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CENOMANIAN PLANKTIC FORAMINIFERAL BIOSTRATIGRAPHY OF SOUTHERN INDIA AND THEIR CORRELATION

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ABSTRACT

Two hundred and forty eight sediment samples were collected systematically from the Karai Shale, exposed between Karai-Kulakkalnattam Villages, Perambalur District, Tamil Nadu, India for the study of Cenomanian planktic foraminiferal biostratigraphy and their correlation. Seventeen species of planktic foraminifera and seventy one species of benthic foraminifera were identified in the present study.

The planktic foraminifers identified are as follows: *Clavihedbergella simplex, Globigerinelloides bentonensis, Globigerinelloides caseyi, Globigerinelloides ultramicra, Hedbergella ambilis, Hedbergella bornholmensis, Hedbergella delrioensis, Hedbergella planispira, Hedbergella portsdownensis, Praeglobotruncana delrioensis, Praeglobotruncana stephani, Rotalipora cushmani, Thalmanninella appenninica, Thalmanninella balernaensis, Thalmanninella evoluta, Thalmanninella greenhornensis* and *Thalmanninella reicheli.*

The benthic foraminifers identified are as follows: *Ammodiscus cretaceus, Ammodiscus planus, Anomalinoides indica, Astacolus jarvisi, Citharina* sp.*, Dorothia filiformis, Dentalina basiplanata, Dentalina cylindroides, Dentalina marginuloides, Dentalina strangulata, Dentalina trujilloi, Eouvigerina uttatturensis, Frondicularia filocincta, Frondicularia goldfussi, Frondicularia mucronata, Gaudryina tailleuri, Gavelinella baltica, Gavelinella cenomanica, Gavelinella intermedia, Gavelinella simionescui, Gavelinella rudis, Globulina lacrima, Globulina prisca, Glomospira charoides, Glomospirella gaultina, Gyroidinoides depressa, Gyroidinoides globosa, Haplophragmoides kirki, Lagena hispida, Lenticulina alexanderi, Lenticulina circumcidanea, Lenticulina gaultina, Lenticulina grata, Lenticulina macrodisca, Lenticulina navarroensis, Lenticulina nuda, Lenticulina ovalis, Lenticulina planiuscula, Lenticulina polygona, Lenticulina rotulata, Lenticulina saxocretacea, Lenticulina secans, Lenticulina stephensoni, Lingulogavelinella albiensis, Lingulogavelinella globosa, Marginulina glabra, Marginulina hamuloides, Marginulina hamulus, Nodosaria affinis, Nodosaria distans, Nodosaria larva, Nodosaria obscura, Nodosaria orthopleura, Oolina apiculata, Oolina simplex, Pleurostomella cullygoodiensis, Pleurostomella nitida, Pleurostomella obtusa, Pseudonodosaria cylindracea, Pseudonodosaria manifesta, Quadrimorphina allomorphinoides, Quadrimorphina camerata, Quinqueloculina antiqua angusta, Ramulina aculeata, Ramulina globulifera, Saracenaria triangularis, Tristix excavata, Tristix tricarinatum acutangulum, Vaginulina kochii, Vaginulina plummerae* and *Vaginulina recta.*

In the present study four planktic foraminiferal bio-zones were identified from Early Cenomanian to Late Cenomanian. The bases of these zones are defined based on the first appearance of a new taxon. The zones in the ascending order are as follows: *Thalmanninella appenninica* Interval Zone*, Thalmanninella greenhornensis* Total Range Zone*, Thalmanninella reicheli* Total Range Zone and *Rotalipora cushmani* Total Range Zone*.* These zones are correlated with the bio-zones reported from Northern California, North Atlantic, Morocco, Tunisia, Egypt, Northern Cyrenica in Libiya, NE Spain, South-Eastern Spain, Umbria, Anglo-Paris basin, Switzerland, Poland, England, SE-Devon, South-western Crimea, Northeast of Kerguelen Ridge and Western Pacific Ocean.

Keywords: Cenomanian, Biostratigraphy, Planktic Foraminifera, Southern India.

