Palaeocene foraminifera from the Ariyalur area, southern India

N. Malarkodi & H.M. Nagaraj

Malarkodi N & Nagaraj HM 1997. Palaeocene foraminifera from the Ariyalur area, southern India. *Palaeobotanist* **46** (1, 2) : 177-185.

The Palaeocene sediments of the Ariyalur area, spread over 80 sq km, are exposed as isolated outcrops and consist mainly of marls, shelly and cream-coloured limestones on the northeastern part of Tiruchirapalli Cretaceous. The present study records well-preserved smaller foraminifera of both benthic and planktic nature. The planktic species suggest a Palaeocene age for the Niniyur Formation. The foraminiferal fauna in general reflects shallow marine to brackish water conditions of deposition. The paper also discusses stratigraphic distribution and zoogeographic affinities of foraminifera of the Niniyur Formation with respect to equivalent horizons in India and abroad.

Key-words— Foraminifera, Palaeocene, Niniyur Formation, India.

N. Malarkodi & H.M. Nagaraj, Department of Geology, Bangalore University, Bangalore 560 056, India.

सारांश

दक्षिणी भारत में अरियालूर क्षेत्र से पेलियोसीन फोरामिनीफर

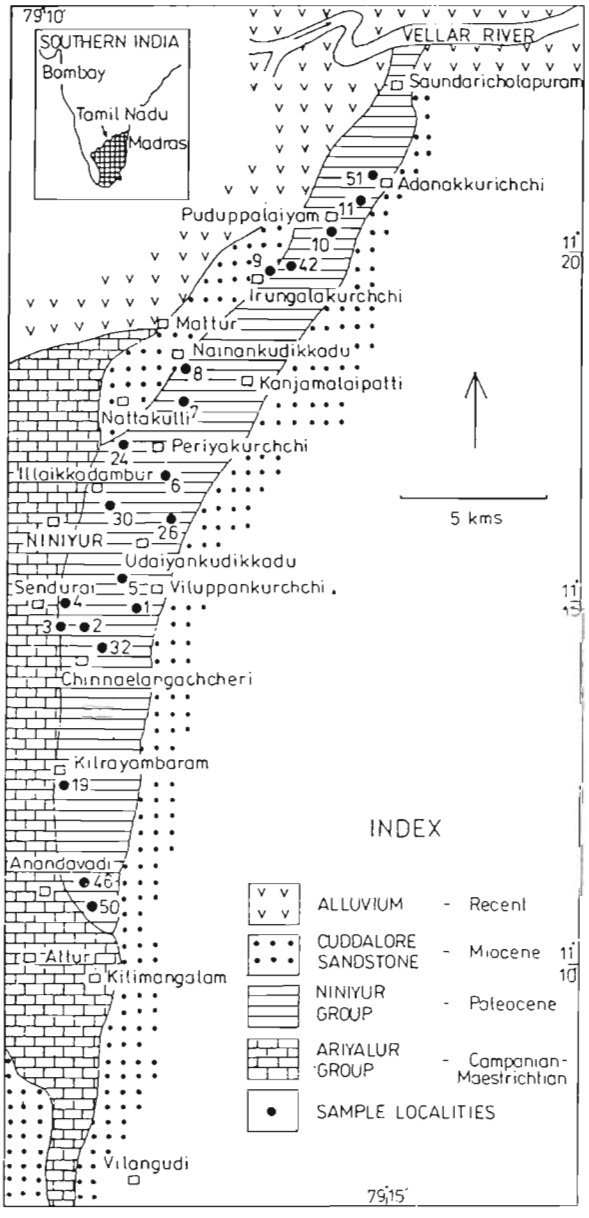
एन. मलारकोडी एवं एच. एम. नागराज

लगभग 80 वर्ग किलोमीटर क्षेत्र में अरियालूर क्षेत्र के पेलियोसीन कालीन अवसाद पृथक दृश्यांसों के रूप में अनावरित हैं तथा त्रिचुरापल्ली के क्रीटेश्यस कालीन उत्तर-पूर्वी भाग में शैली, क्रीम रंग के चूनापत्थरों से युक्त हैं। प्रस्तुत अध्ययन में बेन्थिक एवं प्लवकी प्रकृति के छोटे फोरामिनीफरों का वर्णन किया गया है। प्राप्त फोरामिनीफर निक्षेपण के समय छिछली समुद्री से लवणीय जलवाली परिस्थितियाँ प्रदर्शित करते हैं। इसी शोध-पत्र में निनियूर शैल-समूह के समतुल्य संस्तरों से प्राप्त फोरामिनीफरों के स्तरिकीय वितरण आदि पर भी विवेचना की गई है।

THE Niniyur Formation (Palaeocene) overlying the Ariyalur Group (Campanian-Maastrichtian) is exposed as isolated outcrops along a NNE-SSW trend, between Vellar River in the north and Kavanur in the south, over a strike length of 26 km on the northeastern part of Tiruchirapalli Cretaceous area (Text-figure 1). This covers an area of about 80-90 sq km exposing highly fossiliferous horizons composed of gritty nodular limestones, marls, shelly limestone and cream coloured limestone. The sequence seems to have been deposited in a shallow marine environment during an independent post-Maastrichtian transgression (Nagaraj & Mallikarjuna, 1993; Mallikarjuna & Nagaraj, 1996). The beds are generally flat lying, but occasionally show low dips (5°-10°). The area limits within latitudes 11° 08' to 11° 22' North and longitudes 79° 10' to 79° 17' East. The thickness of the succession is estimated to be of the order of 66 meters (Sundaram & Rao, 1984).

