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SEMINAR ON CRETACEOUS-TERTIARY FORMATIONS OF SOUTH INDIA

PROCEEDINGS

(7th to 9th June, 1966)

BANGALORE

CRETACEOUS-TERTIARY FORMATIONS OF SOUTH INDIA

CONTENTS

GEOLOGICAL SOCIETY OF INDIA

SEMINAR ON CRETACEOUS-TERTIARY FORMATIONS OF SOUTH INDIA

SITTING : *(L. to R.)* M. R. Sreenivasa Rao, P. S. Narayana, N. A. Eremenko, B. P. Radhakrishna, W. B. Metre, B. Rama Rao, A. G. Jhingran, L. Rama Rao, C. S. Pichamuthu, M. N. Qureshy, M. V. A. Sastry, V. V. Sastri, S. Sambe Gowda, S. Narayanaswamy.

STANDING : 1ST ROW : *(L. to R.)* B. S. Venkatachala, V. M. Turin, S. N. Bhalla, C. G. K. Ramanujam, M. G. A. Setty, V. S. Krishnaswamy, R. B. Gupte, P. V. Dehadrai, G. S. Annaiah, T. B. Sundara, S. Venkataraman, K. Gavi Setty, R. K. Banerji, D. Rangaiah, A. Mohamed Khan, V. Venkatachalapathy.

STANDING : 2ND ROW : *(L. to R.)* V. D. Mamgain, Honnappa, B. K. Setty, Dhananjaya Rao, S. Ramanathan, D. A. Rashid, P. B. Murthy, R. B. Badami, D. K. Guha, R. Srinivasan, B. V. Rama Rao, V. S. Upadhyaya, R. H. Sowcar, B. Biswas, J. V. Subbaraman.

STANDING : 3RD ROW : *(L. to R.)* B. Vasudeva Murthy, H. S. Sharma, A. Govindan, M. N. Viswanathiah, V. Venkaiah, B. K. Samanta, S. R. Tatachar, V. N. Deeksithulu, R. V. Viswanath, B. L. Sreenivas, S. R. S. Rao, S. G. Vasudeva, M. N. Malur, D. S. N. Raju.

IDEA AND ORGANISATION

Although the existence of marine fossiliferous rocks of Cretaceous and Tertiary age along the east coast of India has been known to Indian geologists for more than a hundred years, it is only in more recent times that they have attracted serious attention and study on modern lines. In view of several interesting observations of both scientific importance and economic value made as a result of these investigations, an increasingly large number of geologists in different parts of India are now actively engaged in this line of research. The two important All-India organisations specially interested in this field of study are the Geological Survey of India at Calcutta, and the Oil and Natural Gas Commission at Dehra Dun; in addition to these several of the younger research workers in the Indian Universities have also taken up some of these investigations. Thus a large number of enthusiastic workers in different parts of the country are now specialising in the study of these Cretaceous-Tertiary formations of South India, and numerous papers dealing with various aspects of the studies have been published during the last 40 years bringing to light new and significant results.

In response to a proposal made last year by several of these workers, the Geological Society of India decided to organise a Seminar on the "Cretaceous-Tertiary Formations of South India", with a view to provide a common platform which was very much needed for the different workers to meet together for study, discussion, and exchange of ideas on various aspects of mutual interest in this field of research. A Steering Committee composed of Sri M. V. A. Sastry (Calcutta), Sri V. V. Sastri (Dehra Dun) and Dr. S. Sambe Gowda (Bangalore) was constituted to organise this meeting, with Dr. Sambe Gowda as the Convener. Prof. L. Rama Rao agreed to preside and conduct the meetings of the Seminar.

A Circular was accordingly issued in November 1965 announcing the scope and provisional programme of the Seminar and inviting the co-operation of all the workers by presenting papers and participating in the discussions; and it was gratifying to find that the response was most encouraging. We were happy to see that the authorities of the two important organisations doing extensive work in this field—the Geological Survey of India and the Oil and Natural Gas Commission—welcomed the proposal and offered their full co-operation to enable us to achieve our objective. More than 45 papers thus came to be contributed and these were presented and discussed during the 3-day session of the Seminar according to a planned programme notified earlier.