INTRODUCTION

The Cretaceous was one of the most important geological periods in the geological history of Indian subcontinent (Acharyya and Lahiri, 1991). A notable geological event in the Cretaceous is the widespread marine transgression popularly known as the *"Cenomanian transgression"*, which is perhaps the most conspicuous of all marine flooding events indicated in the post-Archaean geological record of India. The Cretaceous sediments exposed in Southern India consist of continuous marine sequence with rich fauna and flora. The Cretaceous sections exposed in Southern India contain a well-diversified foraminiferal assemblage. Foraminifera and also other marine microfossil group are affected by changes in the environment and paleoceanographic conditions. They are globally used for biostratigraphic subdivision and correlation of sedimentary strata. The late Cenomanian extinction event is one of the major global bioevents ranking alongside the K/T boundary and late Eocene events. The Mid-Cretaceous sediments (Uttattur group) have exposed very well in the study area situated about 13 km South of Perambalur town.

STUDY AREA

The Uttattur Group is named after the Uttattur village and best exposures are available east of this village and adjoining areas. It extends about 70 km in length and 4-6 km in width, with an average dip of about 10º east. The study area falls within North Latitudes 11º 06 to 11º 07 and East longitudes 78º 53 to 78º 56 forming part of the toposheet 58 I/16 of Geological Survey of India. The Karai Formation of the Uttattur Group is well exposed as badland developed in an easterly draining catchment to the east of Karai.

MATERIALS AND METHODS

Two hundred and forty eight sediment samples were collected systematically from the Karai Shale exposed between Karai – Kulakkalnattam villages. The samples are processed using standard micropaleontological techniques. The foraminifera obtained are well preserved and have diverse assemblages. From the processed samples, eighty eight species of foraminifera were identified of which seventy one species of benthic foraminifera