Based on the megascopic remains such as gastropods, lamellibranchs and well-known *Hercoglossa danica,* a lower Palaeocene age has been assigned for the Niniyur Formation. The formation is considered to represent a single palaeontological unit having Tethyan and Indo-Pacific zoogeographic affinity.

Practically no detailed work has been done on the foraminifera of Niniyur Formation. However, some of the earlier reports have dealt with the occurrence of algal remains (Rama Rao & Pia, 1936; Rama Rao & Prasanna Kumar, 1934; Rama Rao & Sambe Gowda, 1953, 1954; Sambe Gowda 1953, 1956; Verma 1954; Rama Rao 1956; Rao, *et al.*, 1963). Sastry *et al.* (1965) reported the occurrence of *Globorotalia (Truncorotalia) mossae* Hofker from the Niniyur Formation. Subsequently, some species of agglutinated foraminifera were recorded by Malur



Text-figure 1—Geological map of the Niniyur area, Tiruchirapalli District, Tamil Nadu.

(1969). Recent studies have reported the occurrence of abundant ostracode fauna from the limestone beds of the Niniyur Formation (Mallikarjuna, 1992; Nagaraj & Mallikarjuna, 1993; Mallikarjuna & Nagaraj, 1996).

Table 1 gives the scheme of stratigraphic succession of the Niniyur area (Mallikarjuna, 1992). The samples from different litho-units, viz., Adanakurchchi limestone, Subcrystalline shelly limestone and Argillaceous gritty nodular limestone, have yielded rich and interesting foraminiferal assemblage. The present record documents the foraminiferal taxa reported for the first time from the Niniyur Formation (Plates 1, 2 & 3). This includes 19 benthic and five planktic species. This occurrence of characteristic foraminiferal species seems to be an evidence in support of the boundary limit between Cretaceous and Tertiary sequence in the area.

Table 1—Lithologic succession of the Niniyur, Ariyalur area

FORMATION	LITHOTYPES	LITHOLOGICAL COMPOSITION	THICKNESS (APPROX.)
	CUDDALORE SANDSTONE		
	Argillaceous gritty nodular limestone	Limestone with corals, gastropods and lamellibranchs; variegated marls and clays	
Niniyur Formation	Subcrystalline Shelly Limestone	Subcrystalline shelly limestone	66 m
	Adanakurchchi Limestone	Limestone with milioline tests	
	ARIYALUR GROUP		

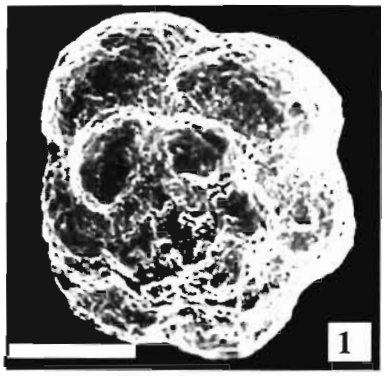
MATERIAL AND METHOD

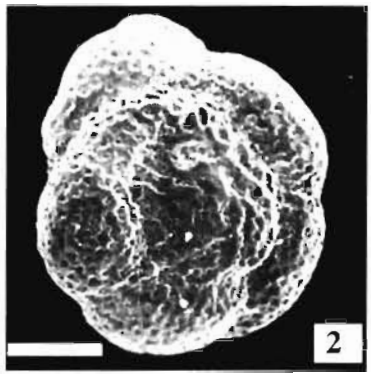
The exposures of Niniyur Formation are very scanty and mainly samples were collected from the unlined dugwells, quarry sections and nala cuttings.

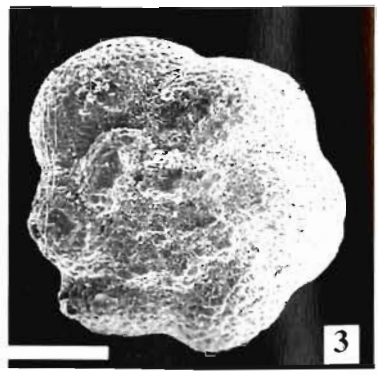
PLATE 1

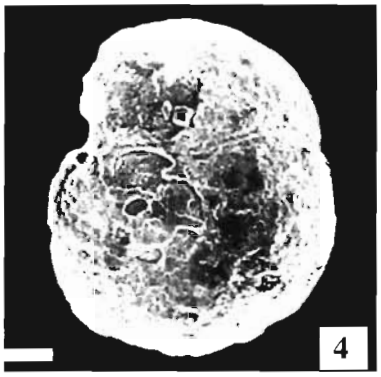
(All figures are of dorsal view; the scale bar on each photograph indicates 100 μm)

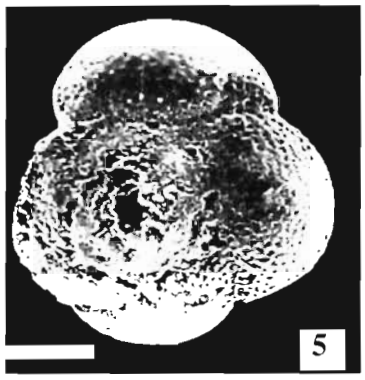
1. *Acarinina spiralis* (Bolli)
2. *Acarinina mckannai* (White)
3. *Morozovella praecursoria* (Morozova)
4. *Rosalina elagans* (Hansen)
5. *Planorotalites chapmani* (Parr)
6. *Planorotalites* cf. *pseudomenardii* (Bolli)
7. *Paralabamina lunata* (Brotzen)
8. *Cibicides aknerianus* (d'Orbigny)
9. *Gavelinella danica* (Brotzen)
10. *Asterigerina bartoniana* (Ten Dam)
11. *Protelphidium brotzeni* (Hofker)
12. *Fissoelphidium* sp.