A special feature of the Seminar was the delivering of "Invited Addresses" by some of the senior and leading geologists reviewing the latest advances in this field of study. Prof. N. A. Eremenko (Dehra Dun) spoke on "Tectonics and Petroleum possibilities of South India"; Sri M. B. Ramachandra Rao (Bangalore) dealt with the "Geophysical aspects of the Cretaceous-Tertiary Basin of South India", and Sri W. B. Metre

(New Delhi) addressed on "Age of the Deccan Trap of Cutch". In addition to these, three 'Evening Lectures' on topics of general interest were also arranged, one by Dr. A. G. Jhingran (Calcutta) on "Certain aspects of mineral economy of India"; the second by Sri W. B. Metre (New Delhi) on "Oil Industry, with particular reference to Asian countries" and the third by Prof. N. A. Eremenko (Dehra Dun) on "Types of Oil and Gas bearing basins of the world".

With a view to make the scope of the Seminar more comprehensive, some of the leading workers engaged in the study of the Cretaceous-Tertiary formations outside India were invited to present 'review papers' in their own special field, and we were glad to receive four such overseas contributions: (i) "The Upper Cretaceous-Paleocene succession in Madagascar" by Dr. M. Collignon (France), (ii) "The Tertiary/Cretaceous Boundary" by Dr. F. E. Eames (England), (iii) "The problem of the Cretaceous-Tertiary Boundary" by Dr. T. Matsumoto (Japan) and (iv) "Late Cretaceous and Early Tertiary Correlations in the Indo-Pacific region" by Dr. B. McGowran (Australia).

At the conclusion of the session, we were happy to note that the Seminar proved to be a success and had achieved the very useful purpose which it was intended to serve. The following pages will give a brief idea of the programme of the Seminar and the scope of the papers presented during the meetings. We take this opportunity of expressing our most sincere thanks, on behalf of the Geological Society of India, to all those who extended their wholehearted co-operation in holding this Seminar.

B. P. RADHAKRISHNA
Secretary
Geological Society of India.

BANGALORE
1st July, 1966

INAUGURAL FUNCTION

The Seminar was formally inaugurated by Dr. A. G. Jhingran, Director-General of the Geological Survey of India at 9 A.M. on Tuesday, 7th June 1966 in an elegant function at which a large number of Fellows of the Society, delegates to the Seminar and distinguished invitees were present. Sri B. Rama Rao, President of the Society occupied the Chair.

After a short welcome speech by Dr. B. P. Radhakrishna, Secretary of the Society, Dr. Jhingran delivered his Inaugural Address. He said:

> "It gives me great pleasure to be with you today on this important occasion and to inaugurate the Seminar on the Cretaceous-Tertiary Formations of South India. I am thankful to the organisers of the Geological Society of India for doing me this honour.
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> The Cretaceous-Tertiary period has always been of great interest to Indian geologists, for it witnessed the outpouring of vast amount of lavas which today form the Deccan Traps, and the rise of Himalayas began during this period from the heart of the great Tethyan sea. Major changes also took place throughout the world in the distribution of land and sea. The Peninsular shield of India which had remained a stable land mass throughout the Palaeozoic era was encroached upon by the Upper Cretaceous sea along the Coromandel Coast. The deposits left by the transgression during this critical phase of the Mesozoic history of India, have attracted naturalists and geologists for more than a century. Thus it is only fitting that a Seminar of this kind has been organised to elucidate and to discuss problems mainly of this region."

He then referred to the earlier investigations made by the pioneer geologists in this region like Forbes, Blanford, Stoliczka and Kossmat and indicated how these studies stimulated considerable interest in those rock formations both in and outside India. Coming to more recent times he said:

> "The discovery of *Discocyclina*-bearing limestones from Pondicherry by Rama Rao (1939) and the report of *Assilina granulosa* from certain bore holes near Pondicherry by Furon and Lemoine (1939), confirmed the presence of Lower Tertiary marine sediments in this area. Blanford had only reported the Cuddalore Sandstones of late Tertiary age, overlying the Cretaceous beds.
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> Since the discovery of Eocene beds from Pondicherry, a more or less complete marine Tertiary succession has been established in this region. This has been recently confirmed in a deep well drilled by the Oil and Natural Gas Commission in Karaikal area, which has passed through more than 1700 metres of Tertiary sediments before reaching the basement.
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> The geophysical surveys conducted by the Geological Survey of India in the eastern coast, South of Madras, have indicated a good

thickness of sediments above the basement. It is very likely that the sediments increase in thickness off shore. Thus, the prospects of encountering suitable stratigraphic traps for oil in the coastal as well as off shore regions are worthy of notice. The exploratory drilling operations being conducted by the Oil & Natural Gas Commission are likely to supplement the knowledge of sub-surface geology of this region.

