The foraminifera of the South Indian Cretaceous-Eocene

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The Foraminifera of the South Indian Cretaceous-Eocene[1])

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With 1 table in the text

PREFACE

The present paper is a brief summary of the dissertation entitled 'The Foraminifera of the South Indian Cretaceous-Eocene and some conclusions as to the geologic age and correlation of certain lithotopes' and presented to the Faculty of Science of the University of Basel.

The investigation of the material has been carried out under the guidance of Prof. Dr. M. REICHEL, to whom the author is grateful. The writer had valuable advice from Prof. Dr. H. SCHAUB in studying the nummulitic material, for which he is highly grateful. Through the kind efforts of Prof. Dr. L. VONDERSCHMITT, the Head of the Institute of Geology and Paleontology, and Prof. Dr. R. GEIGY, the former Rector of the University of Basel, the financial grant from the Government of the Swiss Federation was made to complete the work. To all of them the writer remains grateful.

The following persons have been of assistance in either supplying the type material for comparison and/or in discussing the taxonomic problems in their laboratories: Dr. J. HOFKER (The Hague), Dr. H. HILTERMANN (Hanover), Dr. F. BROTZEN (Stockholm), Dr. B. J. ROMEIN (Heerlen, Holland), Dr. J. H. VAN VOORTHUYSEN (Haarlem, Holland), Dr. R. FURON (Paris), Dr. R. A. REYMENT (Stockholm), Dr. A. NORVANG and Dr. H. W. RASMUSSEN (Copenhagen), Prof. C. W. DROOGER (Utrecht), Dr. C. G. ADAMS of the British Museum, and Prof. K. G. NYHOLM (Stockholm). The writer conveys his sincere thanks to all of them.

INTRODUCTION

A succession of fossil marine beds of Cretaceous-Eocene age occurs in the districts of Trichinopoly, South Arcot and Tanjore of the State of Madras, and in the neighbourhood of the town of Pondicherry. These beds have been considered as 'a veritable field museum of upper Cretaceous palaeozoology' by those who had the good fortune of collecting abundant and varied megafossils. Now these beds are no longer a 'field museum' so far as the megafossils are concerned as the latter are rarely found in great abundance. However, the beds can still be a 'museum' if the microfossils are taken into consideration. The study of the megafossils from these beds by the paleontologists of the last century led KOSSMAT (1895) to recognize 'the type of the Pacific Cretaceous area' in the South Indian region and to

[1]) Author's contribution to the Micropaleontology of South India – No. 1.

believe that they are 'eminently adapted to serve as a starting point for observation on the zoo-geographical conditions of later Cretaceous times'. The same author recognized in the fauna 'the elements both of the eastern and of the western hemispheres' and a 'connecting link between the two hemispheres'.

The intention of the writer was to see whether microfossils from these beds also make the South Indian Cretaceous rocks as interesting as the megafossils have made them. The group of foraminifera among the microfossils is selected for a systematic study. A very rich foraminiferal fauna, consisting of both 'small and large' species, has been recovered from the sediments of the region. The object of the study of the foraminifera was to connect some stratigraphic problems of the region with it. From this point of view a selection of the lithotopes belonging to the various stratigraphic divisions of the South Indian Cretaceous-Eocene succession had to be made. The reader will find in the present paper a very brief summary of the investigation on the foraminifera from 12 lithotopes.

STRATIGRAPHY

The stratigraphic subdivisions established on the basis of the study of megafossils by BLANFORD (1865), STOLICZKA (1864–1873), WARTH (1895), and KOSSMAT (1897) have been reviewed by RAMA RAO (1956) and KRISHNAN (1960). The subdivisions of the Trichinopoly Cretaceous accepted by KRISHNAN are shown in the chart given at the end of the paper. The subdivisions of the Pondicherry area suggested by WARTH and KOSSMAT are also shown in the same chart. The reader can find exhaustive discussion on the stratigraphic problems of the region in a valuable review given by RAMA RAO. One can also find a chronologic listing of references on the research done on the South Indian rocks under discussion in a paper by FURON (1941), who has very meticulously compiled all the literature published up to 1939.