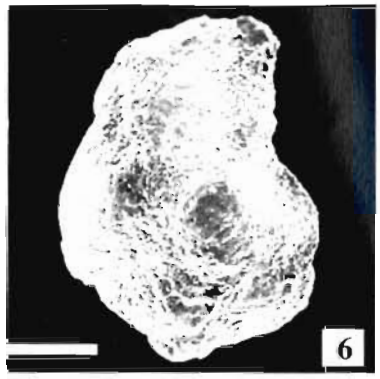


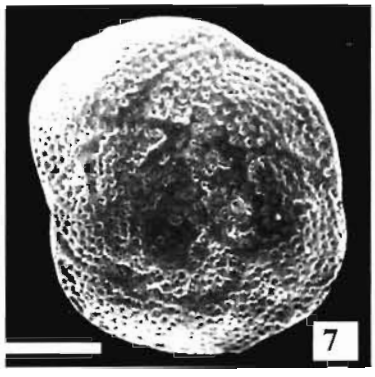


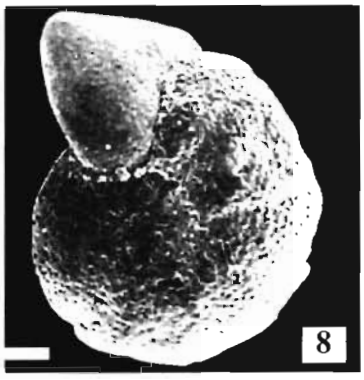


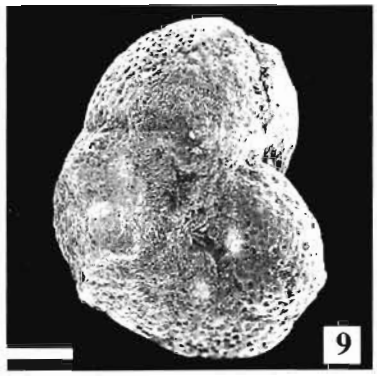


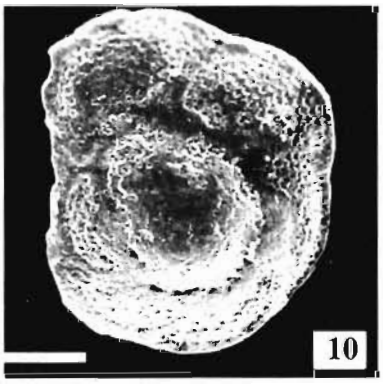


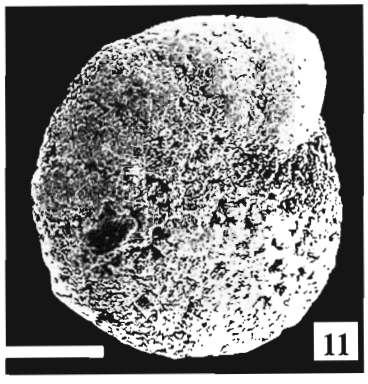












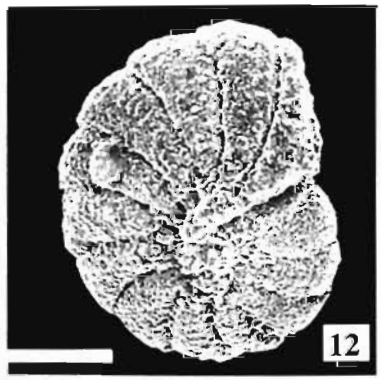


PLATE 1

Table 2—Distribution of foraminifera in the Niniyur Formation

NINIYUR FORMATION															
Adanakurchchi limestone member			Subcrystalline shelly limestone member							Argillaceous gritty Nodular limestone Member					MEMBER
44	51		2	5	6	10	13	14	24	42	1	4	12	19	46	Sample No. / Species
				+					+							*Acarinina mckannai* (White) (P3-P5)
	+															*Acarinina spiralis* Bolli (P2)
	+															*Asterigerina bartoniana* (Ten Dam)
						+										*Bulumina schwager* (Yokoyama)
	+															*Cibicides aknerianus* (d'Orbigny)
						+			+							*Dentalina angusticostata* Cushman
	0															*Discorbis midwayensis* Soldadoensis
	+															*Paralabamina lunata* (Brotzen)
						+										*Fissoelphidium* sp.
									+							*Gavelinella danica* (Brotzen) (P2-P3)
+						@			+							*Globulina gibba* d'Orbigny
0						@			+							*Guttulina problema* d'Orbigny
	+															*Lagena laevis* (montagu)
	-															*Morozovella praecursoria* (Morozova) (P2-P3)
				+												*Nodosaria* sp.
	+															*Oolina apiculata* Reuss
	+															*Planorotalites chapmani* (Parr) (P3-P6)
				+												*Planorotalites* cf. *pseudomenardii* (Bolli) (P4)
	@		+		+	+							+	+	+	*Protelphidium brotzeni* (Hofker)
					+											*Polymorphina paleocenica* (Brotzen)
	@					0			+			+			@	*Quinqueloculina impressa* Reuss
												+		+		*Rosalina elegans* Hansen
												+				*Textularia conica* d'Orbigny
	@						0		0			@	0	0	@	*Triloculina trigonula* (Lamark)

(Abundance : +=<5; 0=5-10; @=>10)

Each sample weighing 200 gm was subjected to disaggregation for the separation of foraminifera and the method followed is the one detailed in Jones (1956). The forty samples examined have yielded rich foraminifera.

