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CALCAREOUS NANNOFOSSILS FROM THE UTATUR GROUP, TRICHINOPOLY DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

The present paper for the first time, comprehensively, describes a varied nannoflora from the Utatur Group of the Upper Cretaceous of South India.

The study is based on more than 160 carefully collected samples along three traverses which cover the entire Utatur Group. A rich and diverse nannoflora of more than 61 species belonging to 36 genera of 15 families of calcareous nannofossils is recorded. This flora is assignable to five standard nannofloral zones of Sissingh (1977).

In the present studies, the base of the Utatur Group is found to be older than the Dalmiapuram Gray Shales and Reefoid Limestones. The base of the Utatur Group is placed in the early Middle Albian, while the upper boundary in the Early and Middle Turonian.

INTRODUCTION

Calcareous nannofossils were discovered by Ehrernberg (1836). However, their biostratigraphic utility was pointed out by Bramlette and Riedel (1954). Since then exhaustive work has been carried out on calcareous nannoplankton by several workers. Standard biozonation schemes proposed for the Cretaceous, include those by Gartner (1986), Bukry (1969) and Cepek and Hay (1969) for North America and Europe; Theirstein (1971a, '73, '74 and '76) for the type sections of the Cretaceous and different Oceanic sections. Verbeek (1976) and Sissingh (1977) have evaluated the nannofossil zonations of sections from Europe and Tunisia. Roth (1978), on the basis of nannoplankton, proposed separate stages for the Cretaceous sediments deposited under oceanic settings, for the samples recovered during the Deep Sea Drilling Project.

Calcareous nannoplankton were first reported from India by Narasimhan (1963) from Assam. Pant (1969) reported the presence of calcareous nannofossils from several successions of varying ages from samples in the repository of the Geological Survey of India, Calcutta. This report includes several species from the Cretaceous succession of the Tiruchchirappally District. Jafar (1982) has calcareous nannoplankton to evaluate the age of the Bagh sediments (Turonaian-Coniacian) from the Narmada valley.

The biostratigraphy of the Utatur Group has been evaluated by several workers in the past few decades, based upon macro- and micro-fossils. Sastry, Rao and Mamgain (1968), Chiplonkar and Phansalkar (1976), Phansalkar and Kumar (1983 a & b) have evaluated the ammonite biostratigraphy of this Group. Naryanan (1977), Sastri, Raju, Sinha, Venkatchala and Banerji (1977), and Phansalkar and Kumar (1983a) have evaluated the foraminiferal biostratigraphy of the Utatur Group. Banerji (1972) and Bhatia and Jain (1969 & 72) have dealt with the stratigraphy and palaeontology of the rocks at Kallakudi. Aiyyasami and Banerji (1984) have commented upon the Cenomanian - Turonian Boundary within the Utatur Group.

Jafar and Rai (1989) have described the Albian nannoflora from the Dalmiapuram Grey Shale and evaluated its palaeo-oceanography.

The present work deals with the calcareous nannoplankton from the Utatur Group, Dalmiapuram Grey Shale Formation and the Dalmiapuram Reefoid Limestone Formation.

METHODOLOGY AND TECHNIQUES OF STUDY

Sampling

Samples were collected along two traverses across the regional strike of the Utatur Group. These are along the Karai - Kulkalnattam and Terani (Mines) and Garudamangalam roads (Fig. 1). Bulk samples have been collected at a 15m stratigraphic interval, without lithological bias. The Dalmiapuram Grey Shale and Dalmiapuram Reefoid Limestone were sampled at the Quarry No. 2 of the Dalmia Cement Company. The sampling intervals were 2m and 5m, vertically in the Grey Shale and Reefoid Limestone Formations.

Technique

The dominant lithology of the Utatur Group, being unconsolidated marls and calcareous clays, pose least problems for the separation of calcareous

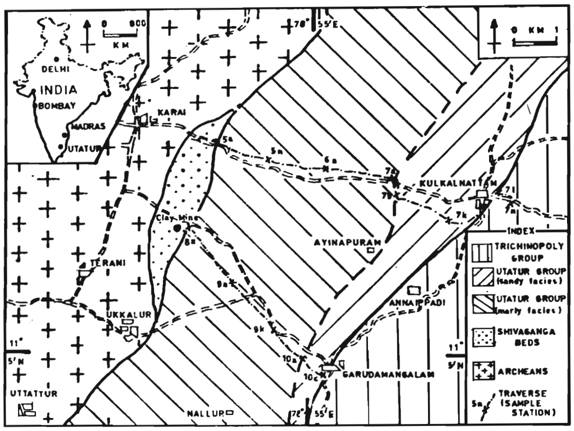

Fig. 1 Location map of sampling traverses across the Utatur Group.

nannoplankton. The method adopted for the separation and mounting of the nannofossil rich size fraction (< 50 μm), of the sediments, is similar to that recommended by Gartner (1968). A total of 162 samples were collected and analysed for their calcareous nannoflora. These were examined under a polarising light microscope (LM) with phase contrast attachment. Systematic as well as biostratigraphic evaluations were done on the basis of LM studies. Samples with well preserved and abundant nannoflora were studied on a Scanning Electron Microscope (SEM) for recording and evaluating the finer morphological details of the nannoplankton.

A part of the sample prepared for LM studies was placed on a coverslip and dried in the oven at 60^{0}c. On drying it was coated with Gold-Palladium by evaporating the metal in vacuum. Cambridge Stereoscan installed at the National Chemical Laboratory, Pune was used during the present studies.

All the samples studied on the LM were graded for:

a) the overall abundance of nannofossils, and

b) the state of preservation of the nannoflora.

The relative abundance of the individual species was determined per 300 fields of view under the LM. This was also counted in relation to their relative abundance with respect to that of *Watznaueria barnesae* (Black 1959) (Plate I, fig. 11; Plate II, fig. 4), which is the most abundant of all the Cretaceous nannofossil species. This also serves as a check for determining the state of preservation of nannofossils in the sample. Figures 2,3 and 4 give the observed range distribution and abundance of stratigraphically important species from the three sections studied.

A total of sixtyone species belonging to thirtysix genera of fifteen families have been recorded. A check list is given at the end of the text.

SYSTEMATIC PALAEONTOLOGY

Of the numerous genera and species of nannoplankton recorded in the cheak list, only the stratigraphically important species are described herewith. The numbered negatives represent the hypotypes and are deposited at the Department of Geology of the University of Poona, Pune—411 007. Perch-Nielsen (1985) has been referred to for taxonomic concepts.

Family **Ahmuellerellaceae** Reinhardt, 1965.

Ahmuellerella octoradiata (Gorka, 1957) Reinhardt, 1966a
(Pl . I, fig. 1)

Description : Elliptical coccoliths with two rim cycles. The distal cycle with dextrally imbricate elements is wider than the proximal cycle. The central area is spanned by eight radial crossbars, four parallel to the axes of the coccolith and four bisecting the angles between the axes. Each bar consists of two biserially arranged rows of elongate elements.

Remarks : *A. octoradiata* is easily recognised under LM in well preserved assemblages. However, in slightly etched or dissolved samples, this species is easily missed, especially if the central structure is dissolved or damaged.

Occurrence : In the present study, the first occurrence (FO) of this species is recorded in the upper part of the *M. decoratus* Zone (Middle to Late Cenomanian) and its range extends to the Maastrichtian.

Family **Arkhangelskiellaceae** Bukry, 1969

Gartnerago nanum Thierstein, 1974
(Pl. I, figs. 2-3)

Description : Elliptical coccoliths with four cycles of elements in the proximal view and two in the distal view. The outer three proximal cycles build the proximal shield, while the innermost cycle lines the central area. The number of elements in each cycle decreases from the outer to the inner cycle. The distal shield cycles have equal number of elements, but alternately opposite imbrication of sutures. The central area is small (width = width of rim), elliptical and occupied by a distally convex calcite central plate.

The central plate is traversed by two recessed sutures parallel to the axes of the ellipse, passing through the centre. These sutures are formed by the straight edges of elements on either side of the suture.

Remarks : *G.nanum* is easily distinguished from other species of the genus *Gartnerago* by the small central area. It is distinguished from the early representatives of the genera *Aspidolithus* Noel (1969) and *Broinsonia* Bukry (1969) by the number of rim cycles, though they have a similar small central area.