FORAMINIFERA

The species of foraminifera noticed in the 12 lithotopes have all been studied systematically. A few of them are not included in the systematic part of the original paper and are indicated by an asterisk in the list of the species given below. The stratigraphic position of each lithotope is shown in the columns II and V of the chart given at the end of the paper. The number of each lithotope refers to the order in which it is dealt with in the present study.

1. Cullygoody Limestone—Upper Albian–Cenomanian

The following species of foraminifera are noticed:

Allomorphina sp. nov.
Anomalina sp. nov.
Astacolus incurvata (REUSS)
Cibicidoides cenomanica BROTZEN ssp. nov.
Conorbina brotzeni GANDOLFI
Dentalina bullata SCHWAGER
Dentalina sp. cf. *ejuncida* LOEBLICH & TAPPAN

Gavelinella sp. nov. B
Gavelinopsis pseudobaccata SAID & KENAWY
Glandulina sp. A
Globorotalites sp. nov.
Globulina prisca REUSS
Gyroidinoides sp. nov. B
Gyroidinoides gracillima (TEN DAM) ssp. nov.
Hedbergella planispira (TAPPAN)
Hedbergella portsdownensis (WILLIAMS-MITCHELL)
Lagena hauteriviana cylindrica BARTENSTEIN & BRAND
Lenticulina macrodisca (REUSS)
Lenticulina nodosa (REUSS)
Marginulina hamulus CHAPMAN
Marginulinopsis sp.
Marginulinopsis tenuissima (REUSS)
Nodosaria sp. B
Pleurostomella obtusa BERTHELIN
Pleurostomella reussi BERTHELIN
Ramulina sp. A
Ramulina sp. B
Rectobolivina sp. nov. A
Saracenaria sp. A
Trochammina sp. nov.

All the species are from the sandy marl which occurs in the form of thin beds within the main body of Cullygoody limestone as seen in the 1st quarry of the Dalmia Cement Company of India. The writer wishes to convey his sincere thanks to the authorities of the Company for permitting him to collect the samples studied here.

All the rock types of the Cullygoody limestone, as well as those of the Coral Reef Limestone bands occurring along the western margin of the Utatur division (at Kullapaudy, Varagupaudy, Kaury, Terany, Naicolum, Agaram, and Tirapattoor), consisting of 70 samples, have been examined. As many as 270 thin sections of the samples were studied to confirm the observations made by BLANFORD on the lithology, paleontology, and stratigraphic relationship of all the limestone bands. The conclusions arrived at by BLANFORD as to the stratigraphic position of the limestone bands and as to the age of them are supported by the occurrence of *Hedbergella planispira* (TAPPAN) and *Hedbergella portsdownensis* (WILLIAMS-MITCHELL). The species *planispira* is the most abundant form in the sandy marl of the Cullygoody limestone. The species *portsdownensis* is quite common in the samples. Both of these planctonic species indicate Upper Albian-Cenomanian age. The other benthonic species of foraminifera listed above show very close relationship to the Albian and Cenomanian foraminiferal fauna of Europe.

Neither the Jurassic age as claimed by NARAYANA RAO (1947) nor the Trichinopoly age (Turonian to Lower Senonian) as suggested by RAMA RAO (1956) for the Cullygoody limestone is acceptable in the light of the evidence provided by the

foraminiferal species. There is no reason at all to doubt the stratigraphic position of the limestone indicated by BLANFORD, who placed the Cullygoody limestone at the base of the Utatur division after discussing the various problems posed by its relationship with the rocks of the Trichinopoly and Ariyalur divisions. He showed the geographic position of the limestone at the contact between the Trichinopoly division and the Ariyalur division in the geological map. It is this fact that led KOSSMAT (1897) to believe that the Kalligadi beds (p. 66) are correlatable with the Valudayur group of the Pondicherry region. There is no doubt at all as to KOSSMAT's mistaking the Cullygoody limestone for Kalligadi beds in the arguments. In view of the occurrence of the two planctonic species of foraminifera mentioned above in the Cullygoody limestone, KOSSMAT is not right in correlating the Valudayur beds of the Pondicherry area with the Cullygoody limestone proper of the Trichinopoly district.