STRATIGRAPHIC DISTRIBUTION OF THE FAUNA

An interesting feature of fossil composition of the Niniyur Formation is the abundant occurrence of fossil algae, rich ostracode fauna and some species of agglutinated foraminifera. Foraminifera constitute moderate part of the microfossil assemblage when compared to Ostracoda and algae. The frequency and distribution of foraminifera are not uniform; they are rich locally, and while absent in other beds. The samples from different litho-units show the presence of characteristic calcareous smaller foraminiferal species (Table 2).

A brief account of lithological and microfossil composition of different lithounits of the Niniyur Formation is given below :

PLATE 2 ⟶

(All figures are of side view, fig. 3 is a dorsal view; the scale bar on each photograph indicates 100 μm)

1. *Textularia conica* (d'Orbigny)
2. *Oolina apiculata* Reuss
3. *Discorbis midwayensis* Soldadoensis
4. *Quinqueloculina impressa* Reuss
5. *Dentalina angusticostata* Cushman
6. *Bulumina schwageri* (Yokoyama)
7. *Triloculina trigonula* (Lamark)
8. *Nodosaria.*
9. *Lagena laevis* (Montagu)
10. *Guttulina problema* d'Orbigny
11. *Globulina gibba* d'Orbigny
12. *Pseudopolymorphina paleocenica* (Brotzen)