Occurrence : The FO of *G. nanum* is in the Late Albian within the *P. columnata* zone (Early to Late Albian) in both the sections of the Utatur Group. The Last Occurrence (LO) of *G.nanum* is of importance, as it is very near the Middle-Late Cenomanian transition. Perch-Nielsen (1079 & '85) regards this as an important event in the *M. decoratus* Zone. In the present study, the LO of this species is distinct in the Karai- Kulkalnattam section, wherein it is within a highly fossiliferous interval. However, in the Terani - Garudamangalam section, the LO of *G. nanum*, base of the *M. decoratus* Zone, FO of *L. acutus* Verbeek and Manivit, in Manivit *et al.* (1977) and the FO of *A.octoradiata* are in four successive samples in a poorly fossiliferous interval. In this section, the LO of *G.nanum* cannot be reliable as an event.

Gartnerago obliquum (Stradner, 1963) Reinhardt 1970
(Pl. I, fig. 4; Pl .II, fig.1)

Description : Large elliptical coccoliths with a thin multitiered rim and large central area. The proximal shield is made up of three cycles. The size of the elements in each cycle is wider than in the preceding outer cycle. The middle cycle has dextrally imbricate elements, while the remaining two cycles have sinistrally imbricate elements. The distal shield is made up of two cycles. The outer distal cycle has small elements with anticlockwise inclined sutures, while the inner has irregularly sized, radially elongate elements. The central area is occupied by a distally convex perforate place, divided into four unequal quadrants by two recessed radial sutures. The longer suture is parallel to the long axis of the coccolith, while the shorter is sinistrally rotated by 5^{o}-10^{o}, from the short axis, in the proximal view.

Remarks : Thierstein (1974) and Smith (1981) have discussed the validity of different, species of genus *Gartnerago* in considerable detail, which are not repeated here. In the presently used definition, all forms with a perforate central plate and oblique short suture are included in *G. obliquum*. A further distinction would be possible only with detailed studies on SEM, on a larger number of samples.

The FO of *G. obliquum* has been used by Thierstein (1976), Verbeek (1976) and Roth (1978) to mark the base of a Late Cenomanian/Early Turonian nannofossil zone, mainly in deep sea sections. *G. stenostaurion* (Hill 1976), Perch-Nielsen 1984, reported by Hill (1976) from the Middle Albian is very similar to *G. obliquum*. Perch-Nielsen (1985) has commented about the overlapping definitions of different species similar to *G. obliquum*, and the need for further studies.

In the present study, *G. obliquum* is recorded impersistantly and in very small numbers (5 indiv./300 fields of view). The FO is recorded in the late Early Cenomanian, in the *Eiffellithus turriseifelii* Zone (Late Albian and Early Cenomanian).

Family **Chiastozygaceae** Rood, Hay and Barnard, 1973

Chiastozygus litterarius (Gorka, 1957) Manivit, 1971
(Pl. I, figs. 5 – 6; Pl. II, fig. 2)

Description : Elliptical coccoliths with a typically 'zeugoid' rim. The distal rim cycle is wider and consists of more than 30 dextrally imbricate elements. The proximal cycle is thin and has small elements with radial sutures. The broad central area is occupied by four radial cross bars. The cross bars are diagonal to the axes of the coccolith. Each cross bar is made up of elongate elements. The cross bars meet at the centre and distally extend into a short hollow stem.

Remarks : The distinction between the different species of the genus *Chiastozygus* Gartner (1968) is based mainly upon the ultrastructure of the radial cross bars. However, there is an absence of any observed evolutionary links between different forms. Perch-Nielsen (1985) has summarised the various distinctions between the Cretaceous members of this genus.

Occurrence: The FO of *C. littetrarius* has been used by Thierstein (1976), Manivit *et al.* (1977), Sissingh (1977), Wise (1983) and Perch-Nielsen (1985) to define the base of an Early Aptian to Early Albian *C. litterarius* Zone. In the present study, *C. litterarius* has been recorded from all the three sections studied. In the Terani-Garudamangalam section it is present from the lowermost fossiliferous sample.

Family **Eiffellithaceae** (Reinhardt 1965), Perch-Nielsen, 1985

Eiffellithus turriseiffelii (Deflandre *in* Deflandre and Fert, 1954) Reinhardt, 1965
(Pl. I, figs. 7-8; Pl. II, fig. 3)

Description : Large elliptical coccoliths with a thin rim consisting of a single cycle, with more than forty dextrally imbricate elements and anticlockwise inclined sutures. The large central area is lined by eight or more plates of calcite which may or may not cover the entire central area, depending upon the state of preservation. The central area is traversed by four cross bars, constructed of fibrous calcite. The cross bars may or may not be aligned diagonally or symmetrically with respect to the axes of the coccoliths. The cross bars meet at the centre to give rise to a hollow distal stem. In the proximal view the cross bars meet to enclose a small open rectangular area at the centre.

Remarks : *E. turriseiffelii* is distinctive under LM and SEM. It is easily recognised in the side views due to the distinctive appearance of the stem in cross polarised light. Perch-Nielsen (1979 & '85) has recognised several species of *Eiffellithus* on the basis of the relation between the cross bars and the axes of the coccolith. However, most of these have overlapping stratigraphic ranges.

Occurrence : The FO of *E. turriseiffelii* is easily recognised and widely used to mark the base of the late Albian to Early Cenomanian nannofossil Zone. In the Utatur Group the FO of *E. turriseiffelii* is within the *M. (M.) inflatum ammonite* Zone of Phansalkar and Kumar (1983a) which covers the Late Albian. This species is extremely abundant from the Early Cenomanian onwards.

Family **Ellipsagelosphaeraceae** Noel, 1968

Ellipsagelosphaera britannica (Stradner, 1963), Perch-Nielsen 1968.
(Pl. I, figs. 12-13; Pl. II, fig. 5)

Description : Elliptical coccoliths with two closely addressed shields, joined together by a tube lining the central area. The proximal and distal shields consist of two cycles each. The outer cycles consist of 35-40 dextrally imbricate elements with counter- clockwise inclined sutures. The inner cycles contain up to 30 dextrally imbricate elements with radial sutures. The central tube has up to 20 prismatic elements, with vertical sutures. The small central area is traversed by a complexly constructed thick bridge parallel to the short axis of the ellipse.

Remarks : The presence of the central tube joining the two shields distinguishes the species of the genus *Ellipsagelosphaera* (Noel 1965) from those of *Watznaueria* Reinhardt (1964). The apparent similarity between *W.biporta* Bukry (1969) and *E.britannica* can be resolved by using a Gypsum Plate. The central bridge of *E. britannica* shows a distinctly different optical orientation from the surrounding cycle, while in *W. biporta* it shows the same optical orientation.

Occurrence : *E. britannica*, though rare in number, is consistently present in the samples from the *C. litterarius* and *P. columnata* Zones. Its LO is recorded in the Early Cenomanian within the *E. turriseiffelii* Zone by Perch-Nielsen (1979, 83 & 85) and Doeven (1983). The LO of this species has been observed in both the sections of the Utatur Group.

Family **Microrhabdulaceae** Deflandre, 1963

Microrhabdulus decoratus Deflandre, 1959
(Pl. I, fig. 29)

Description : Rod shaped nannolith with a circular cross-section, constructed of elongate elements arranged in circular concentric rings around the axis of the rod.

Remarks : This species is easily identified in the LM between crossed polars. The rod shows alternate dark and light rectangles arranged biserially along the axis of the rod.

Occurrence : The FO of this species is used to mark the base of the Middle Cenomanian, *M. decoratus* Zone by Sissingh (1977) and later by Perch-Nielsen (1979, 83 & 85). In the Utatur Group, its FO is recorded in both the sections studied. However, in both the cases it is preceded by an unfossiliferous interval. Its FO coincides with the base of the *A. rhotomagense* ammonite Zone of Phansalkar and Kumar (1983a) in the Karai - Kulkalnattam section.

