especially along the posteroventral, ventral, anterior, and anterodorsal margins. Median dorsal margin with a triangular-shaped depressed region. Adductor muscle scars occur at the ventral side of this depressed region; most of the scars are visible from the exterior. Anterior margin distinctive, with a narrow ridge along the valve periphery and a row of small, mammillate features arranged concentrically along the margin, reflecting the exit of a number of pore canals.

*Occurrence.*--Core UAJ-1: 88.86, 78.6, 55.1, 50.84 m; Meting Limestone.  
Assam, India: Sylhet Formation, *Nummulites atacicus* Zone.

#### Genus CYTHERELLOIDEA Alexander, 1929

*Type species.*--*Cytherelloidea williamsoniana* Jones, 1849

#### *Cytherelloidea sp. 1*

*Occurrence.*--Core UAJ-1: 114.55, 50.84 m; Sohnari Formation, Meting Limestone.

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**APPENDIX 1.--**

Tabulation of species in each sample examined.

**50.84-50.94 m**

*Argilloecia* sp. 1  
*Bairdia* sp. 3  
*Bairdia* sp. 4  
*Bairdia* sp. 5  
*Caudites* sp. 2  
*Cytherella barpatharensis*  
*Cytherelloidea* sp. 1  
*Hermanites* sp. 5  
*Hermanites* sp.  
*Occultocythereis subspinellosa*  
*Paijenborchella* sp. 1  
*Parakrithella* sp. 1  
*Phalcoythere* sp. 3  
*Phalcoythere rete*  
*Schizocythere appendiculata*  
*Schizoptocythere* sp. 1  
*Uroleberis* sp. 1

**55.1-55.2 m**

*Acanthocythereis* sp. 2  
*Acanthocythereis* sp. 3  
*Alocopocythere transcendens*  
*Alocopocythere* sp. 5  
*Argilloecia* sp. 1  
*Bairdia* sp. 5  
*Cytherella barpatharensis*  
*Hermanites* sp. 3  
*Hermanites* sp. 4  
*Hermanites* sp. 5  
*Mosaleberis* sp. 2  
*Occultocythereis subspinellosa*  
*Occultocythereis* sp. 5  
*Parakrithella* sp. 1  
*Phalcoythere* sp. 2  
*Quadracythere aspinosa*  
*Schizocythere appendiculata*  
*Schizoptocythere* sp. 2  
*Schuleridea* sp. 1  
*Uroleberis* sp. 1  
*Veenia* sp. 2  
*Xestoleberis* sp. 1

**67.96-68.06**

*Acanthocythereis* sp. 2  
*Bairdia* sp. 3  
*Bairdia* sp. 5  
*Quadracythere* sp. 2  
*Schizocythere appendiculata*

*Uroleberis* sp. 1  
*Xestoleberis* sp. 1

73.5-73.6 m

*Argilloecia* sp. 1  
*Bairdia* sp. 3  
*Bairdia* sp. 5  
*Caudites* sp. 2  
*Parakrithella* sp. 1  
*Phalcoocythere* sp. 3  
*Quadracythere* sp. 2  
*Schizocythere appendiculata*  
*Uroleberis* sp. 1  
*Xestoleberis* sp. 1

78.6-78.7 m

*Anommatocythere* sp. 2  
*Bairdia* sp. 2  
*Bairdia* sp. 3  
*Bairdia* sp. 4  
*Bairdia* sp. 5  
*Caudites* sp. 2  
*Cytherella barpatharensis*  
*Hermanites* sp. 4  
*Occultocythereis* sp. 3  
*Paracypris* sp. 1  
*Parakrithella* sp. 1  
*Phalcoocythere* sp. 3  
*Quadracythere* sp. 2  
*Schizocythere appendiculata*  
*Uroleberis* sp. 1  
*Xestoleberis* sp. 1