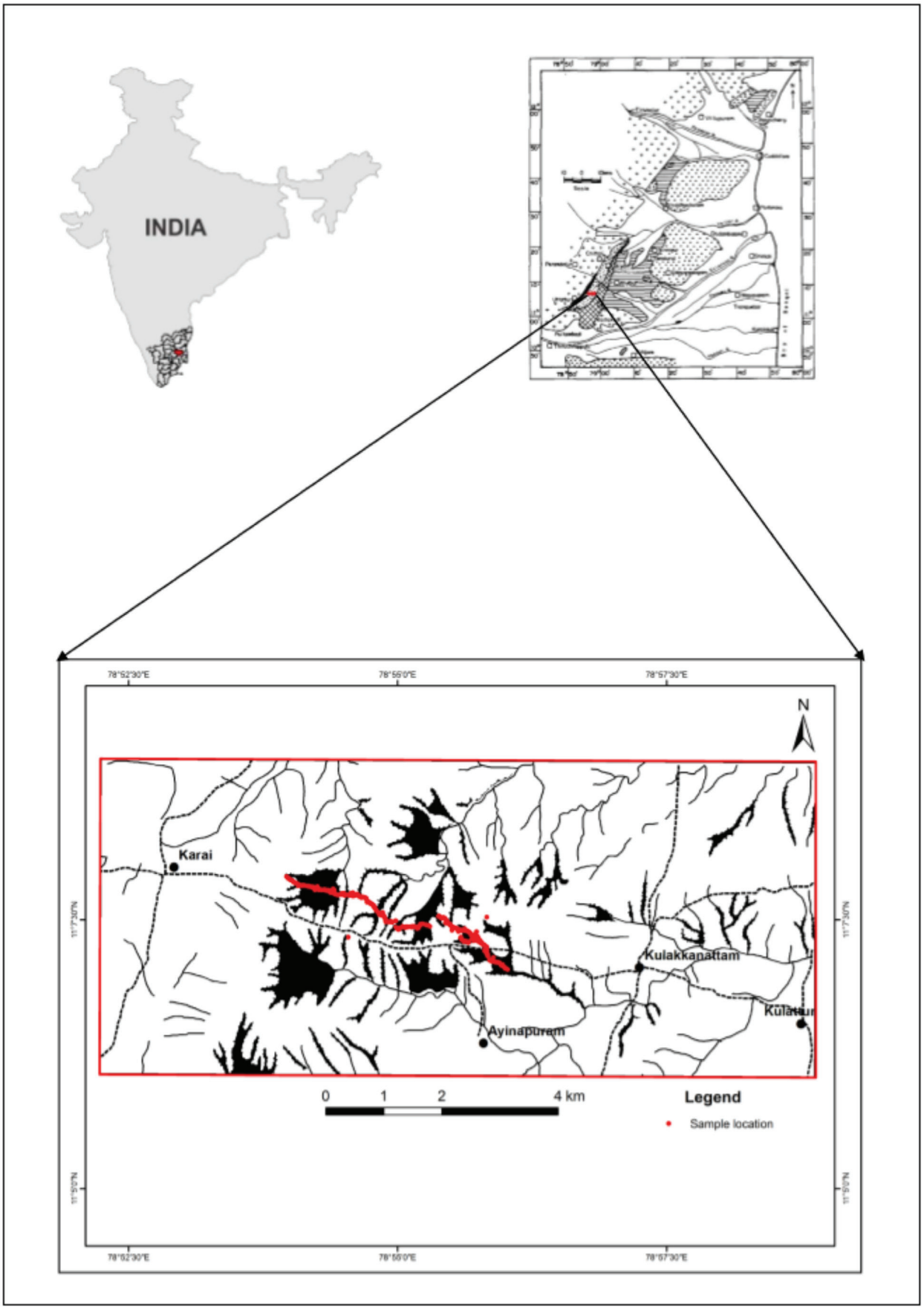


Fig. 1. Location map of the Study Area.

and seventeen species of planktic foraminifera were identified in the present study. The foraminifera have been taxonomically classified using "Foraminiferal Genera and Their Classification" Loeblich and Tappan (1988).

The specific identification of the species were made based on the work of Bolli (1966), Eicher and Worstell (1970), Barr (1972), Narayanan (1972), Venkatachalapathy (1993) and Venkatachalapathy and Ragothaman (1996).

FORAMINIFERAL ASSEMBLAGE

The check list of the species identified is as follows:

Benthic Foraminifera: *Ammodiscus cretaceus, Ammodiscus planus, Anomalinoides indica, Astacolus jarvisi, Citharina* sp.*, Dorothia filiformis, Dentalina basiplanata, Dentalina cylindroides, Dentalina marginuloides, Dentalina strangulata, Dentalina trujilloi, Eouvigerina uttatturensis, Frondicularia filocincta, Frondicularia goldfussi, Frondicularia mucronata, Gaudryina tailleuri, Gavelinella baltica, Gavelinella cenomanica, Gavelinella intermedia, Gavelinella simionescui, Gavelinella rudis, Globulina lacrima, Globulina prisca, Glomospira charoides, Glomospirella gaultina, Gyroidinoides depressa, Gyroidinoides globosa, Haplophragmoides kirki, Lagena hispida, Lenticulina alexanderi, Lenticulina circumcidanea, Lenticulina gaultina, Lenticulina grata, Lenticulina macrodisca, Lenticulina navarroensis, Lenticulina nuda, Lenticulina ovalis, Lenticulina planiuscula, Lenticulina polygona, Lenticulina rotulata, Lenticulina saxocretacea, Lenticulina secans, Lenticulina stephensoni, Lingulogavelinella albiensis, Lingulogavelinella globosa, Marginulina glabra, Marginulina hamuloides, Marginulina hamulus, Nodosaria affinis, Nodosaria distans, Nodosaria larva, Nodosaria obscura, Nodosaria orthopleura, Oolina apiculata, Oolina simplex, Pleurostomella cullygoodiensis, Pleurostomella nitida, Pleurostomella obtusa, Pseudonodosaria cylindracea, Pseudonodosaria manifesta, Quadrimorphina allomorphinoides, Quadrimorphina camerata, Quinqueloculina antiqua angusta, Ramulina aculeata, Ramulina globulifera, Saracenaria triangularis, Tristix excavata, Tristix tricarinatum acutangulum, Vaginulina kochii, Vaginulina plummerae* and *Vaginulina recta.*