Family **Podorhabdaceae** Noel 1965

Axopodorhabdus albianus (Black, 1957), Wind and Wise *in* Wise and Wind, 1977
(Pl. I, fig. 19; Pl. II, fig. 7)

Description : Elliptical coccoliths with two similarly constructed rims of unequal sizes. The distal cycle is larger and has up to 40 elements with slight dextral imbrication and radial sutures. The large central area is occupied by four radial bars aligned with the axes of the coccolith. Each cross bar is constructed of two rows of granular elements. The cross bars flare at their junctions with the rim cycle and meet at the centre to support a hollow distal stem. The four semi-circular openings in between the cross bars are lined by prismatic elements.

Remarks : Different species of *Axopodorhabdus* Wind and Wise *in* Wise and Wind (1977) are distinguished on the basis of the relative width of the rim, size of the openings in the central area, and characters of stem supported by the cross bars (Perch-Nielsen 1985). The present material has relatively equally wide rim and cross bars which slightly flare at their junction with the rim. This agrees with the definition of *A. albianus* (Black).

Occurrence: The FO of *A. albianus* is from the base of the marls in the Karai - Kulkalnattam section and Dalmiapuram Grey Shale. In the Terani — Garudamagalam Section, the FO of this species is within the Early to Late Albian *P. columnata* Zone. Cepek and Hay (1969), Thierstein (1976) and Roth (1978) regard the FO of *A. albianus* as a zonal index marking the base of the Middle Albian.

Doeven (1983) recorded the LO of *A. albianus* to coincide with the FO of *Quadrum gartneri* Prins and Perch-Nielsen *in* Manivit *et al.* (1977) at the Cenomanian - Turonian Boundary. Crux (1982) and Mortimer (1985) have recorded the LO of this species as an event within the Early Turonian, near the Early-Middle Turonian transition in England and the North Sea. In the present work, the LO of this species is recorded only in the Terani - Garudamangalam Section (Fig. 2).

Family **Polycyclolithaceae** Forchheimer, 1972

Eprolithus floralis (Stradne, 1962), Stover, 1966
(Pl. I, figs. 22–25; Pl. II, fig. 6)

Description : Circular cylindrical coccoliths, with a single cycle of rim elements. The rim elements numbering eight to eleven have sutures which are parallel or slightly inclined with respect to the axes of the coccolith. The rim elements are raised equally above and below a central structure. In the side view the coccolith shows an 'H' shape. The ends of the wall elements may be either blunt or pointed and straight or curved outwards. In the axial view, the coccolith resembles a flower. The central area is occupied by two layers of calcite plates, equal in number to the rim elements. These plates have radial sutures and may possess slight imbrication. A circular pore is present at the centre of the coccolith.

Remarks : Perch-Nielsen (1979, '85) has listed several characters, like reduction in the number of elements, increase in the sharpness of the tips of the wall elements, decrease in size of the central area, etc. to distinguish between the different species and sub-species of *Eprolithus* Stover (1966) and *Lithastrinus*, Stradner (1962). In the present work, *E. floralis* (Stradner), *Eprolithus* sp1 Perch-Nielsen (1979) and *Eprolithus* sp2 Perch-Nielsen (1979) have not been distinguished from each other. Distinct trends of variation were observed in *E. floralis*. There is an increase in the height of the coccolith in relation to its diameter. The wall elements tend to curl more towards the outer side from the Albian to the Turonian.

Occurrence: This species is consistently present in the Utatur Group, the Dalmiapuram Grey Shale and the Dalmiapuram Reefoid Limestone from the base onwards. Thierstein (1976) and Wise (1983) have used its FO to mark the base of their Early Aptian *P. angustus* Zone. Perch-Nielsen (1979, '85) has used the FO of this species to subdivide the *C. litterarius* Zone.

Hayesites albiensis Manivit, 1971
(Pl. I, fig. 27)

Description : Star-shaped nannolith, with six or seven rays (elements), which are dextrally imbricate. The outer ends of the elements are sharply pointed. In the side view, the nannolith is cone shaped, with a wide apical angle and a flat base.

Remarks : This species is small in size (5m), however, its distinctive shape and brightness of the elements in cross polarised light make its identification easy.

Occurrence: This species is present from the base of the Utatur Group and the Dalmiapuram section. Its LO is recorded only within the Utatur marls slightly after FO of *E. turriseiffelii*.

Manivit *et al.* (1977) have used the LO of *H. albiensis* to mark the lower sub-zone of the *E.turrisieffelii* Zone in the Late Albian. Taylor (1982) records the LO of this species at the base of the 'dispar'. Zone in the British Isles. In the present work, the LO is taken to mark the uppermost beds of Late Albian age.

Quadrum gartneri Prins and Perch-Nielsen *in* Manivit, Perch-Nielsen, Prins and Verbeek, 1977
(Pl. I, fig. 26)

Description : Cubical calcareous bodies constructed of eight smaller cubical elements of calcite. The inter-element sutures are normal to the sides of the cube and divide it halfway on each face.

Remarks : *Q. gartneri* is distinguished from *Q. gothicum* (Deflandre 1957) and *Q.*sp.1, Prins *in* Perch-Nielsen (1979) by its cubic elements. The elements of *Q. gothicum* (Deflandre) are diagonally elongate, from the corners of the cube. *Q.*sp.1 has additional smaller elements between the larger cubic elements and only one tier of larger elements. *Q. gartneri* is thought to have been evolved from *E. floralis* by the progressive reduction in the number of wall elements.

Occurrence: The FO of *Q. gartneri* is well recorded in the Karai-Kulkalnattam and Terani-Garudamangalam sections. This has been considered to mark the late Late Cenomanian. Theirstein (1976), Manivit *et al.* (1977), Verbeek (1976), Roth (1978), Perch-Nielsen (1979, & 85), Cruz (1982), Doeven (1983) and Haq (1983) consider the base of the *Q. gartneri* Zone to be very near the Cenomanian-Turonian Boundary but within the Late Cenomanian. Bralower (1988) has recorded the FO of *Q. gartneri* in the mid-Cenomanian from thee Rock-Canyon section of the Western Interior Basin. In the present studies, however, the associated mega-fauna suggests that the FO of *Q. gartneri* in the Cauvery Basin is in the late Late Cenomanian. The FO of *Q. gartneri* is recorded after the FO of *Eucalycoceras pentagonaum* (Jukes-Brown) which is considered to mark the late Late Cenomanian (Phansalkar and Kumar 1983a).

Family **Prediscosphaeraceae** Rood, Hay and Barnard, 1971

Prediscosphaera columnata (Stover, 1966), Perch-Nielsen, 1984a
(Pl. I, figs. 31-35; Pl. II, figs. 10 – 11)

Description: Circular coccoliths with a two-cycled wall and a central area spanned by four radial cross bars perpendicular to each other, with a distal stem. The proximal and distal shields are of equal size and each is made up of two cycles of elements, with sixteen elements in each cycle. The outer cycle is wider than the inner cycle.

The central area is spanned by four mutually perpendicular cross bars, each made up of a single elongate element. The distal stem is attached to the shield by means of plate bars. The distal end of the stem flares into four blades parallel to the cross bars of the sheild. Nodes are present on the stem elements half way from the basal plate.

Remarks : *P. columnata* is distinguished from *P. cretacea* (Arkhangelsky 1912) by its circular shield, while *P. cretacea* has an elliptical shield with the cross bars being diagonal to the axes of the coccolith. The Early Albian forms of *P. columnata* are very small in size and appear extremely faint in cross polorised light on the LM (Plate I, figure 31). From the Late Albian onwards, there is a progressive increase in overall size of the species, mostly due to increase in the width of the outer rim cycles. In comparison with the early forms, the Cenomanian forms are almost twice in diameter (Plate I, figure 33). From the Late Albian onwards, *P. columnata* becomes dominant in the nannoflora. It is still a practice of many workers to use a loose species definition and include *P. columnata* in the earlier described *P. cretacea*, eg. Thierstein (1976), Roth (1978), Taylor (1982), Wise (1983), etc. Perch-Nielsen (1985) regards the base of the Early Albian Zone to be marked by the FO of small circular forms assigned to *P. columnata*.

Occurrence: *P. columnata* is common at the base of the Kallakudi Quarry Section (Dalmiapuram Grey Shale Formation) and in the Karai-Kulkalnattam Section. In the Terani-Garudamangalam section the FO of *P. columnata* is about 50 metres above the first fossiliferous sample. This FO is taken to mark the Early Albian in this section.