82.0-82.1 m

*Buntonia boldi*

88.86-88.96 m

*Acanthocythereis* sp. 2  
*Alocopocythere transcendens*  
*Alocopocythere* sp. 5  
*Argilloecia* sp. 1  
*Cytherella barpatharensis*  
*Cytherura* sp. 1  
*Hermanites* sp. 3  
*Mosaleberis* sp. 2  
*Paijenborchella* sp. 1  
*Paijenborchella* sp. 2  
*Paracypris* sp. 2  
*Parakrithella* sp. 1  
*Phalcoocythere* sp. 2  
*Phlyctocythere* sp. 1  
*Schuleridea* sp. 1

*Uroleberis* sp. 1  
*Veenia* sp. 2  
*Veenia* sp. 3

90.6-90.7 m

*Acanthocythereis* sp. 2  
*Acanthocythereis* sp. 3  
*Alocopocythere transcendens*  
*Alocopocythere* sp. 4  
*Alocopocythere* sp. 5  
*Buntonia boldi*  
*Cytherella* sp. 1  
*Parakrithella* sp. 1  
*Schuleridea* sp. 1  
*Veenia* sp. 2

112.0-112.1 m

*Acanthocythereis* sp. 2  
*Acanthocythereis* sp. 3  
*Alocopocythere transcendens*  
*Buntonia boldi*  
*Cytherella* sp. 1  
*Parakrithella* sp. 1  
*Quadracythere aspinosa*  
*Schuleridea* sp. 1

114.55-114.65 m

*Acanthocythereis* sp. 2  
*Acanthocythereis* sp. 3  
*Alocopocythere* sp. 1  
*Bairdia* sp. 1  
*Buntonia boldi*  
*Cytherella* sp. 1  
*Cytherella* sp. 2  
*Cytherelloidea* sp. 1  
*Cytherura* sp. 1  
*Foveoleberis* sp. 1  
*Hermanites* sp. 1  
*Hermanites* sp. 3  
*Mosaleberis* sp. 1  
*Occultocythereis* sp. 2  
*Parakrithella* sp. 1  
*Quadracythere aspinosa*  
*Schizocythere appendiculata*  
*Stigmatocythere* sp. 2  
*Veenia* sp. 2

119.35-119.45 m

*Alocopocythere* sp. 2  
*Buntonia boldi*  
*Cytherella* sp. 1  
*Hermanites* sp. 3

*Parakrithella* sp. 1

119.74-119.76 m

*Pakistanella prima*

137.9-138.0 m

*Acanthocythereis* sp. 1  
*Alocopocythere* sp. 1  
*Buntonia boldi*  
*Cytherella* sp. 1  
*Cytherella* sp. 2  
*Cytherura* sp. 1  
*Mosaleberis* sp. 1  
*Paracypris* sp. 1  
*Quadracythere aspinosa*  
*Soudanella* sp. 1  
*Veenia* sp. 2  
*Xestoleberis* sp. 1

138.8-139 m

*Acanthocythereis* sp. 1  
*Alocopocythere* sp. 1  
*Buntonia boldi*  
*Cytherella* sp. 1  
*Cytherella* sp. 2  
*Cytherura* sp. 1  
*Hermanites* sp. 2  
*Mosaleberis* sp. 1  
*Schizocythere appendiculata*  
*Veenia* sp. 2

141.6-141.7 m

*Acanthocythereis* sp. 1  
*Alocopocythere* sp. 1  
"Alocopocythere" sp. 1  
*Anommatocythere* sp. 1  
*Bairdia* sp. 1  
*Buntonia boldi*  
*Caudites* sp. 1  
*Cytherella* sp. 1  
*Cytherura* sp. 1  
*Hermanites* sp. 1  
*Hermanites* sp. 2  
*Mosaleberis* sp. 1  
*Occultocythereis subspinellosa*  
*Occultocythereis* sp. 4  
*Paracypris* sp. 1  
*Paracytheridea* sp. 1  
*Parakrithella* sp. 1  
*Phalcocythere* sp. 1  
*Schizocythere appendiculata*  
*Schizoptocythere* sp. 1

*Veenia* sp. 2  
*Xestoleberis* sp. 1

143.3-143.4 m

*Acanthocythereis* sp. 1  
*Anommatocythere* sp. 1  
*Bairdia* sp. 1  
*Bairdia* sp. 2  
*Cytherella* sp. 1  
*Hermanites* sp. 1  
*Mosaleberis* sp. 1  
*Occultocythereis subspinellosa*  
*Occultocythereis* sp. 1  
*Occultocythereis* sp. 3  
*Occultocythereis* sp. 4  
*Phalcoythere* sp. 1  
*Schizocythere appendiculata*  
*Schizoptocythere* sp. 1  
*Veenia* sp. 2  
*Xestoleberis* sp. 1

157.6-157.7 m

*"Alocopocythere"* sp. 1  
*Cytherella* sp.