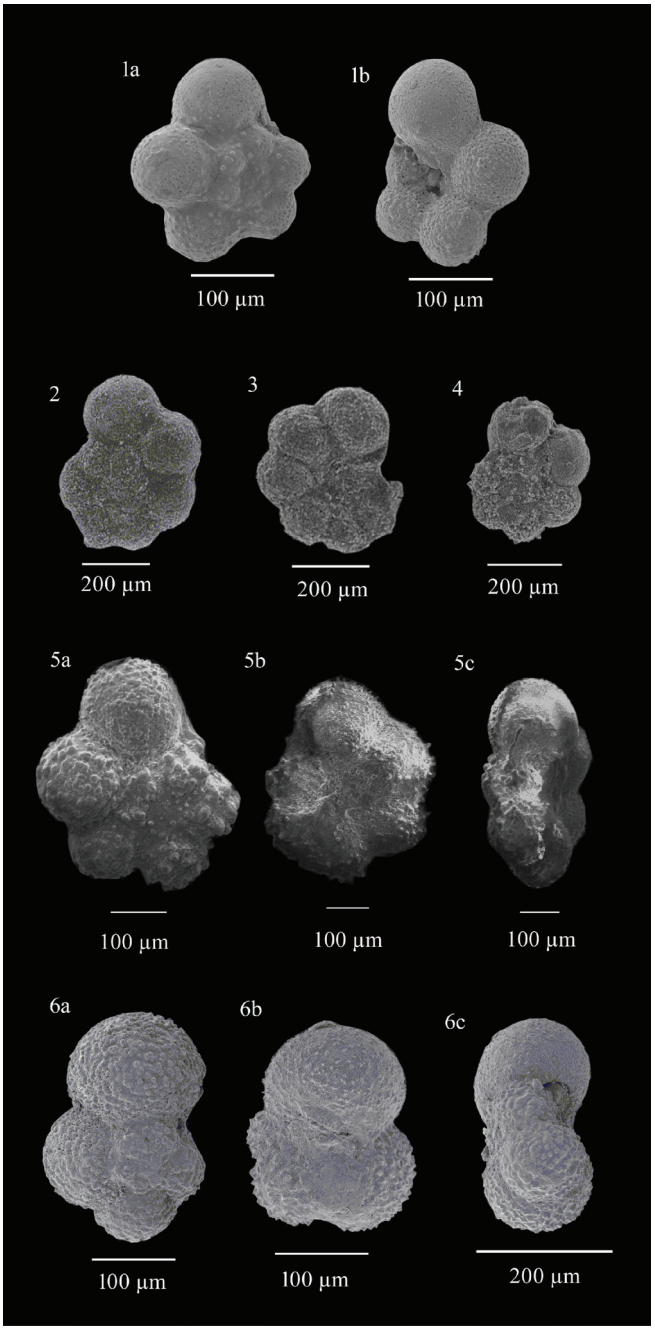
Planktic Foraminifera: *Clavihedbergella simplex, Globigerinelloides bentonensis, Globigerinelloides caseyi, Globigerinelloides ultramicra, Hedbergella ambilis, Hedbergella bornholmensis, Hedbergella delrioensis, Hedbergella planispira, Hedbergella portsdownensis, Praeglobotruncana delrioensis, Praeglobotruncana stephani, Rotalipora cushmani, Thalmanninella appenninica, Thalmanninella balernaensis, Thalmanninella evoluta, Thalmanninella greenhornensis* and *Thalmanninella reicheli.*

BIO-ZONES IN THE STUDY AREA

In the study area, 4 Planktic foraminiferal bio-zones from Early Cenomanian to Late Cenomanian have been recognized. They are based on the first appearances and last occurrences of marker species and their ranges.

These zones in the ascending order as follows: *Thalmanninella appenninica* (Early Cenomanian), *Thalmanninella greenhornensis* (Early-late Cenomanian to early-Middle Cenomanian), *Thalmanninella reicheli* (Middle Cenomanian) and *Rotalipora cushmani* (Middle Cenomanian to Late Cenomanian). The biostratigraphy classification proposed by Robazynski and Caron (1979) were followed. The works of the previous workers viz. Narayanan (1972, 1977); Ayyasami and Banerji (1984); and Venkatachalapathy and Ragothaman (1993, 1995) were also followed for fine-tuning the Stratigraphy of these sediments.

Plate I



EXPLANATION TO PLATE I

Fig. 1. ***Clavihedbergella simplex*** a. Spiral view, b. Umbilical view; Fig. 2. ***Globigerinelloides bentonensis*** (Spiral View); Fig. 3. ***Globigerinelloides caseyi*** (Umbilical View); Fig. 4. ***Globigerinelloides ultramicra*** (Spiral View); Fig. 5. ***Hedbergella amabilis*** a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 6. ***Hedbergella bornholmensis*** a. Spiral view, b. Umbilical view, c. Peripheral view.