Family **Rhagodiscaceae** Hay, 1977

Rhagodiscus angustus (Stradner, 1963), Reinhardt, 1971
(Pl. I, fig. 9)

Description : Highly elliptical to kidney shaped coccoliths with a thin 'zeugoid' rim of inclined elements. The central area is occupied by small granular calcite elements. In the proximal view, a small circular opening is present at the centre. In the distal view, a short distal stem is present. A short bridge parallel to the short axis of the coccolith is present.

Remarks : *R. angustus* is distinguished from *R. asper* (Stradner, 1963) and *R. splendense* (Deflandre, 1953) by its highly elliptical outline, low rim, equal size elements in the central area and the absence of any distal radial elements or struts.

Occurrence : It is present in all the fossiliferous samples of the three sections. It is especially abundant in the Dalmiapuram Grey Shale. The FO of *R. angustus* has been used by Manivit (1971), Thierstein (1971, '76), Roth (1978), Taylor (1982), Wise (1983) to mark the base of the Late Aptian to Early Albian *R. angustus* Zone. Perch-Nielsen (1985) regards its FO as a Late Aptian event in the *C. literarius* Zone.

Family **Stephanolithaceae** Black, 1968

Corollithion kennedyi Crux, 1981
(Pl. I, fig. 17)

Description : Hexagonal coccolith with a rim wall, of two cycles of elements. The thicker outer cycle consists of up to 35 elements with radial, vertical sutures. The inner cycle lining the central area has elongate elements. The central area is dominated by four thick and mutually perpendicular cross bars. Each cross bar is made up of two unequal radial elements.

Remarks : The thick radial cross bars constructed of two elements each distinguish this species from *C. signum* Stradner (1963) which also has four radial bars, which are, however, quite slender and constructed of numerous elongate calcite elements.

Occurrence : The FO of this species is recorded in the Karai-Kulkalnattam and Terani-Garudamangalam sections in the *E. turrisieffielii* Zone. Crux (1982) and Perch-Nielsen (1985) have regarded the FO of this species to mark an event in the Early Cenomanian. Crux (1982) records the LO of this species as an event within the M. Cenomanian. In the Terani-Garudamangalam section, the LO is recorded in the Late Cenomanian.

Corollithion signum Stradner, 1963
(Pl. I, fig. 18)

Description : Hexagonal coccoliths with a rim constructed of two unequal cycles. The outer cycle is thicker, with prismatic elements, while the inner is thiner with elongate elements. The central area is occupied by four slender radial cross bars. Each cross bar is made up of numerous, slightly elongate elements.

Remarks : *C. signum* is distinguished from *C. kennedyi* by the difference in construction of the cross bars. Bukry (personal communication) regards *C. kennedyi* to be an artificial species based upon overgrown specimens.

Occurrence : The FO of *C. signum* is recorded only in the Utatur Group sections after the FO of *A. albianus* and *Tranolithus phacelosus* Stover (1966). It is not recorded in the Dalmiapuram section. Perch-Nielsen (1979 & 85) regards the FO of *C. signum* as an event in the *P. columnata* Zone.

Family **Zygodiscaceae** Hay and Mohler, 1967

Tranolithus phacelosus Stover, 1966.
(Pl. I, fig. 21; Pl. II, figs. 14–15)

Description : Elliptical coccoliths having two rim cycles. The distal cycle is the larger of the two having forty to fifty elements with dextral imbrication. The inclination of the sutures changes from slightly counterclockwise on the outer margin to strongly clockwise near the inner margin. The proximal cycle is thin with up to thirty five blocky elements with vertical sutures. The central area is occupied by four calcite rhombs, each with one of its edges parallel to the short axis of the coccolith.

Remarks : *T. phacelosus* is considered to be synonymous with *T. orionatus* (Reinhardt, 1966), Perch-Nielsen (1968) as both, though separately described in the same year, have the same construction. The assignment of Stover (1966) is retained due to priority. Stover (1966) and Perch-Nielsen (1985) include forms with a single rim cycle in the genus *Tranolithus* (Stover 1966). Some individuals observed during the present study have two rim cycles (Plate II, figure 5).

Occurrence : This species is fairly common throughout the three sections sampled. The FO of this species is recorded in the *P. columnata* Zone in all the three sections. This FO of *T. phacelosus* is considered to be a significant event by Wise (1983) and Perch-Nielsen (1979, '85) in the Albian.

NANNOFOSSIL BIOSTRATOGRAPHY

On the basis of the recorded First Occurrences of species the Utatur Group is found to contain five standard nannofossil zones. The limits of these zones are shown in the Range Charts (Figs. 2,3 and 4) and briefly described herewith. The CC Zones have been defined by Sissingh (1977).

Chaiastozygus litterarius partial range Zone (CC 7)

Definition : FO of *C. litterarius* to the FO of *P. columnata.*

Authors : Thierstein (1971) emend Sissingh (1977).

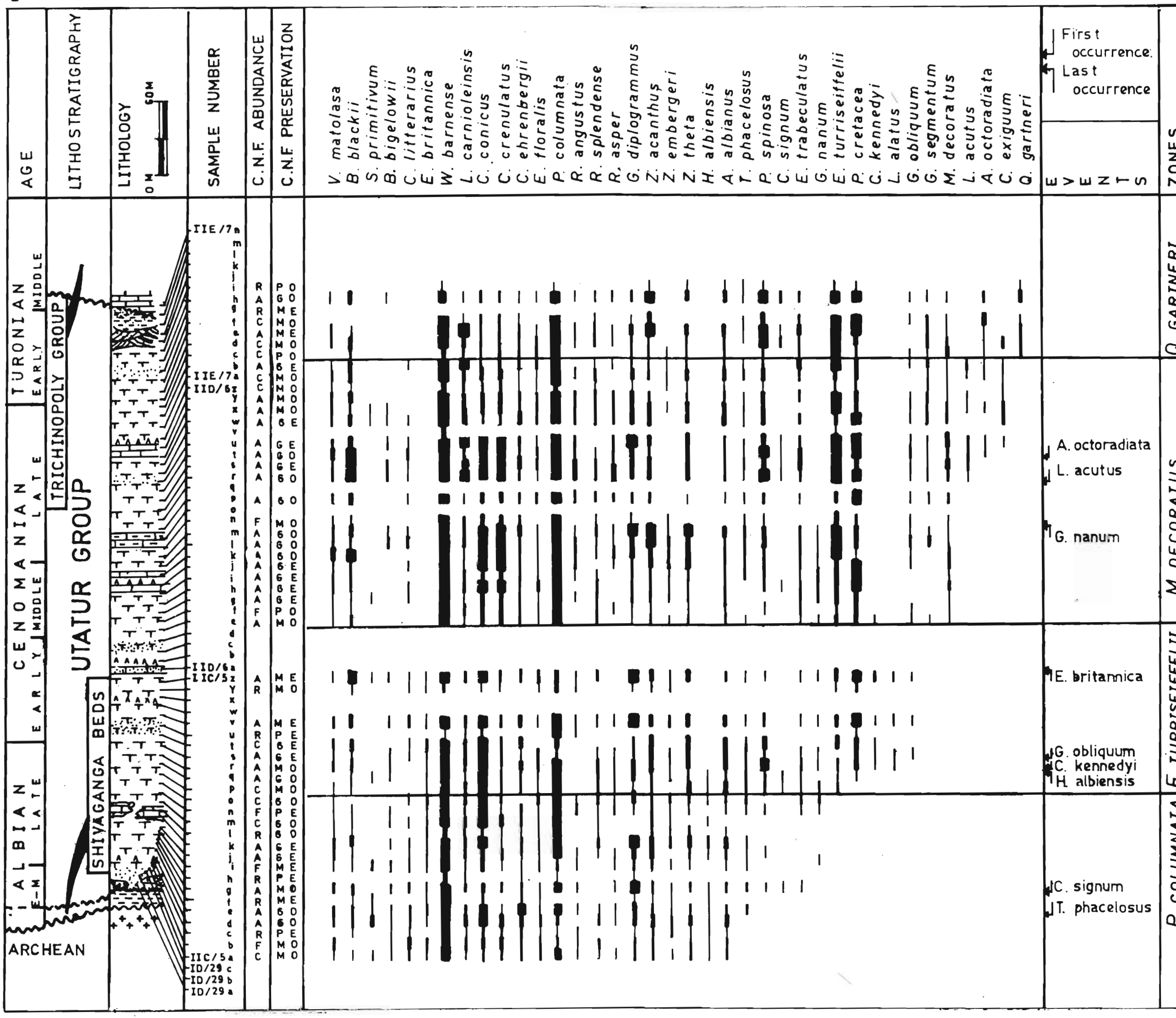

Fig. 2 Range chart of important nannofossil species from the Terani (Mines) to Garudamangalam Traverse.