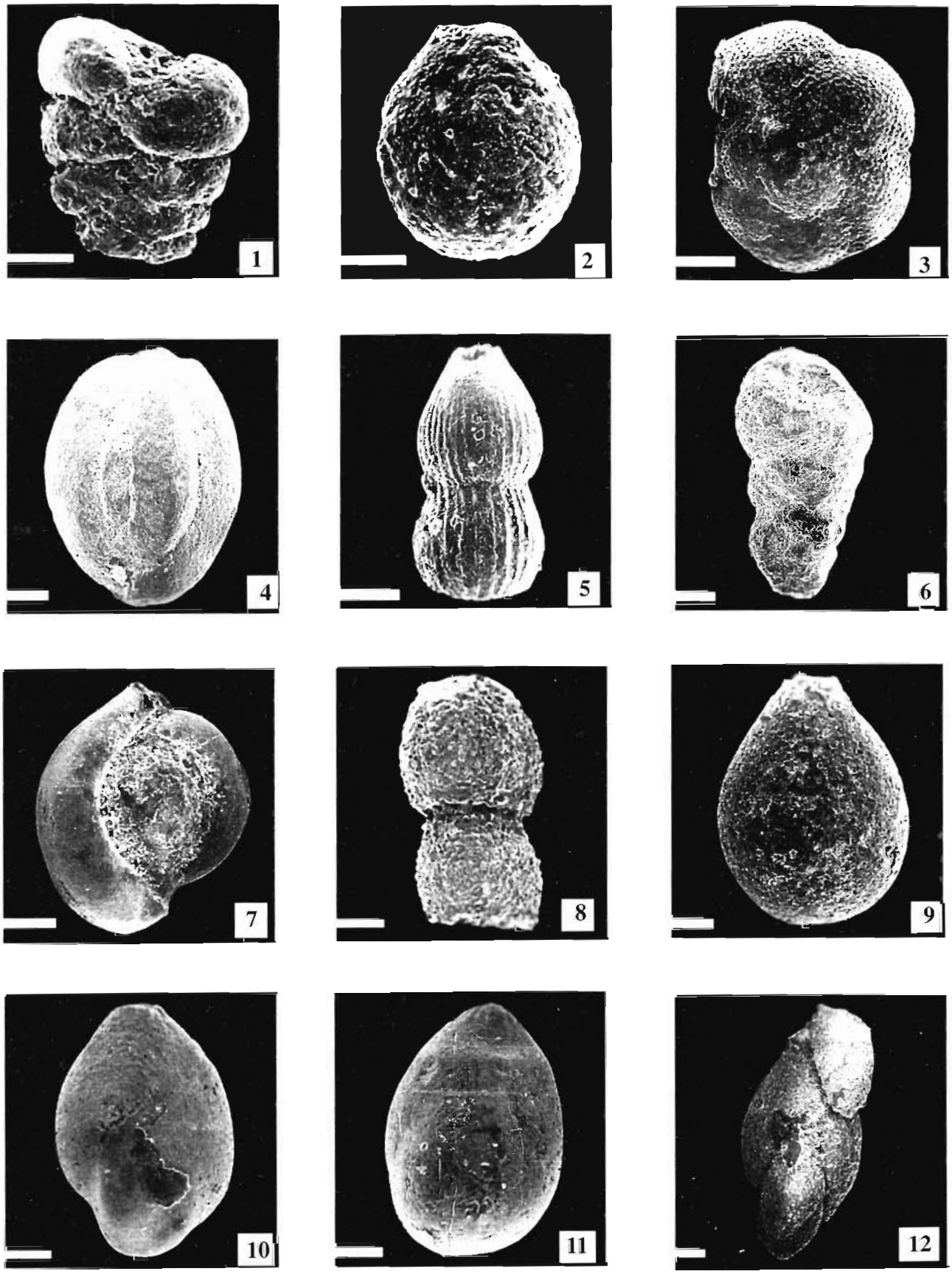


PLATE 2

1. Adanakurchchi limestone

This is the lower fossiliferous unit and is widely exposed in and around Adanakurchchi, Tattar and Soundaricholapuram. It is mainly composed of argillaceous limestone and shows the presence of numerous milioline tests dominated by the genus *Quinqueloculina*. Fourteen species of foraminifera were recorded. The planktic species restricted to this unit are *Acarinina spiralis* (Bolli), *Morozovella praecursoria* (Morozova), and *Planorotalites chapmani* (Parr). The foraminifera are found associated with a rich ostracod fauna and both the groups indicate a shallow water condition of deposition.

2. Subcrystalline shelly limestone

This unit is exposed in and around Illaikadambur, Nattaguli, Chinna and Periya Elangachcheri. It is characterised by large shells of lamellibranchs and gastropods besides foraminifera. The significant megafossil species are *Lucina percrassa* and *Nautilus danicus*. The foraminiferal species recorded from this unit are *Protelphidium brotzeni* Hofker, *Planorotalites pseudomenardii* (Bolli), *Acarinina mckannai* (White), *Bulumina schwageri* (Yokoyama), *Dentalina angusticostata* Cushman, *Guttulina problema* d'Orbigny, *Globulina gibba* d'Orbigny and *Nodosaria* sp.

3. Argillaceous gritty, nodular limestone

This unit exposed near Sendurai, Niniyur, Illaikadambur and Anandavadi villages contains abundant megafossil remains such as corals, lamellibranchs and gastropods. Of these, *Cardita jaquinoti* (= *Cardita beaumonti*) is the most important. Among the microfossils, ostracodes dominate over foraminifera. Of the six species of foraminifera distributed through different rock-types, three are restricted to this member, viz., *Gavelinella danica* (Brotzen), *Textularia conica* (d'Orbigny) and *Rosalina elegans* Hansen.

The planktic assemblages from different lithounits of the Niniyur Formation are very characteristic and show a strong Lower Tertiary (Palaeocene) affinity.

AGE OF THE NINIYUR FORMATION

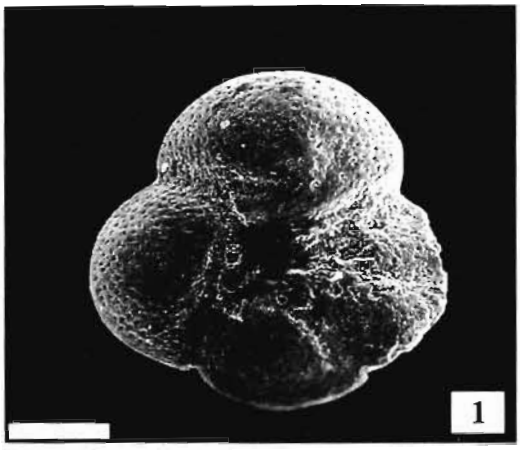
The Niniyur Formation has been traditionally considered Early Palaeocene (Danian) in age on the basis of the occurrence of *Hercoglossa danica*, which is characteristic of the Danian Stage (Blanford, 1862; Rama Rao, 1956). In recent years, emphasis has been shifted to planktic foraminifera. The reported occurrence of *Globorotalia (Truncorotalia) mossae* Hofker from the Niniyur Formation is suggestive of Early Palaeocene age (Sastry *et al.*, 1965). Subsequent record of rich ostracode species from the Niniyur Formation and their affinity with other forms from different parts of the globe confirms the Palaeocene age (Mallikarjuna, 1992). The present study corroborates the previous age assignment and dates precisely the Niniyur Formation on the basis of the following planktic foraminiferal species, *Morozovella praecursoria* (Morozova), *Acarinina spiralis* Bolli and *A. mckannai* (White). They indicate correlation with the planktic foraminiferal zones and suggest that the Niniyur Formation is Early to Late Palaeocene in age.