Apart from the oil potentialities, the Coromandel Coast also contains certain minerals of economic interest such as phosphatic nodules, gypsum, limestone, and celestite in the Cretaceous rocks of Tiruchirapalli district and lignite in the Miocene rocks of South Arcot district. Though the data available on the reserves of phosphatic nodules are not encouraging, it is nevertheless important to explore further when the mineral phosphate is presently playing an important role in India's economy."

After giving a brief account of the recent work on these Cretaceous-Tertiary rock formations of South India by the Geological Survey of India and the Oil and Natural Gas Commission, he concluded:

"It is encouraging to note that a large number of workers from Universities and other institutions are also engaged in the study of various aspects of these formations and have substantially contributed. I am extremely glad that the Geological Society of India has taken initiative in organising the Seminar, so that all workers may voice their opinion from a common platform and join hands in the discussions on various problems connected with this study. This meeting therefore, I am sure, will provide ample opportunities for the young workers who have begun the pursuit of truth, whose foundations were laid by the scientific zeal of some amateur geologists more than a century ago."

The President Sri B. Rama Rao then made a short speech, in the course of which he said:

"Permit me to extend to you all, on my personal behalf, a very hearty welcome to this Seminar. It is very good of Dr. Jhingran to have found some time amidst his various engagements to come over here and inaugurate the Seminar and to have consented to give a public lecture this evening; and of Mr. Metre, Mr. Ramachandra Rao and Prof. Eremenko to have contributed special papers to the Seminar at the request of the Society, and to have agreed to give public lectures in their respective fields in the next two evenings. It is really good of you all to have taken the trouble to come here and present personally the valuable papers you have contributed to the Seminar.

There is hardly any need for me to dilate at length on the advantages of holding such seminars and symposia. All of you know well that they create an opportunity for different workers in parti-

cular fields to come together on a common platform, meet one another and discuss personally the various problems relating to their special fields of investigation, take stock of what has been done and discuss and plan what remains to be done for solving their particular problems.

The subject of the present seminar, "The Cretaceous-Tertiary formations of Southern India" is quite important. Just like the ancient crystalline formations which have raised much controversy regarding their precise mode of origin, classification and correlation, several of the much younger formations also have raised their own problems. The precise classification of the Cretaceous and Tertiary Formations and the correct demarcation of the boundary between the two systems has been one such.

As you know, in the preliminary stages of investigations the classifications would be effected broadly on some readily perceptible differences between the groups; and with more and more detailed and extensive investigations the gaps which had apparently been wide enough to demarcate the different groups become narrower and narrower, so much so that it becomes difficult to ascertain definitely where exactly one group ends and the other commences; in other words, it makes one doubt whether in nature there are any abrupt well-marked breaks between one group and the other, or whether the transition from one to the other is very gradual and almost imperceptible,

I am sure this and the other problems relating to the Cretaceous and Tertiary Formations of Southern India will be fully discussed and thrashed out in the numerous papers that have been contributed to this seminar and will throw considerable light on some of the controversial questions. My friend Prof. L. Rama Rao has been engaged in a comprehensive study of these formations of Southern India for the past 30 years. He is the seniormost Indian Geologist among the well-known workers on the Cretaceous-Tertiary formations of Southern India and is the best person to take the chair and start the sessions for the reading of the papers, which he has kindly agreed to do. For the subsequent sessions during the next two days, three of the other distinguished geologists—Sri M. B. Ramachandra Rao, Former Member, Oil and Natural Gas Commission; Mr. Metre, Director, Oil India Ltd., and Prof. Eremenko, Project Manager, Research and Training Institute, O. N. G. C., Dehra Dun, will take the chair and conduct the proceedings. I am sure under the able guidance of these four distinguished geologists the discussions will reach a high standard and throw much light on the various problems relating to the Cretaceous and Tertiary formations of Southern India, which will be not merely of some local interest but cover a much wider field of the Cretaceous-Tertiary Boundary question of world-wide interest."