2. Odhium Shale—Cenomanian

This lithotope, like the Odhium clay, is studied from the core samples supplied by SRI SUBRAMANIAN, Geologist of Ariyalur, to whom the author conveys his sincere thanks for giving the samples for investigation. The Odhium shale is overlain by Odhium clay and both of them belong to the Middle Utatur stage of BLANFORD and KRISHNAN. The lithotope is very poor in microfossils as compared to the Odhium clay. The following species of foraminifera, represented by very few individual samples, are met with:

Allomorphina sp. nov.
Ceratolamarckina sp. nov.
Gavelinella sp. nov. A
Gyroidinoides gracillima (TEN DAM) ssp. nov.
Höglundina sp. nov.
Höglundina supracretacea (TEN DAM)

3. Odhium Clay—Upper Cenomanian

This lithotope belongs to the Middle Utatur division of BLANFORD and KRISHNAN in which *Acanthoceras* cf. *rhotomagense* is the characteristic index fossil. Quite enough samples are available of this lithotope which is known to be 50 feet in thickness, as revealed in the cores taken under the supervision of SRI SUBRAMANIAN. The lithotope is very rich in microfossils and the preservation of the fauna is wonderful. Only the group of foraminifera is studied systematically and the list of species given here indicates Middle-upper Cenomanian. It seems to be better to assign Upper Cenomanian age to the fauna in view of the fact that the clay belongs to the *Acanthoceras* cf. *rhotomagense* stage. The paleoecological analysis of the microfauna confirms the conclusion arrived at by BLANFORD, according to whom the clay was deposited under marine and brackish waters in the tropical zone. The writer suggests that the area of deposition was part of an estuary, particularly its lower part, or an open bay. For the sake of brevity no attempt is made here to discuss the problem of regional correlation which is being attempted in the original

paper. However, the local correlation of Odhium clay with the clay of Garudamangalam studied by JACOB and SASTRY (1950) has to be mentioned.

List of species occurring in the Odhium clay:

Allomorphina sp. nov.
Ammobaculites sp.
Ammodiscus tenuissimus REUSS
Amphicoryne sp.
Astacolus varians (BORNEMANN)
Bifarina sp.
Bifarina hungarica VADASZ ssp. nov.
Brotzenia sp. nov.
Brotzenia ornata (REUSS)
Brotzenia spinulifera (REUSS)
Bullopora sp. A*
Bullopora sp. B*
Cancris sp.
Ceratolamarckina sp. nov
Cibicides sp. nov. A
Citharina sp. A
Citharina sp. B
Conorboides hofkeri (BARTENSTEIN & BRAND)
Darbyella browntownensis CUSHMAN & DEADRICK
Dentalina cylindrica SCHWAGER
Dentalina legumen REUSS
Dentalina linearis (ROEMER)
Dentalina sp. cf. *paradoxa* HUSSEY
Dentalina terquemi D'ORBIGNY
Epistominita sp. A
Epistominita sp. B
Epistominita sp. nov. A
Epistominita sp. nov. B
Epistominita sp. nov. C
Epistominoides sp. nov.
Frondicularia sp. A
Frondicularia sp. B
Frondicularia sp. C
Gaudryina sp.
Gavelinella sp. nov. A
Gavelinella sp. nov. B
Gavelinella sp. nov. C
Gavelinopsis infracretacea HOFKER ssp. nov.
Glandulina sp. B
Globigerina washitensis CARSEY
Globulina sp. A
Globulina sp. B