165.25-165.35 m

*"Alocopocythere"* sp. 1

172.6-172.7 m

*Acanthocythereis* sp. 1  
*"Alocopocythere"* sp. 1  
*Argilloecia* sp. 1  
*Bairdia* sp. 1  
*Cytherella* sp. 1  
*Cytherella* sp. 2  
*Hermanites* sp. 1  
*Mosaleberis* sp. 1  
*Paracypris* sp. 1  
*Schizoptocythere* sp. 1  
*Stigmatocythere* sp. 2  
*Veenia* sp. 2

176.35-176.45 m

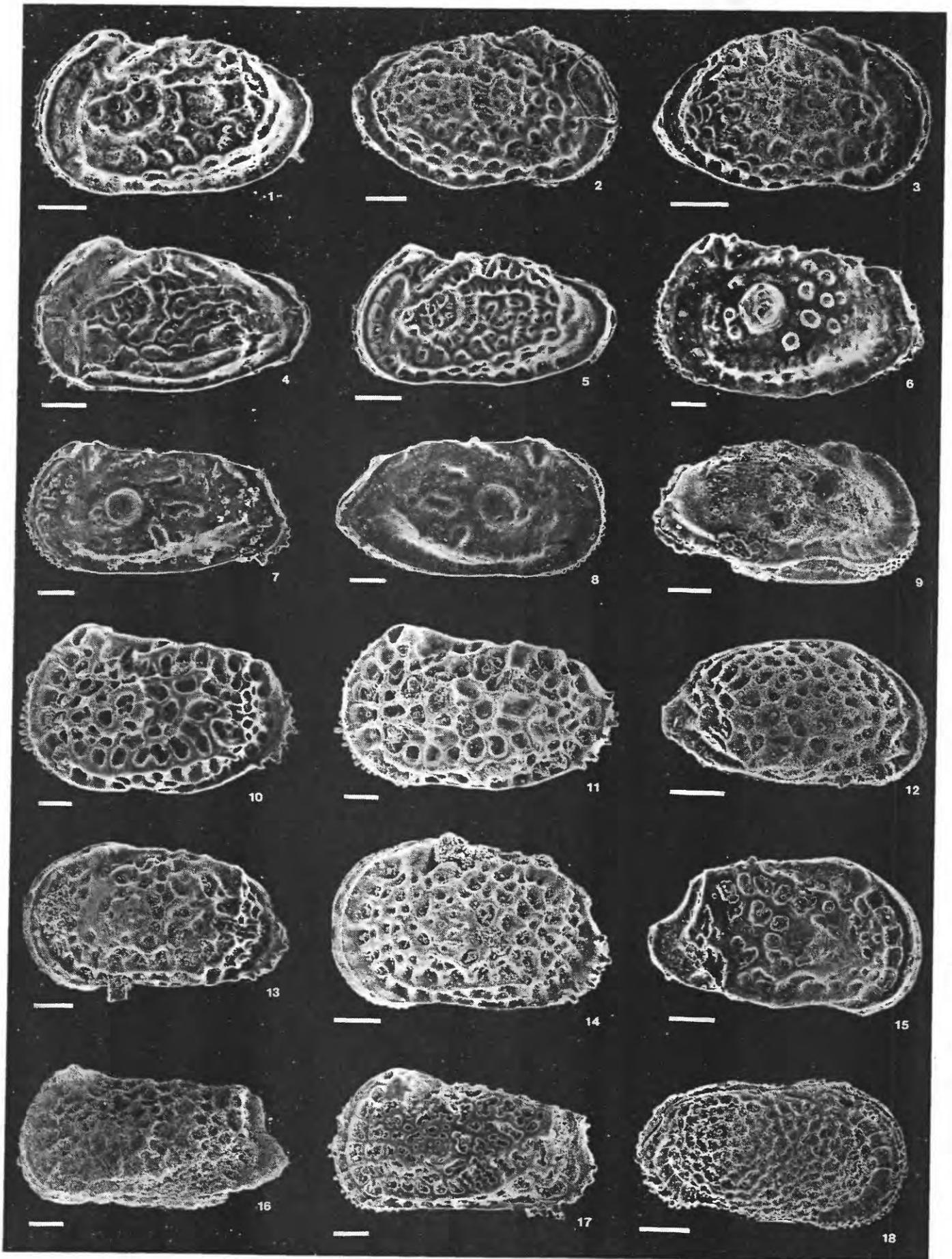
*Acanthocythereis* sp. 1  
*Alocopocythere* sp. 1  
*"Alocopocythere"* sp. 1  
*Argilloecia* sp. 1  
*Cytherella* sp. 1  
*Mosaleberis* sp. 1  
*Paracypris* sp. 1  
*Schizoptocythere* sp. 1  
*Stigmatocythere* sp. 2