The function concluded with a hearty vote of thanks proposed by Dr. S. V. P. Iyengar.

PROGRAMME

7th June 1966:

9–00 a.m. Inaugural Function.

10–00 a.m. Seminar meets

L. Rama Rao, (Chairman): Opening Address: "The Problem of the Cretaceous-Tertiary Boundary."

10–30 a.m. READING OF PAPERS:

M. V. A. Sastry, B. R. J. Rao and V. D. Mamgain: Biostratigraphic zonation of the Upper Cretaceous formations of Trichinopoly District, South India. (1)

D. A. Rasheed and A. Govindan: Stratigraphy of the Cretaceous rocks of Vridhachalam, South India. (6)

V. D. Mamgain, B. R. J. Rao and M. V. A. Sastry: The Niniyur Group of Trichinopoly, South India. (9)

* *A. K. Chatterji:* Foraminifera from the Bore-hole samples near Udayarpalaiyam, South India. (18)

12–30 p.m. Lunch break.

Afternoon Session

2–30 p.m. READING OF PAPERS:

J. V. Subbaraman: Surface and subsurface Geology of the area around Dalmiapuram, Trichinopoly District. (11)

* *D. A. Rasheed and A. Govindan:* Upper Cretaceous Foraminifera of Vridhachalam, South India. (15)

Ranjit K. Banerji: Foraminiferal Biostratigraphy of the Lower Ariyalur stage of Pondicherry and Vridhachalam areas. (5)

* *Honnappa:* Fossil Bryozoans from the Cretaceous rocks of Trichinopoly, South India. (19)

M. G. Anantha Padmanabha Setty: Trigonal *Discocyclina* sp. from the Pondicherry formation, Pondicherry, South India. (16)

5–00 p.m. Invited Address by *N. A. Eremenko:* "Tectonics and Petroleum possibilities of South India."

5–30 p.m. TEA—By the Geological Society of India.

6–00 p.m. Evening Lecture by *A. G. Jhingran:* "Certain aspects of mineral economy of India."

8th June 1966:

9–00 a.m. READING OF PAPERS: *M. B. Ramachandra Rao, Chairman:*

Ranjit K. Banerji: Statistical study of the foraminiferal fauna from the Lower Ariyalur stage of Vridhachalam area. (14)

* *N. G. K. Murthy:* The Upper Cretaceous and Tertiary formations of Pondicherry. (10)

* *T. Narasimhan:* Nannoplanktons from the Upper Cretaceous and Lower Tertiary formations of Pondicherry, South India. (13)

Bimal K. Samanta: The age of the youngest marine horizon present in Pondicherry, South India. (7)

V. V. Sastri and E. Raiverman: On the Basin study programme of the Cretaceous-Tertiary sediments of the Cauvery Basin. (3)

10–30 a.m. Invited Address by *M. B. Ramachandra Rao:* "Geophysical aspects of the Cretaceous-Tertiary Basin of South India."

11–00 a.m. READING OF PAPERS: *M. B. Ramachandra Rao, Chairman:*

S. Ramanathan: Stratigraphy of Cauvery Basin with reference to its Oil prospects. (20)

P. V. Dehadrai and Madan Mohan: Studies on Cretaceous-Tertiary sediments of Cauvery Basin, South India. (21)

S. Venkataraman and M. K. Rangaraju: Oscillatory movements in the Cretaceous-Tertiary Basin of South India. (22)

* *A. K. Dutta and T. S. Bedi:* Faunal aspects and the evolution of the Cauvery Basin. (23)

D. S. N. Raju: Eocene-Oligocene Planktonic Foraminiferal Biostratigraphy of Cauvery Basin, South India. (24)

12–30 p.m. Lunch break.