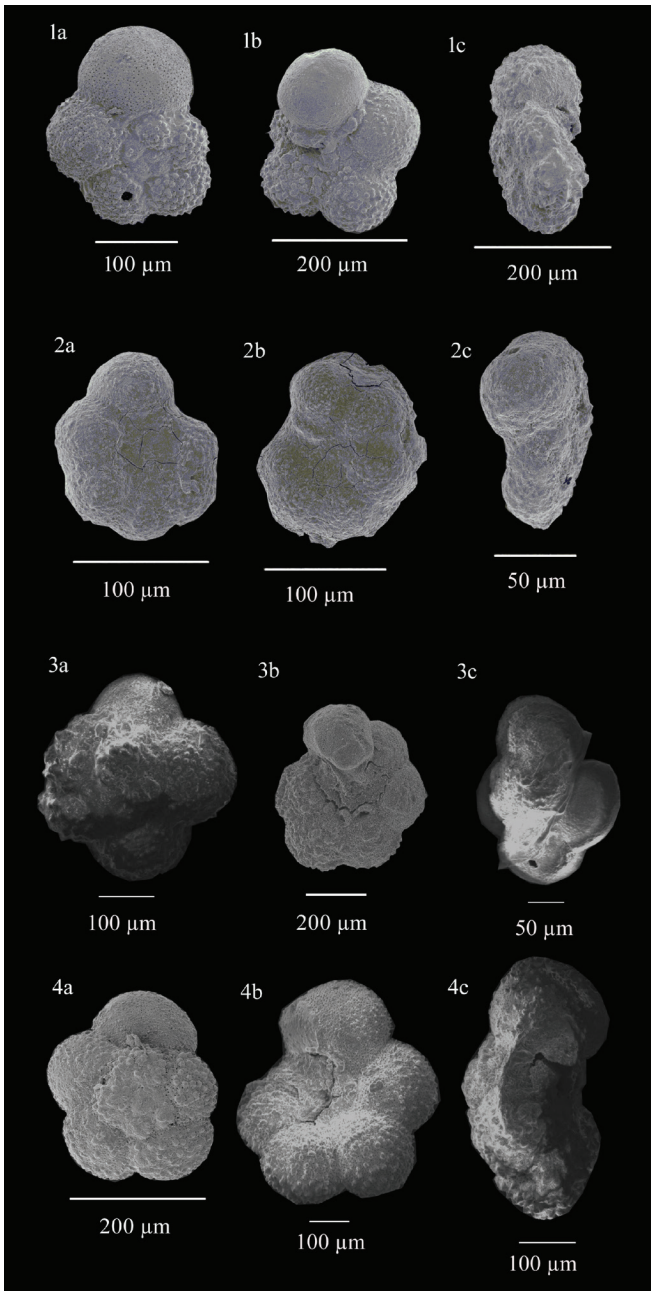
Zone I – *Thalmanninella appenninica* Zone

Category : Interval Zone
Estimated age : Early Cenomanian
Author : Bronnimann (1952)
Sample no. : K120 – K182

Definition: Biostratigraphic interval from first occurrence of *Thalmanninella appenninica* to first occurrence of *Thalmanninella greenhornensis*. In addition to the zonal marker, other planktic foraminiferal species present in this zone are: *Clavihedbergella simplex, Globigerinelloides bentonensis, G. caseyi, Hedbergella portsdownensis, H. ultramicra, Thalmanninella appenninica, Th. evoluta.*

Occurrence: This Zone is reported from Franciscan Complex, Northern California (Sliter, 1984), Hilal shale in Marsa al hilal area, Northern Cyrenica in Libiya (Barr, 1972),