Globigerinelloides eaglefordensis (MOREMAN)
Gubkinella sp.
Gyroidinoides sp. nov. B
Gyroidinoides gracillima (TEN DAM) ssp. nov.
Haplophragmoides sp. A
Haplophragmoides sp. B
Haplophragmoides sp. C
Heterohelix sp.*
Höglundina sp. nov.
Höglundina supracretacea (TEN DAM)
Hedbergella infracretacea (GLAESSNER)
Hedbergella planispira (TAPPAN)
Lagena sp. nov.
Lagena acuticostata REUSS
Lagena apiculata (REUSS)
Lagena globosa (MONTAGU)
Lenticulina macrodisca (REUSS)
Lenticulina pondi (CUSHMAN)
Lenticulina rotulata LAMARCK
Lenticulina spissocostata (CUSHMAN)
Lenticulina sternalis (BERTHELIN)
Lenticulina sp. cf. *L. taylorensis* (PLUMMER)
Lenticulina yabei TAKAYANAGI
Lamarckina sp.*
Lingulina sp.
Lingulina loreyi (BERTHELIN)
Marginulina sp. nov.
Marginulina hamulus CHAPMAN
Marginulinopsis comma (ROEMER)
Marginulinopsis robusta (REUSS)
Nodosaria sp.
Nodosaria sp. cf. *N. zippei* REUSS
Nonion sp. A
Nonion sp. B
Patellina sp. nov.*
Patellina subcretacea CUSHMAN & ALEXANDER
Patellinella sp. A*
Patellinella sp. B*
Patellinella sp. C*
Planularia sp. A
Planularia sp. B
Praeglobotruncana stephani (GANDOLFI)
Quinqueloculina sp.
Ramulina sp. C
Rectobolivina sp. nov. B
Rectoglandulina regularis (CRESPIN)
Rectoglandulina tenuis (BORNEMANN)

Rectoglandulina vulgata (BORNEMANN)
Reophax scorpiurus MONTFORT
Rotalipora appenninica (RENZ)
Rotalipora evoluta SIGAL
Saracenaria sp. A
Saracenaria sp. B
Saracenaria crassicostata EICHENBERG
Spirillina sp. A
Spirillina sp. B
Spirillina sp. nov.
Textularia anceps REUSS
Tristix sp.
Tristix excavatum (REUSS)
Trochammina sp. nov.
Trocholina? sp.*
Turrilina sp. nov.
Uvigerina (s.l.) sp.
Vaginulina sp. A
Vaginulina sp. cf. *V. truncata* REUSS
Vaginulinopsis sp.
Vaginulinopsis cephalotes (REUSS)

4. Kunnam Clay—Turonian

This lithotope occurs as lenticular body in the black shell limestone which shows unconformable relationship with the beds of Upper Utatur stage. The clay is very poor in microfossil content. Only the following 4 species of foraminifera have been recovered from it:

Anomalina sp.*
Globulina sp.*
Höglundina sp. nov.
Trifarina sp.*

From the black limestone the writer was able to extract a single specimen of the genus *Desmoceras* (s.l.) which is not specifically identified. The Turonian age of the clay is suggested because of the stratigraphic position of the black shell limestone.

5. Kallacurchi Limestone—Maestrichtian

The limestone belongs to the Upper Ariyalur stage of the Trichinopoly district. It occurs near the village of Kallacurchi. The limestone is built up of *Gryphea* and other lamellibranch shells and is therefore commonly referred to as Gryphea bed in the literature. The limestone is equally rich in orbitoid fauna. A sandy variety of limestone is easy to separate smaller foraminifera as well as the tests of orbitoid forms. The latter group of foraminifera have been studied by RAMA RAO in thin sections of the rock, an exhaustive study of which is made in a paper by him (1957). The writer has studied not only these orbitoid fauna but the other smaller bentho-

nic and planctonic species as well, using the isolated specimens. The list below gives the number and nature of the foraminiferal fauna.