Age : Aptian and Early Albian.

Occurrence : Present only in the Terani - Garudamangalam section.

Prediscosphaera columnata partial range Zone (CC 8)

Definition : FO of *P. columnata* to FO of *E. turriseiffelii.*

Authors : Thierstein (1971) nom. corr. Manivit *et al.* (1977)

Age : Early Albian to Late Albian.

Occurrence: This zone has been recorded in all the three sections studied. In the Karai-Kulkalnattam section and the Dalmiapuram Grey Shale its base is not recorded.

Eiffellithus turriseiffelii partial range Zone (CC 9)

Definition : FO of *E. turriseiffelii* to the FO of *M. decoratus.*

Authors : Thierstein (1971) emend Sissingh (1977).

Age : Late Albian to Early Cenomanian.

Occurrence : Recorded only in the Terani-Garudamangalam and Karai-Kulkalnattam sections.

Microrhabdulus decoratus partial range Zone (CC 10).

Definition : FO of *M.decoratus* to the FO of *Q. gartneri.*

Authors : Sissingh (1977).

Age : Middle to Late Cenomanian.

Occurrence : Present in the Terani-Garudamangalam and Karai - Kulkalnattam sections.

Quadrum gartneri partial range Zone (CC 11)

Definition : FO of *Q. gartneri* to the FO of either

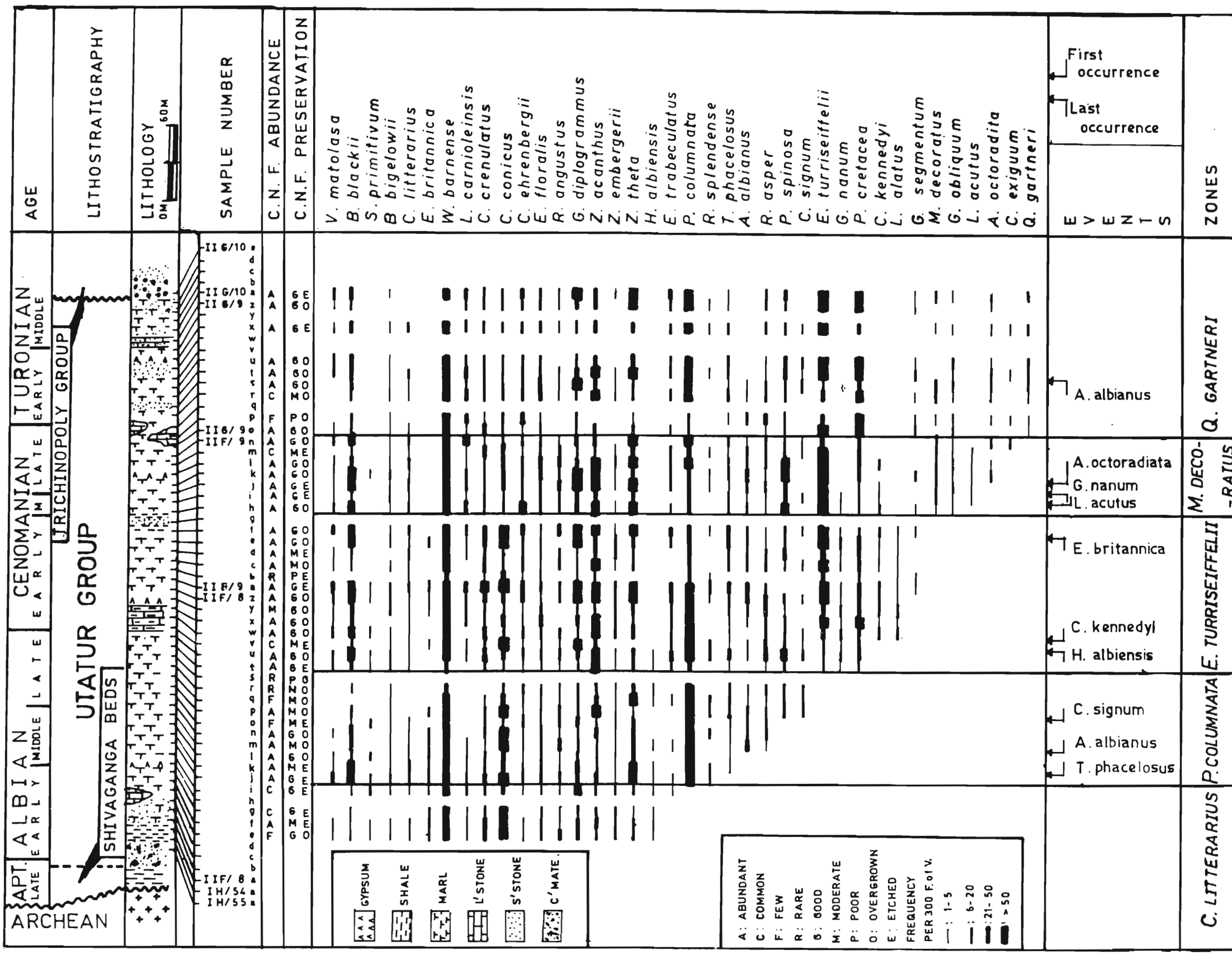

Fig. 3 Range chart of important nannofossil species from the Karai to Kulkalnattam Traverse.

Lucianorhabdus maleformis Reinhardt (1966) or *E. eximus* (Stover, 1966).

Authors : Cepek and Hay (1969) emend Sissingh (1977), nom. corr. Manivit *et al.* (1977).

Age : Late Cenomanian to Middle Turonian. (Bralower, 1988 has recorded the FO of *Q. gartneri* in the Middle Cenomanian from the Rock Canyon Section of the Western Interior Basin of N. America. Most other workers have recorded the FO of Q. gartneri not earlier than late Late Cenomanian or at the base of the Turonian.)

Occurrence : The base of this zone is recorded in the Terani-Garudmangalam and Karai-Kulkalnattam sections. Its top is, however, not recorded in both these sections.

DISCUSSION

The age limits of the Utatur Group have been previously evaluated by a number of workers, based mainly upon ammonites and planktonic foraminifera. Both these groups of fossils, though reliable as age markers, are either absent or extremely rare in occurrence in the sediments at and near the lithological boundaries of the Utatur Group.

The basal marls and clays of the Utatur Group rest unconformably upon the Precambrian Basement rocks or disconformably upon the Neocomian Shivaganga Formation along the western margin of the Cauvery Basin. The presence of reefoid limestones near the base of the Utatur marls is known since Balnford (1862). Sastry *et al.* (1968), Chiplonkar and Phansalkar (1976) and Phansalkar and Kumar (1983 a & b) have assigned an Upper Albian age to the base of the Utatur Group. This is based upon the presence of the *Mortoniceras* (M.) *inflatum/Stoliczkia dispar* ammonite zone. Banerji and Radha (1970) recognised the *Lenticulina macrodisca* Zone and *Hedbergella planispira* planktonic foraminiferal Zone (Lower - Middle Albian) at the base of the Utatur Group in the Utatur - Nallur tract, assigning a Lower - Middle Albian age to it. Phansalkar and Kumar (1983a) have described the presence of the *Planomalina buxtorfi* Zone (Upper Albian) at the base of the Utatur Group.

On the basis of the nannofloral assemblage, the basal sediments of the Utatur Group in the Terani - Garudamangalam section are assigned to the *Chiastozygus litterarius* Zone. This indicates a Late Aptian (?) to Early Albian age for these sediments. The presence of species like E. *floralis, R. angustus*, etc. further indicate that these sediments fall into the upper part of the *C. litterarius* Zone. The unfossiliferous sediments below this may represent slightly older age for the base of Utatur Group. In the Karai-Kulkalnattam section, *P. columnata* is present from the base. The FO's of *A. albianus* and *T. phacelosus* are slightly higher up in the section. This indicates that the base of the Utatur marls in this section is in the later part of the Early Albian.