## Plate 1

All figures are scanning electron photomicrographs.  
White bar equals 100 micrometers.

### Figure

- 1 *Alocopocythere* sp. 1, lateral view of left valve, 176.35-176.45 m, Sohnari Formation.
- 2 *Alocopocythere* sp. 5, lateral view of right valve, 88.86-88.96 m, Meting Limestone Member.
- 3 *Alocopocythere transcendens*, lateral view of right valve, 90.6-90.7 m, Meting Limestone Member.
- 4 *Alocopocythere* sp. 2, lateral view of left valve, 119.35-119.45 m, Sohnari Formation.
- 5 *Alocopocythere* sp. 1, lateral view of left valve, 138.8-138.9 m, Sohnari Formation.
- 6 *Stigmatocythere* sp. 2, lateral view of left valve, 176.35-176.45 m, Sohnari Formation.
- 7 *Veenia* sp. 2, lateral view of left valve, 114.55-114.65 m, Sohnari Formation.
- 8 *Veenia* sp. 2, lateral view of right valve, 137.9-138.0 m, Sohnari Formation.
- 9 *Veenia* sp. 2, lateral view of right valve of carapace, 55.1-55.2 m, Meting Limestone Member.
- 10 *Quadracythere aspinosa* Sohn, 1959, lateral view of left valve, 112.0-112.1 m, Sohnari Formation.
- 11 *Quadracythere aspinosa* Sohn, 1959, lateral view of left valve, 55.1-55.2 m, Meting Limestone Member.
- 12 *Schizocythere appendiculata* of Khosla, 1972, lateral view of right valve of carapace, 55.1-55.2 m, Meting Limestone Member.
- 13 *Phalcocythere* sp. 3, lateral view of left valve, 50.84-50.94 m, Meting Limestone Member.
- 14 *Phalcocythere* sp. 3, lateral view of left valve, 73.5-73.6 m, Meting Limestone Member.
- 15 *Hermanites* sp. 3, lateral view of right valve, 114.55-114.65 m, Sohnari Formation.
- 16 *Hermanites* sp. 4, lateral view of left valve of carapace, 78.6-78.7 m, Meting Limestone Member.
- 17 *Hermanites* sp. 1, lateral view of left valve, 143.3-143.4 m, Sohnari Formation.
- 18 *Phalcocythere rete* Siddiqui, 1971, lateral view of right valve of carapace, 50.84-50.94 m, Meting Limestone Member.