Acervulina sp.*
Alabamina dorsoplanata (BROTZEN)
Baggatella sp.*
Bolivina incrassata REUSS
Buliminella sp. cf. *B. parvula* BROTZEN
Cibicides sp. nov. B
Cibicides compressus HOFKER
Cibicides sandidgei BROTZEN ssp. nov.
Cibicides voltziana (D'ORBIGNY)
«*Daviesina primitiva*» HOFKER*
Dentalina confluens REUSS
Dentalina megapolitana REUSS
Dyocibicides sp.*
Epistominella minusae (VISSER)
«*Eponides*» sp.
Fissurina sp. A
Fissurina sp. B
Fissurina sp. cf. *F. carinata* REUSS
Fissurina socuyiensis (DE CIVRIEUX) ssp. nov.
Fissurina sp. nov.
Fursenkoina navarroana (CUSHMAN)
Gaudryina arguta BANDY
Globigerinella aspera (EHRENBERG)
Globigerinella messinae messinae BRÖNNIMANN
Globorotalites sp.
Globotruncana fornicata PLUMMER
Globotruncana sp. cf. *marginata* (REUSS)
Globulina lacrima REUSS var. *subsphaerica* (BERTHELIN)
Guttulina trigonula (REUSS)
Gyroidinoides sp. nov. A
Hedbergella monmouthensis (OLSSON)
Heterohelix globulosa (EHRENBERG)
Heterohelix striata (EHRENBERG)
Kathina minuscula (HOFKER)
Kathina sp. nov.
Lagena amphora REUSS
Lagena amphora REUSS *paucicosta* FRANKE
Lagena hystrix REUSS
Lagena sp. cf. *L. substriata* WILLIAMSON
Lepidorbitoides blanfordi NARAYANA RAO
Lepidorbitoides inornata NARAYANA RAO
Marginulina inequalis REUSS
Nonionella sp. nov.

Nonionella sp. nov. A
Nonionella africana LE ROY
Nonionella thalmanni HAQUE
Nummofallotia malmousteri (HOFKER)
Nummofallotia sp. nov.
Orbitocyclina ariyalurensis NARAYANA RAO
Orbitocyclinoides sp. nov.
Planularia tripleura REUSS
Praeglobotruncana havanensis (VOORWIJK)
Reophax sp.
Reusella cristata (MARSSON)
Reusella cushmani BROTZEN
Rosalina sp. nov.
Rotalia (s.l.) sp. nov. A
Rotalia (s.l.) sp. nov. B
Rotalia (s.l.) *roestae* (VISSER)
Siderolites calcitrapoides LAMARCK
Spiroplectammina? sp.
Spiroplectammina baudouiniana (D'ORBIGNY)
Vaginulina sp. B
Vaginulina sp. C

The fauna listed above leaves no doubt as to the Maestrichtian age of the limestone. The most abundant and characteristic species of foraminifera are those of *Siderolites* and orbitoid genera. The occurrence of a 'retarded' genus, *Orbitocyclinoides*, is of some interest in the study of the evolutionary changes in the members of the family Orbitoididae. In the same fauna is found a group of strictly rotalid species to which *Cibicides roestae* belongs. A new supraspecific taxon is proposed. In the present list it is listed under the genus *Rotalia* (s.l.). The occurrence of planctonic species in the strictly benthonic facies makes the fauna more interesting. However, it must be pointed out that the planctonic species, eight in number, are represented by very few individuals.

6. Vilangudi Limestone—Maestrichtian

The limestone belongs to the Upper Ariyalur stage of the Trichinopoly district. It occurs in the village of Vilangudi, near which is shown the eastern limit of the Upper Ariyalur stage of BLANFORD. In reviewing the knowledge of Cretaceous rocks of India RAMA RAO (1956) states that the 'Niniyur sea must have extended as far south as Vilangudy and that the Niniyur beds, immediately after deposition, must have covered all this area'. In other words he suggests that the Niniyur stage may have to be extended beyond Vilangudi as is indicated in his text-fig. 5. According to his views the Niniyur division is strictly Danian. Our investigation of the Vilangudi limestone has not revealed any characteristic Danian foraminifera and therefore Danian age is not considered for the limestone. We have followed the suggestion of KRISHNAN (1960) in considering the Niniyur stage as representing both Maestrichtian and Danian. Therefore the Niniyur stage, in the chart given at the end of this paper, is shown against Maestrichtian and Danian.