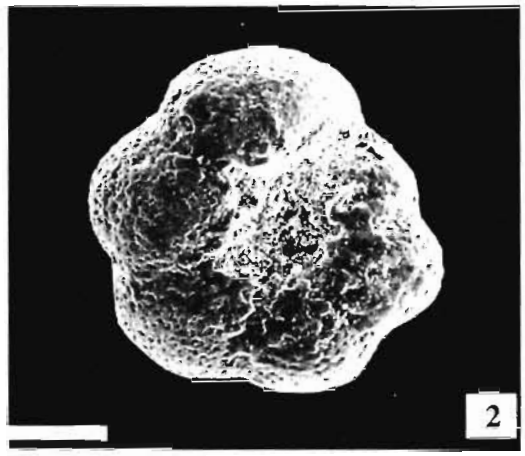
TAXONOMIC AND BIOSTRATIGRAPHIC DATA

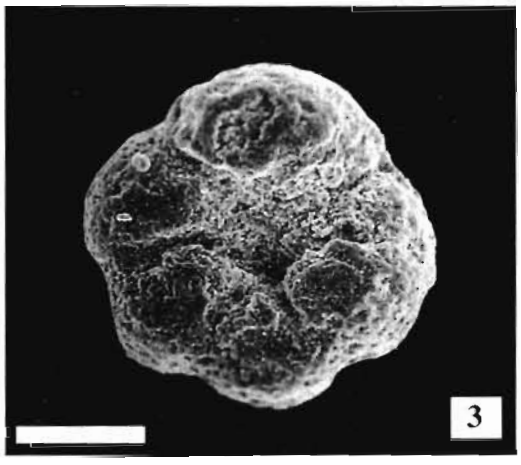
The important Palaeocene species of the present work are *Planorotalites* cf. *pseudomenardii* (Bolli), *P. chapmani* (Parr), *Morozovella praecursoria* (Morozova), *Acarinina spiralis* (Bolli) and *A. mckannai* (White).

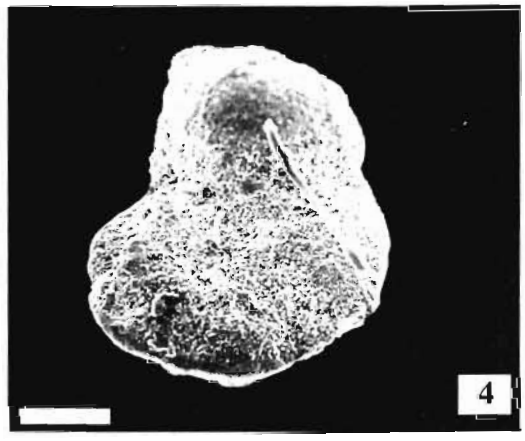
Planorotalites cf. *pseudomenardii* (Bolli) has biconvex and lenticular test with imperforate keel. Since it is poorly preserved, the wall structure is very difficult to identify. This species coincides with the *Planorotalites pseudomenardii* Zone (P4) of Blow (1969) and assigned a Late Palaeocene age. The species is known from the Mathew Landing Marl Member and Salt Mountain Limestone of Alabama, Hornerstown and Vincentown Formations of New Jersey, and Velasco Formations of Mexico (Loeblich & Tappan, 1957).

Morozovella praecursoria (Morozova) has high trochospiral test with subangular chambers increasing rapidly in size. Two and a half whorls are visible on the umbilical side. Sutures are distinct and depressed. Wall is calcareous and perforated. The species differs from *M. uncinata* by large number of chambers in the last whorl and from *A. spiralis* by having globular chambers. The species has been reported from the Early Palaeocene of N. Caucasus, Russia (Subbotina, 1953) and Montian of Tunisia (Salaj, 1980). *M. praecursoria* (Morozova) coincides with









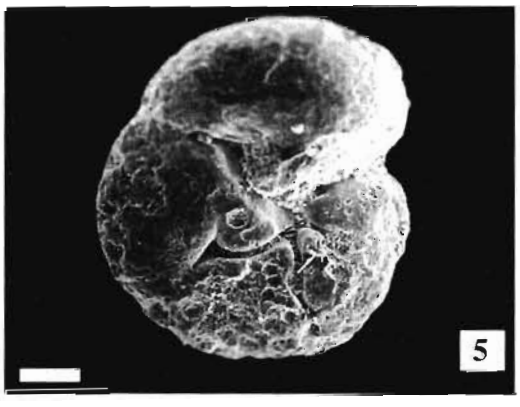


PLATE 3

(All figures are of ventral view, fig. 6 is a side view; the scale bar on each photograph indicates 100 μm)

1. *Planorotalites chapmani* (Parr)
2. *Morozovella praecursoria* (Morozova)
3. *Acarinina spiralis* (Bolli)
4. *Planorotalites* cf. *pseudomenardii* (Bolli)
5. *Rosalina elagans* (Hansen)
6. *Gavelinella danica* (Brotzen)

M. uncinata Zones (P2-P3) of Blow (1969), and Berggren and Van Couvering (1974), and assigned Lower Palaeocene to Middle Palaeocene age.

Acarinina mckannai (White) has five chambers in the final whorl. These chambers are considerably larger than those of the initial whorls and encroach on narrow and deep umbilicus. The outline of the test is almost subglobular with deep umbilicus. It is known from the Palaeocene of the Lizard Spring Formation, Trinidad (Bolli, 1957a), N. Caucasus, Russia (Subbotina, 1953) and Velasco Formation, Mexico (Shutskaya, 1958).

Acarinina spiralis (Bolli) shows high trochospirally coiled test resulting in a nearly globular shape; chamber globular and increasing rapidly in size; two or three whorls are visible on the spiral side and six chambers in the final whorl, sutures distinct and depressed; wall calcareous perforate and a broad umbilical aperture and interiomarginal arch in the final chamber. The species has been assigned a Lower Palaeocene (Upper Danian) age. It is reported from the Vincentown and Hornerstown Formations of New Jersey and Salt Mountain Limestone of Alabama (Loeblich & Tappan, 1957).