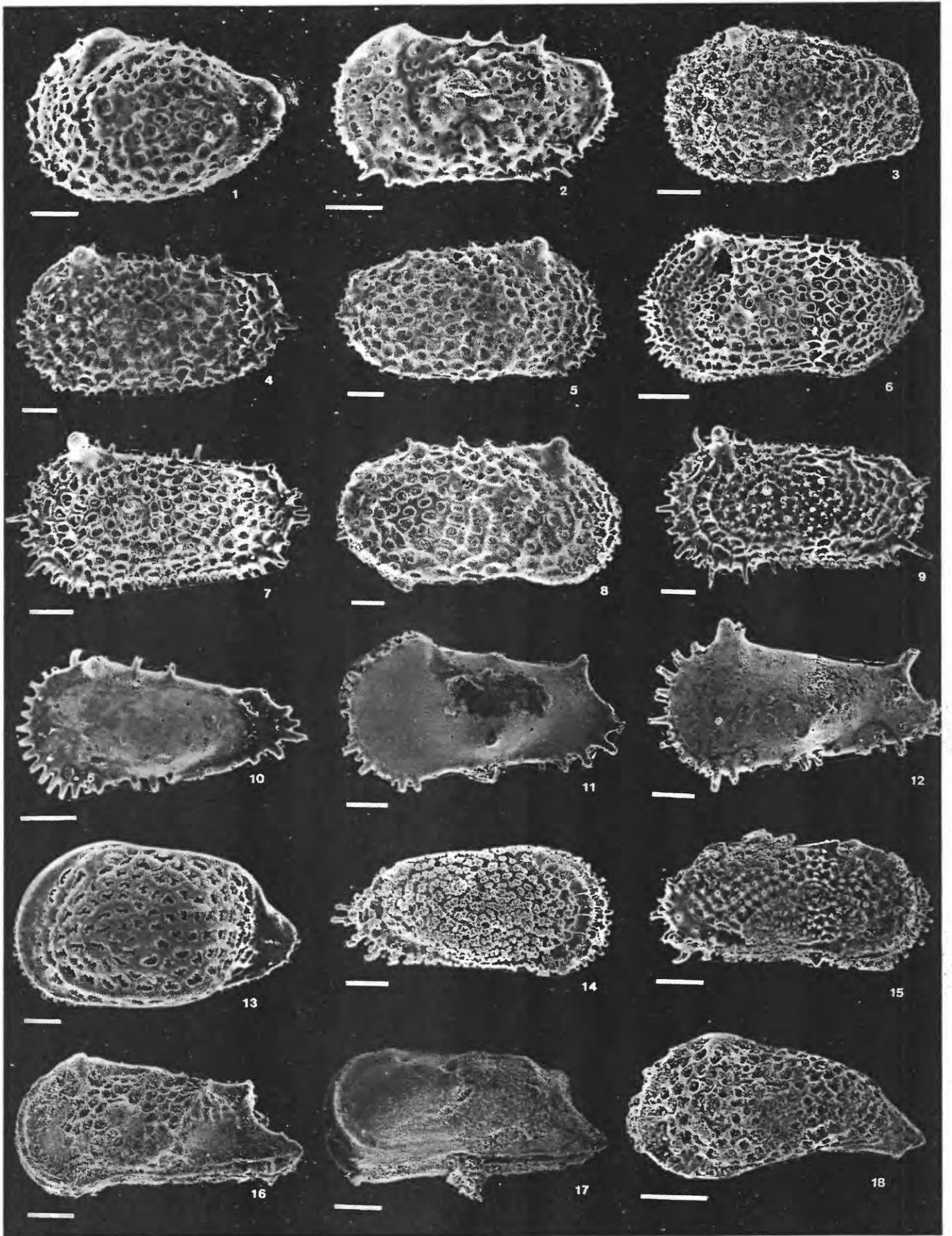


## Plate 2

All figures are scanning electron photomicrographs.  
White bar equals 100 micrometers.