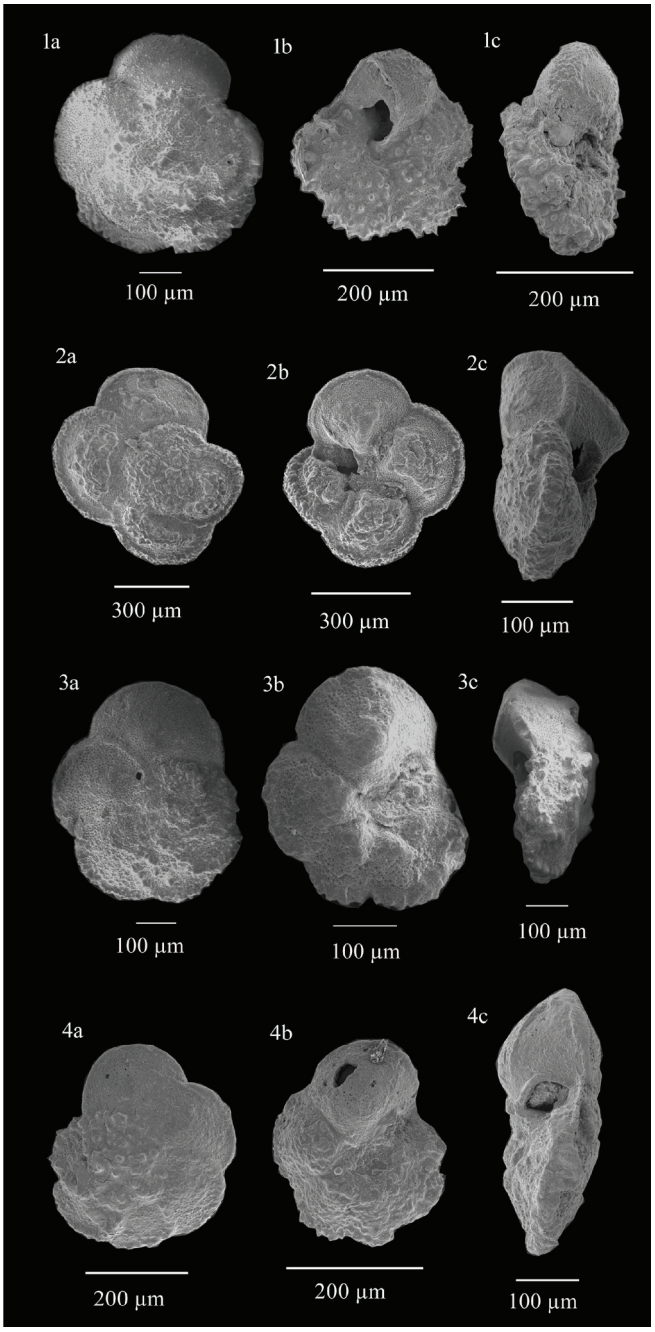
Plate II



EXPLANATION TO PLATE II

Fig. 1. ***Hedbergella delrioensis,*** a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 2. ***Hedbergella planispira,*** a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 3. **Hedbergella portsdownensis**, a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 4. ***Praeglobotruncana delrioensis,*** a. Spiral view, b. Umbilical view, c. Peripheral view.

Plate III



EXPLANATION TO PLATE III

Fig. 1. ***Praeglobotruncana stephani,*** a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 2. ***Rotalipora cushmani,*** a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 3. ***Thalmanninella appenninica,*** a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 4. ***Thalmanninella balernaensis,*** a. Spiral view, b. Umbilical view, c. Peripheral view.

North of Velez blanco, South- Eastern Spain (Jansen *et al.*, 1984) and in Silesian Nappe, Poland (Krzysztof Bak, 2007).

Zone II - *Thalmanninella greenhornensis* Zone

Category : Total Range Zone (TRZ)
Estimated age : Early-late Cenomanian to early-Middle Cenomanian
Author : Bronnimann (1952)
Sample no. : K183 – K246

Definition: The base of zone is placed at the first evolutionary appearance of *Thalmanninella greenhornensis*. The upper limit of this zone is placed at the level of first appearance of *Th. reicheli*.

In addition to the zonal marker, other foraminiferal species present includes: *C.simplex, H.ambilis, H.portdownensis, H.delrioensis, H.planispira, H.borhornensis, G.bentonensis, G.caseyi, P. delrionensis, Th.evoluta, Th. appenninica* and *Th. greenhornensis.*

Occurrence: This zone is reported in Eastern Mariana Basin, Western Pacific Ocean (Premoli Silva and Sliter, 1981); Franciscan Complex, Northern California (Sliter, 1984); North of Velez blanco, South- Eastern Spain (Jansen *et al.*, 1984); North of Abbots Cliff Chalk Formation; Plenus Marl Succession, England (Hart, 1996); Silesian Nappe, Poland (Krzysztof Bak, 2007) and Tarfaya Basin, Morocco (Keller *et al.*, 2008).

Zone III – *Thalmanninella reicheli* Zone

Category : Total Range Zone (TRZ)
Estimated age : Middle Cenomanian
Author : Bolli (1966)
Sample no. : K247 – K290

Definition: Interval of Total Range of *Thalmanninella reicheli*.

In addition to the zonal marker, other foraminiferal species present in this zone are: *Clavihedbergella simplex, Globigerinelloides bentonensis, G. caseyi, Hedbergella portsdownensis, H. ultramicra, Thalmanninella appenninica, Th. balerneansis, Th. evoluta* and *Th.reicheli.*

Occurrence: This species reported from Northeast of Kerguelen Ridge (Quilty, 1973); Kalaat Senan region, Central Tunisia (Robszynski and Gale, 1993); and Tarfaya Basin, Morocco (Keller *et al.,* 2008).