The foraminifera seen in the limestone are the following, and can be definitely associated with some specific names:

Nummofallotia sp. nov.
Rotalia (s.l.) sp. nov. A
Rotalia (s.l.) *roestae* (VISSER) (= *Cibicides roestae* VISSER)

The above-mentioned species are studied in the thin sections of the rock. The identification of these species is based on, and controlled by, the study of isolated tests occurring in the Kallacurchi limestone. The age of Vilangudi limestone is considered as Maestrichtian because the three species mentioned above occur in the undoubtedly Maestrichtian Kallacurchi limestone. More discussion as to the alternative age of the Vilangudi limestone and to the correlatability of it with the Kallacurchi limestone, and also on the need to make a check in the field as to the stratigraphic and/or geographic (lateral) continuity between the two limestones is attempted in the main paper.

7. Karsur Limestone—Maestrichtian

The limestone occurs in the Pondicherry area and belongs stratigraphically to the 'E' zone of WARTH, whose description of the lithology of the zone leaves no doubt as to the stratigraphic level of the limestone.

The most characteristic species of foraminifera in the limestone is the *Siderolites calcitrapoides* LAMARCK. The identification of the species in the thin sections of the rock is controlled by the study of sections of isolated specimens from the Kallacurchi limestone. Therefore the age of the limestone is considered as Maestrichtian and it is correlated with the Vilangudi limestone and the Kallacurchi limestone of the Trichinopoly district.

8. Karsur Shale—Maestrichtian and/or Campanian

The shale underlies the Karsur limestone, a fact which can be easily observed in a nullha situated on the way from Karsur to Saidarampet. That the shale belongs to the Trigonoarca beds of KOSSMAT (1897) and the 'D' zone of WARTH is proved by the occurrence of *Cypraea* sp., *Euptycha larvata* STOLICZKA, *Hippagus aemilianus* STOLICZKA, *Terebratula arabilis* FORBES and *Trigonoarca galdrina* D'ORBIGNY in the shale.

The rock is completely devoid of any species of foraminifera. The age of the shale indicated above is based on the stratigraphic relationship with the Karsur limestone and on the occurrence of the megascopic invertebrate species mentioned above.

9. Tutipet Limestone-Nodules—Danian

About half a mile due east of the village of Tutipet and on the left side of the road leading from Tutipet to Kadapperikuppam are found a large number of limestone nodules which are embedded in the calcareous sandstone.

The sandstone forms a distinct bed, as seen in the open pits that are available for observation. The thickness of the bed varies from two to three feet. The lower limit of the bed was not observed by the writer. The sandstone shows very clearly the 'graded' nature as to the colour and the organic content. The fragments of

foraminiferal tests, coralline algae and bryozoans constitute the organic content. Minute casts of lamellibranch shells and hollow cavities are other characteristics of the sandstone. The hollow cavities are very narrow and lenticular in cross section, and are arranged in a definite direction, usually with their longer axes parallel to the bedding plane. These can be seen even with the naked eye.

The very brief description of the sandstone given above is intended to help the reader to understand the problem of the relationship between the limestone nodules and the sandstone.

The limestone nodules have been treated as a distinct lithotope for the sake of convenience. Inside the nodules are found specimens of *Nautilus danicus*. Therefore the nodules are considered as belonging to the 'F' horizon of WARTH and the Nerinea beds of KOSSMAT (1897). In the thin sections of the rock one can see *Globigerina*, *Globorotalia* and anomalinid forms. The sections of foraminifera are neither abundant nor helpful in the specific identification. The lithology and paleontology of these limestone nodules are used in distinguishing the next lithotope discussed below. It is these limestone nodules that are correlated with the upper part of the Niniyur stage of the Trichinopoly district.

10. Saidarampet Limestone—Post-Danian (=Middle Paleocene)

The limestone is named after the village, Saidarampet, for the sake of clarifying the conclusions arrived at by the writer in regard to the age and stratigraphic position of it.

The results of a detailed microscopic investigation of the limestone and the observations in the field in regard to the 'structure' and the extent of the limestone are discussed more fully in the main paper. The writer wants to make it clear that the Saidarampet limestone is the same as what WARTH (p. 19) has described as 'the only continuous bed of hard rock in the Pondicherry Cretaceous'. The limestone should, without any doubt, be taken as a member of the 'F' horizon of WARTH and the Nerinea beds of KOSSMAT (1897).