### Figure

- 1 *Alocopocythere* sp. 4, lateral view of left valve, 90.6-90.7 m, Meting Limestone Member.
- 2 *Acanthocythereis* sp. 3, lateral view of left valve, 112.0-112.1 m, Meting Limestone Member.
- 3 *Phalcoocythere* sp. 2, lateral view of left valve of carapace, 55.1-55.2 m, Meting Limestone Member.
- 4 *Acanthocythereis* sp. 2, lateral view of left valve, 112.0-112.1 m, Meting Limestone Member.
- 5 *Acanthocythereis* sp. 2, lateral view of right valve, 55.1-55.2 m, Meting Limestone Member.
- 6 *Acanthocythereis* sp. 1, lateral view of left valve, 138.8-138.9 m, Sohnari Formation.
- 7 *Acanthocythereis* sp. 1, lateral view of left valve, 176.35-176.45 m, Sohnari Formation.
- 8 *Acanthocythereis* sp. 2, lateral view of right valve, 88.86-88.96 m, Meting Limestone Member.
- 9 *Acanthocythereis* sp. 1, lateral view of left valve, 143.3-143.4 m, Sohnari Formation.
- 10 *Schizoptocythere* sp. 1, lateral view of left valve, 141.6-141.7 m, Sohnari Formation.
- 11 *Schizoptocythere* sp. 2, lateral view of left valve, 50.84-50.94 m, Meting Limestone Member.
- 12 *Schizoptocythere* sp. 2, lateral view of left valve, 55.1-55.2 m, Meting Limestone Member.
- 13 *Anommatocythere* sp. 1, lateral view of left valve, 143.3-143.4 m, Sohnari Formation.
- 14 *Occultocythereis* sp. 5, lateral view of right valve of carapace, 143.3-143.4 m, Sohnari Formation.
- 15 *Occultocythereis subspinelloa* Khosla, 1972, lateral view of right valve of carapace, 55.1-55.2 m, Meting Limestone Member.
- 16 *Caudites* sp. 2, lateral view of left valve of carapace, 50.84-50.94 m, Meting Limestone Member.
- 17 *Caudites* sp. 2, lateral view of left valve of carapace, 73.5-73.6 m, Meting Limestone Member.
- 18 *Paijenborchella* sp. 2, lateral view of left valve, 88.86-88.96 m, Meting Limestone Member.



### Plate 3

All figures are scanning electron photomicrographs.  
White bar equals 100 micrometers.

#### Figure

- 1 *Phalcoocythere* sp. 1, lateral view of left valve, 141.6-141.7 m, Sohnari Formation.
- 2 "*Alocopocythere*" sp. 1, lateral view of right valve, 172.6-172.7 m, Sohnari Formation.
- 3 *Phalcoocythere* sp. 2, lateral view of right valve, 88.86-88.96 m, Meting Limestone Member.
- 4 *Mosaleberis* sp. 1, lateral view of left valve, 138.8-138.9, Sohnari Formation.
- 5 *Schuleridea* sp. 1, lateral view of left valve, 55.1-55.2 m, Meting Limestone Member.
- 6 *Buntonia boldi* Khosla, 1972, lateral view of left valve, 90.6-90.7 m, Meting Limestone Member.
- 7 *Schizocythere appendiculata* of Khosla, 1972, lateral view of left valve, 141.6-141.7 m, Sohnari Formation.
- 8 *Schizocythere appendiculata* of Khosla, 1972, lateral view of left valve, 50.84-50.94 m, Meting Limestone Member.
- 9 *Uroleberis* sp. 1, lateral view of right valve of carapace, 50.84-50.94 m, Meting Limestone Member.
- 10 *Cytherura* sp. 1, lateral view of left valve, 138.8-138.9 m, Sohnari Formation.
- 11 *Bairdia* sp. 2, lateral view of right valve, 143.3-143.4 m, Sohnari Formation.
- 12 *Bairdia* sp. 1, lateral view of right valve, 143.3-143.4 m, Sohnari Formation.
- 13 *Parakrithella* sp. 1, lateral view of right valve, 114.55-114.65 m, Sohnari Formation.
- 14 *Parakrithella* sp. 1, lateral view of right valve, 112.0-112.1 m, Sohnari Formation.
- 15 *Paracypris* sp. 1, lateral view of left valve of carapace, 172.6-172.7 m, Sohnari Formation.
- 16 *Cytherella barpatharensis* Neale and Singh, 1985, lateral view of left valve, 55.1-55.2 m, Meting Limestone Member.
- 17 *Cytherella* sp. 2, lateral view of left valve, 138.8-138.9 m, Sohnari Formation.
- 18 *Cytherella* sp. 1, lateral view of left valve, 114.55-114.65 m, Sohnari Formation.
- 19 *Argilloecia* sp. 1, lateral view of left valve, 172.6-172.7 m, Sohnari Formation.