Zone IV – *Rotalipora cushmani* Zone

Category : Total Range Zone (TRZ)
Estimated age : Middle Cenomanian to Late Cenomanian
Author : Borsetti (1962)
Sample no. : K291 – K355

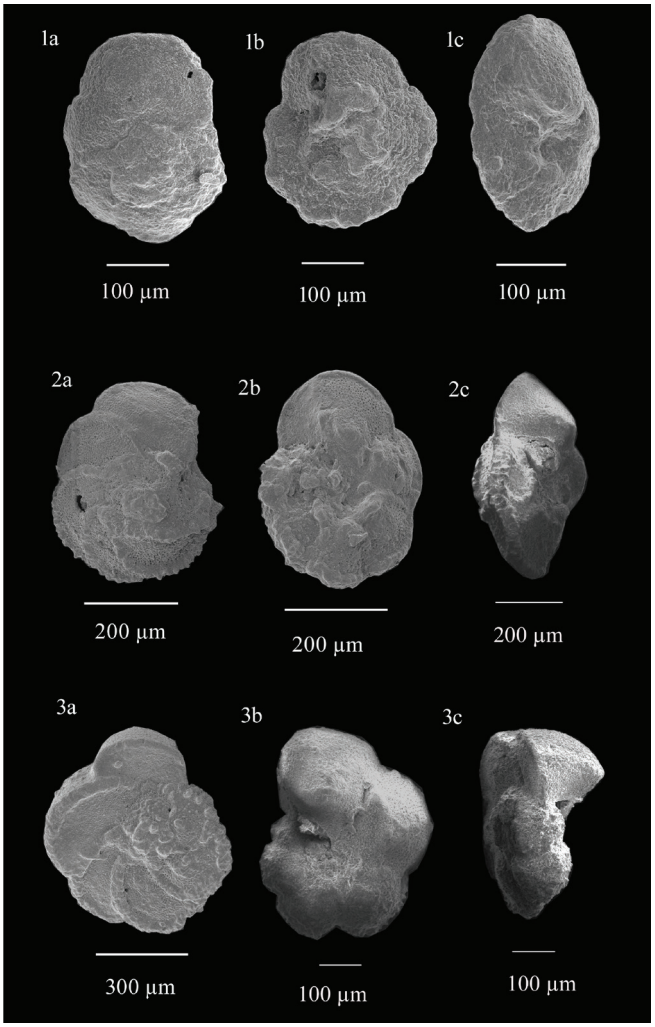
Definition : Interval of total range of *Rotalipora cushmani.*

Remarks: Biostratigraphic interval characterized by the first occurrence of *Whiteinella baltica* in the lower part of zone and *Whiteinella paradubia, Helvetoglobotruncana prehelvetica* and *Dicarinella algeriana* in the upper part of the zone. Extinction of the genus *Rotalipora* marks the upper limit of the zone. Narayanan (1977) recognized the extinction of *R.cushmani* at the top of Cenomanian and made this extinction level a boundary marker for the Cenomanian-Turonian boundary. This stratigraphically important species is also considered here to have disappearance at the end of the Cenomanian.

In addition to the zonal marker, other foraminiferal species present in this zone are: *Clavihedbergella simplex, Globigerinelloides bentonensis, G. caseyi, Hedbergella portsdownensis, Praeglobotruncana delrioensis, P. stephani, Rotalipora cushmani, Thalmanninella evoluta* and *Th. reicheli.*

Occurrence: It has been reported from Northeast of Kerguelen Ridge, Quilty (1973); Eastern Mariana Basin, Western Pacific Ocean (Premoli Silva and Sliter, 1981), Franciscan Complex, Northern California (Sliter, 1984); North of Velez blanco, South- Eastern Spain (Jansen *et al.*, 1984); Hooken Cliffs, SE-Devon (Jarvis *et al.*, 1988); Kalaat Senan region, Central Tunisia (Robszynski, 1993); Abbots cliff Chalk Formation, Plenus Marl succession (Hart, 1996); Gamga Zongshan section, southern Tibet (Lamolda, 1996); Sopeira basin, NE Spain (Caus *et al.,* 1997); Oued Mellegue, Norther-Western Tunisia (Nederberagt, A.J. and Fiorentino, A, 1999); North Atlantic DSDP site 597 (Nederbrgt *et al.,*2001); Hemipelgic sediment of Roter sattlel

Plate IV



EXPLANATION TO PLATE IV

Fig. 1. ***Thalmanninella evoluta***, a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 2. ***Thalmaninella greenhornensis***, a. Spiral view, b. Umbilical view, c. Peripheral view; Fig. 3. ***Thalmanninella reicheli,*** a. Spiral view, b. Umbilical view, c. Peripheral view.