The age of this limestone has been discussed in a comprehensive review by RAMA RAO (1956). There are two opposing views on the age of the limestone: one favouring the Danian age (KOSSMAT, 1897; SHARMA, 1953) and another favouring the Paleocene (=post-Danian) age (RAMA RAO, 1939). The identification of a very rich fauna of *Discocyclina* and *Daviesina*, occurring in the limestone, by the present writer confirms, without any doubt, the Paleocene age. The following species are noticed in the limestone.

Daviesina sp.
Daviesina sp. cf. *D. danieli* SMOUT
Discocyclina seunesi DOUVILLÉ
Discocyclina forma *alpha*
Discocyclina forma *beta*
Discocyclina sp. cf. *D. douvillei* (SCHLUMBERGER)

The form identified and illustrated by KOSSMAT (1897) as *Orbitoides* sp. is shown by the present writer to consist of two different species of *Discocyclina*. One of these two species is what is identified as *Discocyclina* sp. cf. *D. douvillei* (SCHLUMBERGER). The form identified by KOSSMAT as *Amphistegina* is shown to be, on the basis of a very detailed study of 9 axial sections, *Daviesina* sp. cf. *D. danieli* SMOUT. The most important species to fix the age of the limestone as Paleocene is the *D. seunesi* DOUVILLÉ, the identification of which, as it occurs in the limestone, is based on the study of the megalospheric embryonal apparatus and the axial sections.

11. Nummulitic Limestone—Late Cuisian

The details, both stratigraphic and geographic, about the limestone were given by FURON (1941). By the kind permission of Prof. R. FURON the writer was able to examine the material in Paris, especially the material illustrated in fig. 1 of plate 2 by FURON. Part of the material was given to the writer, who has been able to re-study the species of foraminifera occurring in it with the help of Professor H. SCHAUB. The writer has preferred to give a name to the lithotope under discussion for the sake of convenience. The following species of foraminifera are identified in thin sections of the limestone.

Assilina laxispira (DE LA HARPE)
Assilina major (HEIM)
Discocyclina sp. A
Discocyclina sp. B
Nummulites sp. cf. *N. distans* DESHAYES

The species identified by FURON as *Assilina granulosa* is considered as *A. major* (HEIM) in the present report. Another species of *Assilina* noticed in the same material is identified as *A. laxispira*. It is to be remembered that the form described by D'ARCHIAC & HAIME as *A. granulosa* in 1853 is synonymous with *laxispira* of DE LA HARPE. The species of *Nummulites* s. st. is noticed for the first time in the Pondicherry limestone.

The stratigraphic distribution of *Assilina* studied by SCHAUB (1955) shows that the species of *Assilina* mentioned above are restricted to late Early Eocene. The association of *Nummulites* cf. *distans* with these assilines is also indicative of such an age as late Early Eocene. Therefore the Nummulitic limestone of the Pondicherry area is considered as Late Cuisian in age.

The two species of *Discocyclina* seen in the limestone cannot be associated with any known specific names since no equatorial sections of the embryonic apparatus are seen. On the basis of the vertical sections alone are the two species recognised and distinguished from one another.

12. Discocyclina-Marl—Lutetian to Auversian

The samples of this lithotope were given to the writer by Dr. FURON. Information about the material is given by FURON in his paper. This Pondicherry rock is built up mainly of tests of *Discocyclina*, which were examined as thoroughly as

possible to observe both the external and internal characters. A detailed discussion on the identification of the *Discocyclina* species is to be found in the original paper. The identification of the species by FURON as *D. pratti* is confirmed by the present writer. In addition to this single species of *Discocyclina*, there are smaller foraminifera in the marl and these are identified. Only one of them is studied in the systematic part of the original paper, that being a species of *Globorotalia*. The following species are found in the marl.

Anomalina sp.*
Anomalina acuta PLUMMER var. nov.*
Anomalina acuta PLUMMER var. *ypresiensis* (TEN DAM)
Cibicides sp.*
Cibicides sp. aff. *C. proporicus* (BROTZEN)*
Cibicides tenellus (REUSS)*
Darbyella wilcoxensis CUSHMAN & GARRET*
Discocyclina pratti (MICHELIN)
Eponides sp.*
Globorotalia sp. cf. *G. conicotruncata* SUBBOTINA
Lenticulina yagauatensis (BERMUDEZ)*
Parrella sp.*
Quinqueloculina sp.*

The age of the marl is considered as Lutetian-Auversian mainly on the basis of the occurrence of *D. pratti* (MICHELIN).