Afternoon Session

2–30 p.m. READING OF PAPERS: *N. A. Eremenko, Chairman:*

S. N. Bhalla: Cretaceous-Tertiary Boundary in the Pangadi area, West Godavari Dist., Andhra Pradesh. (29)

D. K. Guha: Young Cenozoic marine Ostracoda from subcrops of South India. (26)

* *L. N. Kailasam:* Some results of Geophysical exploration over the Cretaceous-Tertiary formations of the Madras coast. (32)

* *D. Das and S. N. Sengupta:* A Gravity profile across the northern part of Cauvery Basin. (33)

* *K. K. Verma:* Bagh Beds–their fauna and affinities with the South Indian Cretaceous formations. (45)

* *K. N. Prasad:* Some observations on the Cretaceous Dinosaurs of India. (46)

OVERSEAS CONTRIBUTIONS

M. Collignon (France): The Upper Cretaceous-Paleocene succession of Madagascar. (48)

B. McGowran (Australia): Late Cretaceous and Early Tertiary correlations in the Indo-Pacific region. (51)

F. E. Eames (England): The Tertiary/Cretaceous Boundary. (49)

T. Matsumoto (Japan): The Problem of the Cretaceous-Tertiary Boundary. (50)

(Summaries by L. Rama Rao)

5–30 p.m. TEA—By the Department of Mines and Geology.

6–00 p.m. EVENING LECTURE—by *Sri W. B. Metre:* "Oil Industry with particular reference to Asian countries."

9th June 1966

9–00 a.m. READING OF PAPERS: *W. B. Metre, Chairman:*

V. N. Deekshitulu: Gravity and magnetic anomaly pattern on the Cretaceous and younger formations of the Godavari Valley, Andhra Pradesh. (34)

N. K. Balasunder: Tertiary deposits of Neyveli Lignite Field. (2)

N. K. Balasunder: Confined Tertiary aquifers of Neyveli Lignite Field. (35)

L. V. Agashe and R. B. Gupte: Some significant features of the Deccan Trap. (30)

D. Rangaiah: Fauna & Flora of the intertrappean beds of Gurumatkal area, Gulbarga District, Mysore State. (31)

* *S. S. Sarkar: Hercoglossa danica* and the Cretaceous-Tertiary Boundary in South India. (40)

* *G. W. Chiplonkar:* A note on the Cretaceous-Tertiary Boundary in South India. (41)

* *A. K. Ghosh:* Palynological evidences on Cretaceous-Tertiary Boundary. (42)

* *S. V. L. N. Rao:* Marine transgressive sedimentary formations of Southern Indian Peninsula and their relation to the Deccan Trap igneous activity. (47)

10–30 a.m. INVITED ADDRESS: *W. B. Metre:* "Age of the Deccan Trap of Cutch."

11–00 a.m. READING OF PAPERS: *W. B. Metre, Chairman:*

N. Rajagopalan: Occurrence of marine Paleocene sediments in the Vridhachalam area, South India. (8)

N. Rajagopalan: A re-study of the Pondicherry formation. (4)

B. Laskar and A. S. Narasimhan: Rock Phosphate deposits in the Cretaceous rocks of South India. (37)

S. Sambe Gowda: Eocene Bituminous limestone from the Pondicherry area and its significance. (38)

B. R. J. Rao, V. D. Mamgain and M. V. A. Sastry: Globotruncana in Ariyalur Group of Trichinopoly Cretaceous, South India. (17)

* *A. K. Dey:* On the Mineral resources and geology of the Cretaceous and Tertiary Rocks of South India. (36)

12–30 p.m. Lunch break.

Afternoon Session

2–30 p.m. READING OF PAPERS: *W. B. Metre, Chairman:*

C. G. K. Ramanujam: Some observations on the flora of the Cuddalore Sandstone Series. (12)

K. V. Poulose and S. Narayanaswami: The Tertiaries of Kerala Coast. (27)

G. Victor Rajamanickam: Heavy mineral studies of the Cretaceous-Tertiary formations of Pondicherry, South India. (44)

K. Varadarajan and P. N. Jagtap: Photogeological characters of the Cretaceous-Tertiary sediments of Trichinopoly District, Madras State. (39)

S. Sambe Gowda: Standardization of stratigraphic nomenclature of the Cretaceous and Tertiary sediments of South India. (43)

* *D. Banerjee and C. M. Misra:* Cretaceous microflora from South India. (25)

* *C. Narasimha Rao and D. S. N. Raju:* Stratigraphy and sedimentation of Miocene Rajahmundry formation, Andhra Pradesh, with special reference to sedimentary structures. (28)

5–30 p.m. TEA—by the Geological Survey of India, (Mysore Circle).