The planktic assemblage of the Niniyur Formation also contains a few long ranging species such as *Planorotalites chapmani* (Parr). The species ranges from Middle Palaeocene to Lower Eocene (P3-P6) and is characterised by the imperforate marginal band which gives the appearance of a keel. The forms have an equally biconvex arrowhead shape in profile, which has been recorded from the Palaeocene of King's Park Shale, Western Australia (McGowran, 1964), and Upper Eocene of southern Australia (Crespin, 1954).

Gaveltnella danica (Brotzen) ranges from Lower Palaeocene to Upper Palaeocene (P2-P3) and has trochospiral test having slightly larger pores; spiral side evolute, umbilical side involute with deep and open umbilicus; periphery angular. In general, the periphery of the last chamber is more rounded than that of the earlier part. Aperture is interiomarginal. The species is more common in Palaeocene benthonic foraminiferal middle shelf depths (100 m) and rare in the midway of the Gulf Coast and its equivalents on the Atlantic Coastal Plain, as well as in Libya, where as it is rather common in the somewhat deeper-water sediments of Tunisia and the Aquitaine Basin.

These species of foraminifera are also known from the Palaeocene rocks of Sweden, Poland, Holand, Egypt, Texas, Alabama, Maryland, New Jersey, Mexico, Denmark and Australia. This distribution suggests their cosmopolitan character and also indicates wide geographic distribution of similar palaeoclimatic conditions facilitating extensive migration over long distances (Loeblich & Tappan, 1957; Berggren, 1974; Kureshey, 1984).

CONCLUSIONS

The post-Cretaceous transgression during Early Tertiary resulted in the deposition of the Niniyur Formation which is not only lithologically different from the underlying Kallamedu Formation (Upper Maastrichtian) but is also palaeontologically distinguishable. The Cretaceous-Tertiary boundary occurs over the continental sandstone beds of the Kallamedu Formation and below the marine limestones of the Niniyur Formation. This is marked by the complete disappearance of Upper Cretaceous (Maastrichtian) planktic foraminifera such as *Globotruncana* and some of the associated mega-invertebrate fauna, and the emergence of Lower Tertiary (Palaeocene) planktic species in the Niniyur Formation. The Lower Tertiary rocks of the Ariyalur area contain a relatively highly diversified and rich assemblage of foraminifera which indicate deposition of the Niniyur Formation in a shallow marine to brackish water environment with restricted influence of open marine conditions. The associated benthic species are geographically widely distributed and a few of them are common between Tethyan and Indo-Pacific biogeographic provinces. They are cosmopolitan in character and indicate prevalence of broadly similar palaeoclimatic conditions over distant areas.

The recorded planktic foraminifera corroborate the assigned Palaeocene age for the Niniyur Formation.

CHECK LIST OF FORAMINIFERA FROM THE NINIYUR FORMATION

Textularia conica (d'Orbigny)
Quinqueloculina impressa Reuss
Triloculina trigonula (Lamark)
Dentalina angusticostata Cushman
Nodosaria sp.
Lagena laevis (Montagu)
Globulina gibba d'Orbigny

Guttulina problema d'Orbigny
Pseudopolymorphina paleocenica (Brotzen)
Oolina apiculata Reuss
Planorotalites cf. *pseudomenardii* (Bolli)
Planorotalites chapmani (Parr)
Acarinina spiralis (Bolli)
Acarinina mckannai (White)
Morozovella praecursoria (Morozova)
Bulumina schwageri (Yokoyama)
Paralabamina lunata (Brotzen)
Cibicides aknerianus (d'Orbigny)
Gavelinella danica (Brotzen)
Protelphidium brotzeni (Hofker)
Discorbis midwayensis Soldadoensis
Rosalina elegans (Hansen)
Asterigerina bartoniana (Ten Dam)
Fissoelphidium sp. A

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the help of Dr Govindan, Dr C.N. Ravindran and Dr Reddy, ONGC, Madras in offering valuable taxonomic comments on the foraminiferal species. Our sincere thanks are due to Dr (Mrs) Neera Sahni, CAS, Punjab University, Chandigarh for her generosity in taking SEM photomicrographs.

REFERENCES

Berggren WA 1974. Palaeocene benthic foraminiferal biostratigraphy, paleobiogeography and paleoecology of Libya and Mali. *Micropaleontology* **20** (4): 449-465.

Berggren WA & Aubert J 1975. Palaeocene benthonic foraminiferal biostratigraphy, palaeobiogeography and palaeoecology of Atlantic Tethyan regions: Midway-type fauna. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **18**: 73-192.

Berggren WA & Van Couvering JA 1974. The late Neogene biostratigraphy, geochronology and palaeoclimatology of the last 15 million years in marine and continental sequences. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **16** (1-2) : 1-216.

Blanford HF 1862. On the Cretaceous and other rocks of South Arcot and Trichinopoly districts, Madras. *Mem. geol. Surv. India* **4**: 1-217.

Blow WH 1969. Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. *Proc I Int. Conf. Planktonic microfossils, Geneva, 1967.* **1**; 199-422.

Boersma A & Premoli Silva I 1983. Palaeocene planktonic foraminiferal biogeography and paleo-oceanography of the Atlantic Ocean. *Micropaleontology* **29** (4): 355-381.

Bolli HM 1957a. The genera *Globigerina* and *Globorotalia* in the Palaeocene-Lower Eocene Lizard Spring Formation of Trinidad. *B.W.I. U.S. Natl. Mus. Bull.* **215**: 61-82.