The Dalmiapuram Grey Shale and the Dalmiapuram Reefoid Limestone Formation yield *P. columnata, A. albianus* and *T. phacelosus* from the basal sample. This indicates that the base of the Grey Shale is Middle Albian in age. The topmost fossiliferous sample from the Reefoid Limestone yields a flora of the *P. columnata* Zone, thereby restricting its upper age to late Middle Albian or early Late Albian.

During the present work, it was observed that the Grey Shale shows the presence of calcareous laminae in increasing proportions towards its top. This finally grades into a thinly laminated marl (5 to 10 cm thick) over which rests the Reefoid Limestone. The Reefoid limestone on its flanks is observed to be interfingering with the Utatur marls.

Since its discovery (Subbaraman, 1968), the Dalmiapuram Grey Shale and the Dalmiapuram Reefoid Limestone Formations have been taken - as Formations - at the base of the Utatur Group (Ramanathan, 1968; Sastry *et al.*, 1977, Phansalkar and Kumar, 1983 a, b, etc.); Bhatia and Jain (1969, '72) and Banerji (1972) opined that the succession at Dalmiapuram is older than and distinct from the Utatur Group.

Jafar and Rai (1989) have recorded the FO of *P. columnata* in a sample about 2.5 m above the base of the Dalmiapuram Grey Shale, while two other samples (KL9 & KL10) very near the base have not yielded *P. columnata* to them. On the basis of this they have placed the lower portion of the Grey Shale in the Aptian - Early Albian *C. litterarius* Zone (CC 7). During the present work, *P. columnata* has been recorded in a sample at the base of the Dalmiapuram Grey Shale (sample No. KL1 of the present study, Text Figure 4). Further, the presence of *A. albianus, T. phacelosus* and *Cribosphaerella ehrenbergi*, (Arkhangelsky, 1912) Deflandre *in* Piveatu (1952) (Plate I, fig. 20 and Plate II, fig. 18) definitely point to a late Early Albian to Middle Albian age for the base of the Grey Shale.

Subcrops of the Dalmiapuram Grey Shale have been reported from the Garudmangalam - Saradmangalam tract (Subbaraman, 1968) and near the base of the Utatur Group by Ramanathan (1968) and Sastry *et al.* (1977). The basal relationships of the Dalmiapuram Grey Shale in these subcrops are not known.

The present work suggests that the Dalmiapuram Grey Shale has been deposited contemporaneously with the marls and clays of the Utatur Group. The later development of the reefoid facies is a widespread phenomenon in the basin. The Middle-Late Albian reefoid rocks are present near the base of the Utatur Group at numerous localities, ex. Neykulam Varagupadi, Kalpadi, Maravattur, etc.

The suggestion of Jafar and Rai (1989) that the Dalmiapuram Formation should include only the Grey Shale, while the Reefoid Limestone should be a part of the 'Utatuar Formation' is presently accepted with a slight modification. Based upon the field relationships and the age, the Grey Shale appears to represent an anoxic event in the Cauvery Basin subsequent to the initial tansgression of Late Aptian (?) - Early Albian age. There has been a contemporaneous deposition of marls and clays in other parts of the basin along with the Grey Shale.

The Reefoid Limestone shows an intertonguing relationship with gypsiferous marls of the Utatur Group on the flanks of the main reef body at the Quarry No. II of Dalmiapuram (considered to be the type section for the Dalmiapuram Formation). It definitely implies the development of reefoid facies contemporaneously with the back-reef facies in which the Lower Utatur marls and clays were deposited.

In view of these evidences, it is proposed that the Dalmiapuram Grey Shale and the Dalmiapuram Reefoid Limestone should be considered as Formations within the Utatur Group.

The upper limit of the Utatur Group shows variable relation with the overlying Trichinopoly Group. Towards the North, around Kunnam and Adanur, the Garudamangalam Shell Limestone Formation, of the Trichinopoly Group overlies the sandy clays of the Utatur Group with a distinct angular unconformity. This gradually gives way to a disconformable relation between the two near Kulkalnattam. South of Garudamangalam the Utatur sandy clays grade into coarse sandstones and finally into intertonguing conglomerates and coquinid limestones of the Trichinopoly Group.

Sastry *et al.* (1968) recognise the presence of the Cenomanian (?) - Turonian *Mammites conciliatum* ammonite Zone at the top of the Utatur Group. Phansalkar and Kumar (1983a & b) recognise the Lower Turonian *Pseudaspidoceras footeanum* ammonite assemblage Zone at the top of the Utatur Group. Narayanan (1977) records the *Marginotruncana helvetica - Marginotruncana sigali* assemblage zone at the top of the Utatur Group assigning an Early Turonian age. Phansalkar and Kumar (1983a), while recording the *Praeglobotruncana helvetica* Zone (Early - Middle Turonian), have commented upon the problem posed by the presence of a considerable thickness of unfossiliferos clastics at the top of the Utatur Group.

Several fossiliferous samples from the upper sandy horizons in the Utatur Group have yielded a well preserved nannoflora in the Karai - Kulkalnattam and Terani - Garudamanglam sections. In the latter, the LO of *A. albianus* is recorded within the *Q. gartneri* Zone. This LO has been regarded as an event very near the Early Middle Turonian boundary. On the basis of these, a variable age from the Early to Middle Turonian has been recognised for the top of the Utatur Group.

CONCLUSIONS

The Utatur Group has a well preserved and diverse nannoflora. Five nannofossil zones (viz. *Chiastozygus litterarius, Prediscosphaera columnata, Eiffellithus turriseiffelii, Microrhabdulus decoratus* and *Quadrum gartneri*) are recognised within the Utatur Group. On the basis of the nannoflora the base of the Utatur Group is assigned a Late Aptian (?) - Early Albian age. The upper age limit of the Utatur Group is placed in the Middle Turonian. The Dalmiapuram Grey Shale and Dalmiapuram Reefoid Limestone Formations are Middle Albian in age and a part of the

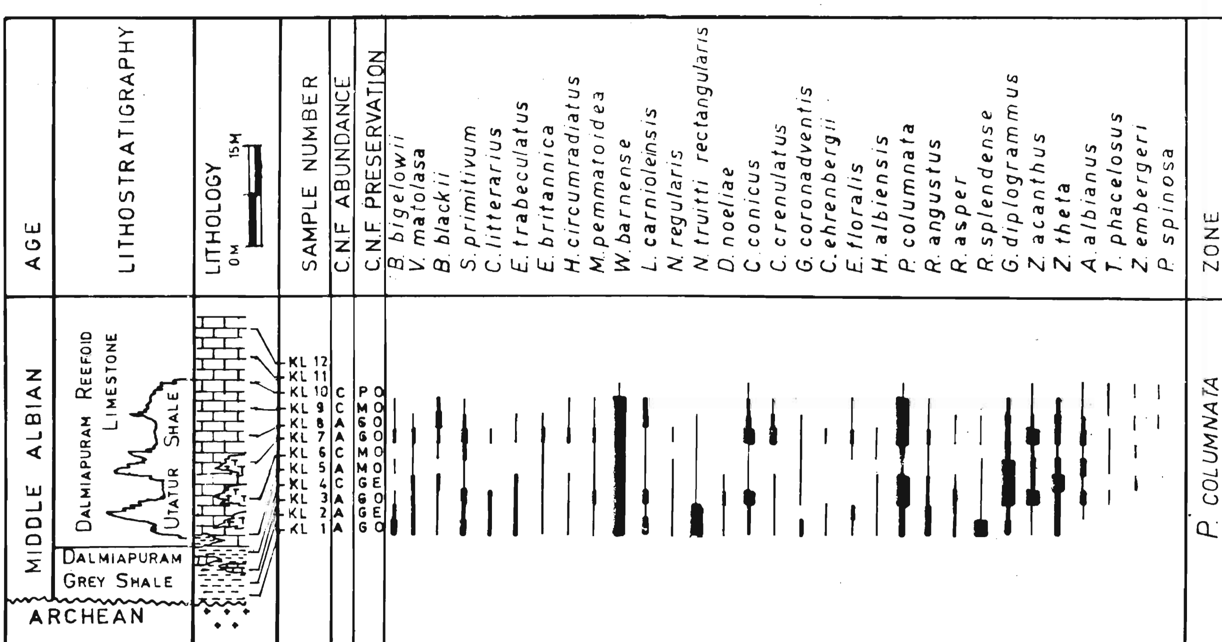

Fig.4 Range Chart of important nannofossil species from the Kallakkudi Quarry.