6–00 p.m. EVENING LECTURE—by *N. A. Eremenko:* "Types of Oil and Gas bearing basins of the world."

6–30 p.m. CONCLUDING SESSION.

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* Taken as read in the absence of the authors.

OPENING ADDRESS

BY

L. RAMA RAO

Chairman of the Seminar

THE PROBLEM OF THE CRETACEOUS-TERTIARY BOUNDARY

As you are all aware, the problem of the Cretaceous-Tertiary boundary is a live problem of world-wide interest and has been receiving attention for more than a hundred years. In spite of all these efforts, the problem still remains highly controversial; and it looks as though new ideas and new discoveries have often created new difficulties and seldom solved the old ones. In a paper of mine recently published (8) I reviewed the present position of this boundary problem with special reference to India and adjacent countries, and inter alia raised a number of questions for consideration in dealing with this as one of the fundamental problems in Stratigraphy. Since writing the above, I have seen some further contributions on this subject, and have also received several comments on the observations I have made and the stand I have taken in my review. In the light of all these ideas, I wish to take this opportunity of giving a reappraisal of the position in this matter, and pointing out the need for clarifying some of the traditional stratigraphical and palaeontological concepts involved in the elucidation of this problem. Such a review, I think, will also be appropriate for this occasion since this 'boundary problem' is sure to figure very largely in the ensuing discussions in this Seminar on the "Cretaceous-Tertiary Formations of South India."

Reduced to its simplest terms, the problem is merely this: where exactly do we draw the 'boundary line' in the Stratigraphical Scale between the Cretaceous and the Tertiary? Where does one end and the other begin? These questions naturally imply that there *is* a boundary somewhere between the two, and our whole problem is to decide where exactly to place it.

At the very outset, it should be noted that there are two aspects of this question; one is to recognise and locate this boundary in the Upper Cretaceous-Lower Tertiary succession in any particular area, and the other is to 'fix' this boundary in the internationally accepted 'Standard Stratigraphical Scale'. These two aspects, though similar in objective, are still, I think, fundamentally distinct, and must be tackled differently; it will not be right to think of solving one in terms of the other. In this Address I do not propose to deal with the first aspect of this work concerning the details of regional studies, although there is no doubt that the results of these investigations constitute most valuable additions to our knowledge of the Cretaceous-Tertiary transition in the concerned areas. My main object today is to deal with the second aspect of this problem viz., the fixing of this boundary line in the Standard Stratigraphical Scale.

Any attempt to tackle this problem on the basis of comparing and correlating the observations made in different areas with a view to evolve a universally acceptable solution raises a number of questions involving some of our basic concepts of stratigraphical classification and palaeontological correlation. Let us now proceed to analyse the intricacies of this question and see what exactly is the real problem. In this connection, I would like to refer to the valuable Report on "Definition of Geological Systems" (3) by the International Sub-commission on 'Stratigraphic Terminology' under the chairmanship of Hollis D. Hedberg, and published during the recent session of the International Geological Congress at New Delhi. In this short Report which really constitutes an important document, various views have been expounded which have a particular relevance to the problem we are now considering, and vis-a-vis some of the points I had raised in my own paper of 1964. I would particularly like to recapitulate here some of the statements made in this Report.

1. However, giving full recognition to the indispensable role of fossils as *guides* to the identification and delimitation of Systems, still it should also be recognised that biostratigraphic units—units bounded by the limits of the physical range of certain fossils or by other palaeontologic features —are not in themselves chronostratigraphic units, units which by definition must have boundaries which are everywhere isochronous.

2. There are a number of considerations which clearly reveal the fallacies in attempting to *require* the boundary of a System (a world-wide chronostratigraphic unit) to be defined as the upper or lower limit of occurrence of a certain fossil, fossil zone, or other palaeontologic feature.

3. In time-correlation of Systems, their boundaries, and other component Stages, no method or means should be considered as having preference over another except as its competence as an indicator of age or time equivalence may be superior in the specific case under consideration.

It is well to bear in mind the full implications of these observations and their value in rationalising our approach and outlook in dealing with our present problem of the Cretaceous-Tertiary boundary.