DESCRIPTION OF FORAMINIFERA

All the species not indicated by an asterisk in the list of species given above are described and figured in the original paper. Among the total of 235 species studied are 18 planctonic species, 13 species of 'larger foraminifera' and 204 «smaller» benthonic species. A total of 43 new species are described, 7 of which are not given specific names. The names of new species are not given in the present paper to avoid them becoming *nomen nudum*. However, when more than one new species of a genus are mentioned in the present paper, they are designated as sp. nov. A, B, etc. (example: *Cibicides* sp. nov. A, *Cibicides* sp. nov. B).

The genus *Epistominita* GRIGELIS, 1960, is emended after a detailed study of 5 species which occur, in the writer's material, of Upper Cenomanian age, along with a new species of *Epistominoides*. A new generic name is proposed to cover *Cibicides roestae* VISSER which is strictly a rotalid species. In the present report *roestae* and two other new species are referred to the genus *Rotalia* (s.l.).

SUMMARY

In the present paper is given a brief account of the investigation carried out on the foraminifera from 12 lithotopes belonging to the Cretaceous-Eocene succession of the South Indian region. The species of foraminifera occurring in each of the lithotopes are listed and on the basis of those species the age, the classification and/or correlation of the lithotopes are discussed. A total of 235 species is studied, of which 43 are new and 18 are planctonic; there are 13 species of 'larger foraminifera' in the fauna represented by the genera *Lepidorbitoides*, *Orbitocyclina*, *Orbitocyclinoides*, *Discocyclina*, *Assilina* and *Nummulites*.

Table 1. Classification and Correlation of the South Indian Cretaceous-Eocene Succession

Age \ Area / Author				South India				Assam	Sind
				Trichinopoly	Pondicherry				
				KRISHNAN 1960	WARTH 1895	KOSSMAT 1897	GOWDA 1964	NAGAPPA 1959	NAGAPPA 1959
Eocene	Upper							Kopili	Kirthar
	Middle						Discocyclina Marl ⑫	Sylhet Lst. Prang	
	Lower						Nummulitic Lst. ⑪	Narpuh	Laki
Paleocene	U.P.						Ranikothalia Lst.	Lakadong	Ranikot
	L.P.	Danian		Niniyur ⑥	F	Nerinea Beds	Saidarampet Lst. ⑩	Therria	C. Beaumonti Beds
							Tutipet Lst.-Nodules ⑨	Langpar	
Maestrichtian			Ariyalur	U ⑤	E	Trigonoarca Beds	Karsur Lst. ⑦	Mahadek	'Pab Sandstone'
					D		Karsur Shale ⑧		Hemipneustes Beds
Senonian				L	C	Anisoceras Beds or 'Valudayur' Beds			
					B				
			Trichinopoly	U	A				
Turonian				L ④					
			Utatur	U					
Cenomanian to U. Albian				M ③ ②					
				L ①					
I				II	III	IV	V	VI	VII

Please note: 1. The Niniyur stage of the Trichinopoly area is shown against both Maestrichtian and Danian following the suggestion of KRISHNAN (1960, p. 459). — 2. The stratigraphic stages recognised in Sind and Assam are shown in the chart to suggest the probable equivalents of those stages in the Pondicherry area. The equating of stages of Sind and Assam areas with the European stages is after NAGAPPA (1959). — 3. The discovery of Ranikothalia (*Nummulites* cf. *thalicus* DAVIES of RAMA RAO, NARAYANA RAO & NAGAPPA, 1940) in a limestone from Valudavur area indicates a younger zone than the one represented by Saidarampet limestone and is therefore taken as a separate unit in the correlation and classification suggested for the Pondicherry deposits. — 4. The numbers in the columns II and V refer to the lithotopes discussed in the present paper.

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