Utatur Group.

ACKNOWLEDGEMENTS

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Checklist of Calcareous nannoplankton identified in the Utatur Group

Ahmuellerella Reinhardt 1964.
Ahmuellerella octoradiata (Gorka 1957), Reinhardt 1966.
Vegalapilla Bukry 1969.
Vegalapilla matalosa (Stover 1966), Thierstein 1973.
Broinsonia Bukry (1969).
Broinsonia enormis (Shumenko 1968), Manivit 1971.
Broinsonia signata (Noel 1969), Noel 1970.
Gartnerago Bukry 1969.
Gartnerago nanum Thierstein 1974.
Gartnerago obliquum (Stradner 1963), Reinhardt 1970.
Gartnerago striatum (Stradner 1963), Forchhemir 1972.
Biscutum Black *in* Black and Barnes 1959.
Biscutum blackii Gartner 1969.
Seribiscutum Filewicz *et al. in* Wise and Wind 1977.
Seribiscutum primitivum, (Thierstein 1974), Filewicz *et al. in* Wise and Wind 1977.
Braarudosphaera Deflandre 1947.
Braarudosphaera bigelowii (Gran and Braaud 1935), Deflandre 1947.
Chiastozygus Gartner 1968.
Chiastozygus amphipons (Bramlette and Martini 1964), Gartner 1968.
Chiastozygus litterarius (Gorka 1957) Manivit 1971.
Chiastozygus plicatus Gartner 1968.
Tegumentum, Thierstein *in* Roth and Thierstein 1972.
Tegumentum stradneri Thierstein *in* Roth and Thierstein 1972.
Eiffellithus Reinhardt 1965.
Eiffellithus trabeculatus (Gorka 1957), Reinhardt and Gorka 1967.
Eiffellithus turriseiffelii (Deflandre *in* Deflandre and Fert 1954) Reinhardt 1965.
Ellipsagelosphaera Noel 1965.
Ellipsagelosphaera britannica (Stradner 1963), Perch-Nielsen 1968.
Haquis Roth 1978.
Haquis circumradiatus (Stover 1966), Roth 1978.
Manivitella Thierstein 1971.
Manivitella pemmatoidea (Deflandre ex Manivit 1965), Thierstein 1971.
Watznaueria Reinhardt 1964.
Watznaueria barnesae (Black *in* Black and Barnes 1959), Perch-Nielsen 1968.
Watznaueria biporta Bukry 1969.
Lithraphidites Deflandre 1963.
Lithraphidites alatus Thierstein *in* Roth and Thierstein 1972.
Lithraphidites acutus Verbeek and Manivit *in* Manivit *et al.* 1977.
Lithraphidites carnioleinsis, Deflandre 1963.
Microrhabdulus Deflandre 1959.
Microrhabdulus decoratus Deflandre 1959.
Microrhabdulus attenuatus (Deflandre 1959), Deflandre 1963.
Nannoconus Kamptner 1931.
Nannoconus regularis Deres and Acheriteguy 1980.
Nannoconus truitti rectangularis Deres and Acheriteguy 1980.
Axopodorhabdus Wind and Wise, *in* Wise and Wind 1977.
Axopodorhabdus albianus (Black 1967), Wind and Wise *in* Wise and Wind 1977.
Dodekapodorhabdus Perch-Nielsen 1968.
Dodekapodorhabdus noeliae Perch-Nielsen 1968.
Tetrapodorhabdus Black 1971.
Tetrapodorhabdus decorus (Deflandre *in* Deflandre and Fert 1954),

Wind and Wise *in* Wise and Wind 1977.
Cretarhabdus Bramlette and Martini 1964.
Cretarhabdus conicus Bramlette and Martini 1964.
Cretarhabdus crenulatus Bramlette and Martini 1964.
Cretarhabdus striatus (Stradner 1963), Black 1973.
Gephyrorhabdus Hill 1976.
Gephyrorhabdus coronadventis (Reinhardt 1966) Hill 1976.
Cribosphaerella Deflandre *in* Piveateau 1952.
Cribosphaerella ehrenbergi (Arkhangelsky 1912), Deflandre *in* Piveateau 1952.
Eprolithus Stover 1966.
Eprolithus floralis (Stradner 1962) Stover 1966.
Hayesites Manivit 1971.
Hayesites albiensis Manivit 1971.
Quadrum Prins and Perch-Nielsen *in* Manivit *et al.* 1977.
Quadrum gartneri Prins and Perch-Nielsen *in* Manivit *et al.* 1977.
Radiolithus Stover 1966.
Radiolithus planus Stover 1966.
Prediscosphaera Vekshina 1959.
Prediscosphaera columnata (Stover 1966), Perch-Nielsen 1984.
Prediscosphaera cretacea (Arkhangelsky 1912), Gartner 1968.
Prediscosphaera ponticula (Bukry 1969), Perch-Nielsen 1984.
Prediscosphaera spinosa (Bramlette and Martini 1964), Gartner 1968.
Rhagodiscus Reinhardt 1967.
Rhagodiscus angustus (Stradner 1963), Reinhardt 1971.
Rhagodiscus asper (Stradner 1963), Reinhardt 1967.
Rhagodiscus splendens, (Deflandre 1953) Verbeek 1977.
Corollithion Stradner 1961.
Corollithion exiguum Stradner 1961.
Corollithion kennedyi Crux 1981.
Corollithion signum Stradner 1963.
Cylindralithus Bramlette and Martini 1964.
Cylindralithus sp. aff. *C. serratus* Bramlette and Martini 1964.
Stoverius Perch-Nielsen 1984b.
Stoverius achylosus (Stover 1966) Perch-Nielsen 1984b.
Stoverius baldiae (Stradner and Adamiker 1966), Perch-Nielsen 1984b)
Rotelapillus Noel 1973.
Rotelapillus sp.
Glaukoltithus Reinhard 1964.
Glaukoltithus diplogrammus (Deflandre 1954), Reinhardt 1964.
Tranolithus Stover 1966.
Tranolithus exiguus Stover 1966.
Tranolithus gabalus Stover 1966.
Tranolithus phacelosus Stover 1966.
Zeugrhabdotus Reinhardt 1965.
Zeugrhabdotus acanthus Reinhardt 1965.
Zeugrhabdotus embergeri (Noel 1958) Perch-Nielsen 1984b.
Zeugrhabdotus theta (Black *in* Black and Barnes 1959) Black 1973.

EXPLANATION OF PLATE

Plate I

(Figures in brackets are negative numbers of hypotypes)
(CPL = Cross Polarised Light)

1) *Ahmuellerella octoradiata* (Gorka 1957) Reinhardt 1964, proximal view, CPL, (121191).

2) *Gartnerago nanum* Thierstein 1974, proximal view, CPL, (121232).

3) *Gartnerago nanum, Thierstein 1974, same specimen as 2, phase contrast, (121234).*

4) *Gartnerago obliquum* (Stradner 1963) Reinhardt 1970, proximal view, CPL, (121314).

5) *Chiastozygus litterarius* (Gorka 1957) Manivit 1971, proximal side, CPL, (131095).

6) *Chiastozygus litterarius* (Gorka 1957) Manivit 1971, distal view, CPL, (131090).

7) *Eiffellithus turriseiffelli,* (Deflandre 1954) Reinhardt 1965, Distal view, CPL, (121200).

8) *Eiffellithus turriseiffelii* (Deflandre 1954) Reinhardt 1965, proximal view, CPL, (121260), 1800x.

9) *Rhagodiscus angustus* (Stradner 1963) Reinhardt 1971, proximal view, CPL, (131099).

10) *Rhagodiscus splendense* (Deflandre 1953) Verbeek 1977b, distal view, CPL, (121336).

11) *Watznaueria barnesae* (Black 1959) Perch-Nielsen 1968, distal view, CPL, (131041).

12) *Ellipsagelosphaera britannica* (Stradner 1963) Perch-Nielsen 1968, proximal view, CPL, (131041).