Bolli HM 1957. The genera *Praeglobotruncana, Rotalipora, Globotruncana* and *Abathomphalus* in the Upper Cretaceous of Trinidada. *B.W.I. Bull. U.S. Natn. Mus.* **215**: 51-60.

Bolli, HM 1957b. Planktonic foraminifera from the Eocene Navet and San Fernando formations of Trinidad. *B.W.I. Bull U.S. Natn. Mus.* **215**: 155-172

Crespin I 1954. Stratigraphy and micropaleontology of the marine Tertiary rocks between Adelaide and Aldinga, South Australia. *Rep. Bur. Miner. Resour. Australia* **12**: 1-65.

Jones JD 1956. *Introduction to microfossils, Harper's Geoscience Series.* Carey Croneis, Ed., : 7-18. New York.

Kureshy Ashfag A 1984. Palaeocene foraminifera of Pab, Pakistan, *II. Int. Symp. benth. foraminifera, El Aquitaine.* 349-351.

Leoblich A & Tappan H 1957. Studies in Foraminifera. *U.S. Natn. Mus. Bull.* **215** (9) : 173-198.

Mallikarjuna UB 1992. The study of ostracodes from the sedimentary sequences of Ariyalur and Niniyur groups of Tiruchirapalli District, Tamil Nadu, India. *Unpublished. Ph.D. Thesis.* Bangalore University, India.

Mallikarjuna UB & Nagaraj HM 1996. Ostracodes from the Ariyallur Group (Late Cretaceous), Cauvery Basin, southern India. *J. geol. Soc. India* **48**: 189-201.

Malur MN 1969. Agglutinated foraminifera from the unfossiliferous sandstone near Niniyur, Tiruchirapalli area, south India. *Curr. Sci.* **19**: 464.

McGowran B 1964. Foraminiferal evidence for the Palaeocene age of the Kings's Park Shale (Perth Basin, Western Australia). *Proc. R. Soc. W. Australia* **47** (3) : 81-86.

Nagaraj HM & Mallikarjuna UB 1993. Ostracodes from the Niniyur Group (Lower Tertiary) of Tiruchirapalli District, south India. *In*: Mckenzie, KG & Jones PJ (Editors)—*Ostracodes in life and Earth Science. Proc. 11th Int. Symp. ostracoda, Australia:* 207-212. A A Balkema.

Rama Rao L 1956. Recent contributions to our knowledge of the Cretaceous rocks of south India. *Proc. Indian Acad. Sci.* **B44**: 185-245.

Rama Rao L & Prasanna Kumar C 1934. On the flint and cherts from the upper most Cretaceous beds (Niniyur Stage) of the Trichinopoly District, south India. *Proc. Indian Acad. Sci.* **1** (10): 10-18.

Rama Rao L & Gowda SS 1953. Occurrence of *Clypeina* (Dasycladaceae) of the south Indian Cretaceous. *Curr. Sci.* **22**: 332-333.

Rama Rao L & Gowda SS 1954. Solonoporaceae from the Cretaceous rocks of south India. *Curr. Sci.* **23**: 177-179.

Rama Rao L & Pia J 1936. Fossil algae from the uppermost Cretaceous beds (Niniyur Group) of the Trichinopoly District, south India. *Mem. geol. Surv. India, Palaeont indica,* N.ser., **21** (4) : 1-49.

Rao BRJ, Mamgain VD & Sastry MVA 1963. A note on the Niniyur Stage of Cretaceous formations of Trichinopoly District, Madras. *Indian minerals* **17** (2): 190-192.

Salaj J 1980. Microbiostratigraphie du cretace et du Palaeogene de la Tunisie septentrionale et orintale. *Institut Geologique dionyz stur, Bratislava:* 9-241.

Sambe Gowda SS 1953. Occurrence of *Holosporella* in the Niniyur Group (Danian) of the Trichinopoly Cretaceous, south India. *Curr. Sci.* **22**(6) : 169- 170.

Sambe Gowda SS 1956. *Piania niniyurensis,* a new dasycladaceous alga from the Niniyur Group (Danian) of the Trichinopoly Cretaceous, south India. *J. geol. Soc. India* **1**: 152-155.

Sastry MVA, Rao BRJ & Mamgain VD 1965. Note on the occurrence of Globorotalia in Niniyur Stage, south India. *Curr. Sci.* **34** (4): 199-120.

Shutskaya EK 1958. Foraminifery Verknikh sloev "Datsko-Montskikh" izvestnyakov yugo-zapadnogo kryma. *VNIGRI Trudy* **9**: 197-210.

Subbotina NN 1953. Fossil foraminifers of the USSR: *Globigerinidae, Hantkeninidae* and *Globorotaliidae. Trudy VNIGRI,* new series **79**: 296 (in Russian). Translated into English by E. Lees. Fossil foraminifera of the USSR, *Globigerinidae, Hantkeninidae and Globorotaliidae, Collect's Ltd., London* and *Wellingborough,* 321.

Sundaram R & Rao PD 1984. Lithostratigraphy of Cretaceous and Palaeocene rocks of Tiruchirapalli District, Tamil Nadu, south India. *Rec. geol. Surv. India* **115** (5): 9-19.

Verma CP 1954. On the algal genera *Neomeris* and *Acicularia* from the Niniyur (Danian) beds of the Trichinopoly area. (S. India). *Proc. natn. Inst. Sci. India* **20** (3).