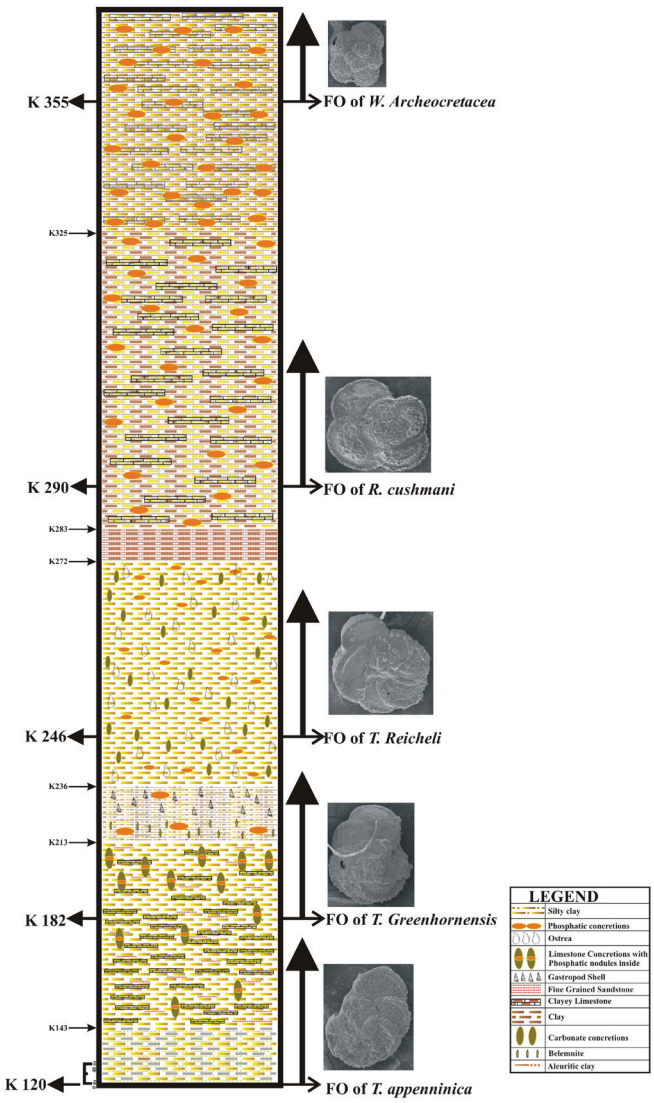


Fig. 2. Litholog and faunal occurrence of the Samples.

in Switerland (Strasser *et al.,* 2001); Wadi Feiran, Egypt (Kassab and Obaidalla, 2001); Southern Morocco and Tunisia (Luning, 2004); Crimea (Fisher *et al.*, 2005); Aksu-Dere section, Southwestern Crimea (Badulina and Kopaevich, 2007); Silesian Nappe, Poland (Krzysztof Bak, 2007); Tarfaya Basin, Morocco (Keller *et al.,* 2008); and Bahloul Formation of Bou Ghanem Central Tunisia (Robaszynski *et al.,* 2009).

CONCLUSIONS

In the present study, two hundred and forty eight sediment samples were collected systematically from the Karai Shale, exposed between Karai-Kulakkalnattam Villages, Perambalur District, Tamil Nadu, India. Seventeen species of planktic foraminifera and seventy one species of benthic foraminifera were identified in the present study. The presence of planktic foraminifers *Praeglobotruncana delrioensis, P. stephani, Rotalipora cushmani, Thalmanninella appenninica, Th. balernaensis, Th. evoluta, Th. greenhornensis* and *Th. reicheli* indicates a Cenomanian age for the samples. Four planktic foraminiferal bio-zones were identified from Early Cenomanian to Late Cenomanian. The zones in the ascending order are as follows: *Thalmanninella appenninica* Interval Zone (Early Cenomanian), *Thalmanninella greenhornensis* Total Range Zone (Early Cenomanian), *Thalmanninella reicheli* Total Range Zone (Middle Cenomanian) and *Rotalipora cushmani* Total Range Zone (middle Late Cenomanian). These zones are correlated with the bio-zones reported from Northern California, North Atlantic, Morocco, Tunisia, Egypt, Northern Cyrenica in Libiya, NE Spain, South- Eastern Spain, Umbria, Anglo-Paris basin, Switzerland, Poland, England, SE-Devon, South-western Crimea, Northeast of Kerguelen Ridge and Western Pacific Ocean. The benthic foraminifers of the genus *Gavelinella, Gyroidinoides* and *Lenticulina* are present abundantly along with the agglutinated foraminifera and keeled rotaliiporids indicating an outer neritic to upper bathyal environment for the samples.

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