13) *Ellipsagelosphaera britannica,* (Stradner 1963) Perch-Nielsen 1968, same individual as 12, transmitted light, (131042).

14) *Seribiscutum primitivum* (Thierstein 1974) Filewicz *et al.* 1977, proximal view, CPL (131100).

15) *Braarudosphaera bigelowii* (Gran and Braarud 1935) Deflandre 1947, proximal view, CPL, (131023).

16) *Corollithion exiguum* Stradner 1961, axial view, CPL, (121185).

17) *Corollithion kennedyi* Crux 1981, axial view, CPL, (121357).

18) *Corollithion signum* Stradner 1963, overgrown individual, axial view, CPL, (121087).

19) *Axopodorhabdus albianus* (Black 1957) Wind & Wise 1977, distal view, CPL, (121249).

20) *Cribosphaerella ehrenbergii,* (Arkhangelsky 1912) Deflandre 1952, proximal view, CPL, (121119).

21) *Tranolithus phacelosus* Stover 1966, distal view, CPL, (121355).

22) *Eprolithus floralis,* (Stradner 1962) Stover 1966, M. Albian, axial view, CPL, (121203). 1800x.

23) *Eprolithus floralis* (Stradner 1962) Stover 1966, E. Cenomanian, axial view, CPL, (121016).

24) *Eprolithus floralis* (Stradner 1962) Stover 1966, M. Cenomanian, axial view, CPL, (121110).

25) *Eprolithus floralis,* (Stradner 1962) Stover 1966, M. Albian, side view, CPL, (121084).

26) *Quadrum gartneri* Prins and Perch-Nielsen 1968, axial view, CPL, (121224).

27) *Hayesites albiensis* Manivit 1971, axial view, CPL, (131080).

28) *Lithraphidites alatus* Thierstein 1972, CPL, (121345).

29) *Microrhabdulus decoratus* Deflandre 1959, CPL, (121373).

30) *Microhabdulus attenuatus* (Deflandre 1959) Deflandre 1963, CPL, (121364).

31) *Prediscosphaera columnata* (Stover 1966) Perch-Nielsen 1984, E. Albian, proximal view, CPL, (131108).

32) *Prediscosphaera columnata* (Stover 1966), Perch-Nielsen 1984, L. Albian, proximal view, CPL, (191128).

33) *Prediscosphaera columnata* (Stover 1966) Perch-Nielsen 1984, large form, M. Cenomanian, distal view, (121128).

34) *Prediscosphaera columnata* (Stover 1966) Perch-Nielsen 1984, overgrown, Cenomanian, distal view, CPL, (121054).

35) *Prediscosphaera columnata* (Stover 1966) Perch-Nielsen 1984, side view, CPL, (121076).

Plate II

Bar = 2 mm)

(Figures in brackets are negative numbers of hypotypes)

1) *Gartnerago obliquum* (Stradner 1963) Reinhardt (1970) distal view, (E11477)

2) *Chiastozygus litterarius*, (Gorka 1957) Manivit (1971) distal view. (E1137)

3) *Eiffellithus turriseiffelii* (Deflandre 1954) Reinhardt (1965) distal view. (E11470)

4) *Watznaueria barnense*, Black (1959) Perch-Nielsen (1968), distal view. (E111005)

5) *Ellipsagelosphaera britannica* (Stradner 1963) Perch-Nielsen (1968), overgrown, distal view. (E11145)

6) *Eprolithus floralis* (Stradner 1962) Stover (1966), axial view. (E11013)

7) *Axopodorhabdus albianus* (Black 1957) Wind and Wise (1977), slightly etched, distal view. (E11053)

8) *Cribosphaerella ehrenbergii*, (Arkhangelsky 1912) Deflandre (1952) proximal view. (E11466)

9) *Glaukolithus diplogrammus* (Deflandre 1954) Reinhardt (1964) proximal view. (E11005)

10) *Prediscosphaera columnata* (Stover 1966) Perch-Nielsen (1984) Albian, Overgrown, distal view. (E11401)

11) *Prediscosphaera columnata* (Stover 1966) Perch-Nielsen (1984), Cenomanian, distal view. (E11441)

12) *Nannoconus truitti rectangularis* Deres and Acheriteguy (1980), side view (E11073).

13) *Nannoconus regularis* Deres and Acheriteguy (1980), side view. (E11063)

14) *Tranolithus phacelosus* Stover (1966), distal view (E11288).

15) *Tranolithus phacelosus* Stover (1966), proximal view, with two rim cycles. (E11289).

Plate I

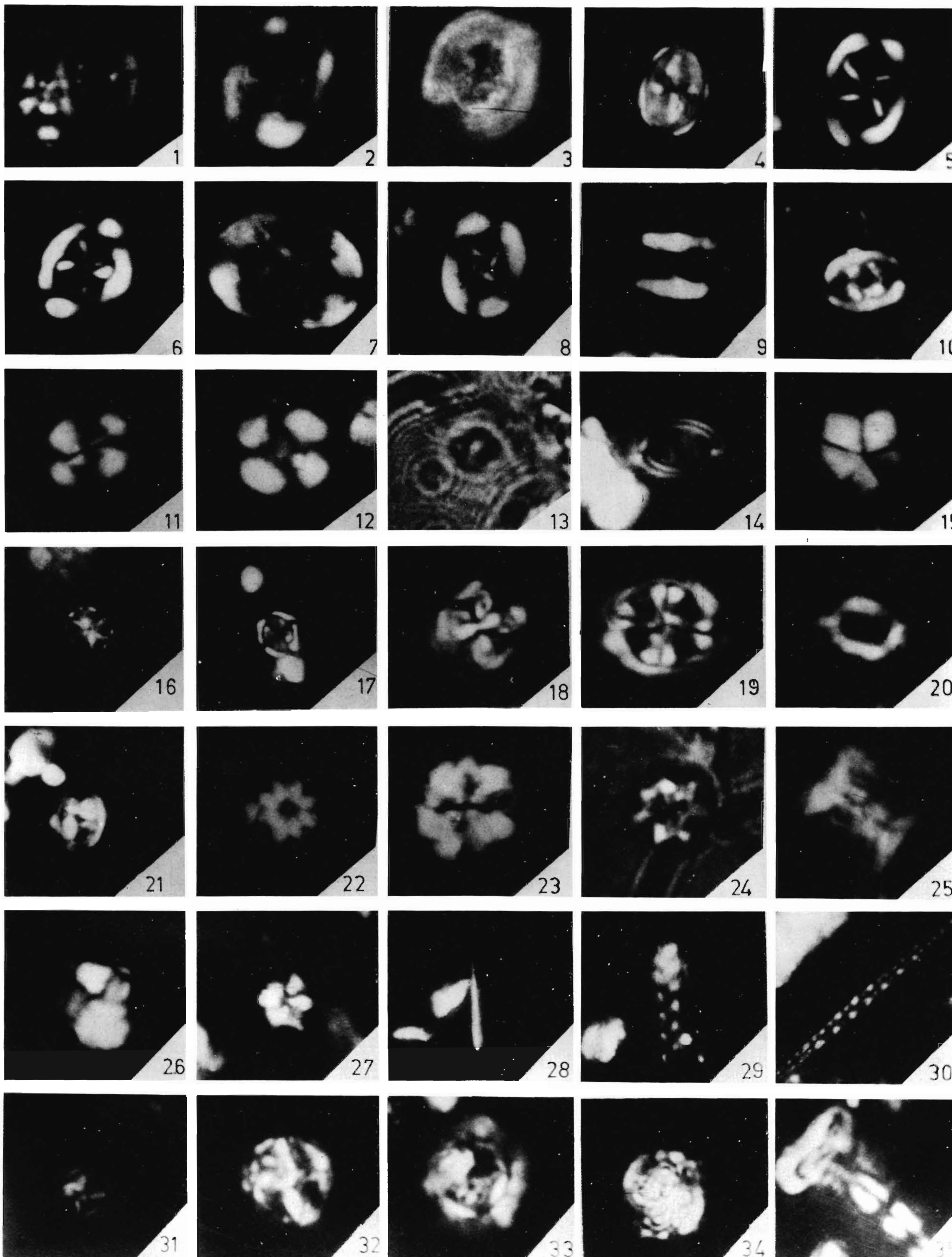
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Plate II