In any marine fossiliferous Upper Cretaceous-Lower Tertiary succession, the transition from one to the other is normally covered by the three Stages—Danian, Montian and Thanetian. The Montian and Thanetian are together considered as constituting the oldest Tertiary subdivision—the Paleocene; opinion is, however, still sharply divided in regard to the Danian. Some consider it as part of the Cretaceous, forming its youngest subdivision; others think that it is *not* Cretaceous, but belongs to the Tertiary forming part of the Paleocene; there are again some others who believe that the Danian is *not* part of the Cretaceous, it is also *not* part of the Paleocene, but is a distinct unit still undoubtedly a part of the Tertiary; and strangely enough there are some who think that there is really no stratigraphical unit like the Danian and that this term should be abandoned as 'useless' and 'superfluous.' In addition to all these varying opinions regarding the Danian, there is also the important question

as to what exactly is the Paleocene and how it is to be defined in terms of the 'Danian–Montian–Thanetian succession' on the one hand and the following Ypresian on the other.

It would naturally appear that the best way of solving the Cretaceous-Tertiary boundary problem is to study in detail the 'Danian' of Denmark (where it was first described as an independent stratigraphical unit more than a hundred years ago), and then use it as a type section for comparison and correlation with the 'Danians' of other areas; indeed this is what Rosenkrantz (9) had in mind when he said in his opening Address to Section 5 of the Copenhagen Session of the International Geological Congress 1960: "The problem of the Cretaceous-Tertiary boundary has become so involved and so wrapped up in errors, misunderstandings, and traditions that its definite settlement has become important, not least in this country where we possess the type section of the Danian".

This method of approach naturally raises the question of what exactly we mean by a 'type section' for the Danian, particularly now when rocks of similar age have been noticed and described in several other parts of the Earth; and in many of these areas, outside the region of Denmark, the rocks representing this stratigraphical position seem to be more fully developed and much better studied; even so, should we still continue to maintain that the Denmark succession constitutes the 'type section' for the Danian; or shall we select the succession in some other area which is better qualified to serve as a standard for reference and use *that* as a 'type section'. In either case, the more fundamental question is still there, does the Danian stage of any area, however complete it may be in the local stratigraphical succession, really include beds of all possible ages covering the post-Maestrichtian to pre-Montian interval in the overall Stratigraphical Scale; in other words, is any so-called 'type section' really so complete as to represent the entire Danian time? If not, it seems more reasonable, from the point of view of world stratigraphy, to reconstruct on the basis of the correlation of the Danians of all the areas a 'synthetic or generalised section' and use *this* as a hypothetical 'type section' for comparing the Danian of any given area, remembering at the same time that the period between the Maestrichtian and the Montian was perhaps a very large one, and may therefore "need the recognition of other stages in addition to the Danian to fill the gap." If we will thus broadbase our concept of a type section for the Danian, it will also be helpful in solving many questions which are now puzzling us regarding the so-called abrupt faunal 'change over' from the Upper Cretaceous to the Lower Tertiary.

As matters stand, the crux of our present problem is this: where shall we draw the boundary line between the Cretaceous and the Tertiary? Should we draw it *below* the Danian, or should it be *above* the Danian? Or in other words is the Danian Cretaceous or Tertiary? A review of the recent literature on this question shows how sharply and strongly the opinion is divided on this issue.

The arguments in favour of the pro-Cretaceous view have been cate-

gorically put forward by Eames (2) in reviewing the Discussion on the Cretaceous-Tertiary boundary at the 1960 Copenhagen session of the International Geological Congress; he concluded by saying: "All this leads me at present to no other conclusion but that Desor was right and that the Danian constitutes the last stage of the Cretaceous." In his paper read before the same session of the Congress, Yanshin (10) also put forward a number of evidences and made out an elaborate case in support of the view that (i) the Danian stage should remain within the Cretaceous system and that (ii) there is no sufficient justification for a reconsideration of Desor's original conclusion that the Danian should remain within the Cretaceous. Glaessner has also adopted the same view in his well known book—"Principles of Micropalaeontology". That this is also the considered opinion of an authoritative body of stratigraphical geologists in the U. S. S. R. is evident from the fact that in the Standard Stratigraphical Scale given by Orlov (6) as approved by the inter-departmental committee for Stratigraphy in the U. S. S. R., the Danian is shown undoubtedly as the youngest stage of the Cretaceous.

As against this view, a large volume of opinion is now growing, especially since the publication in 1957 of the well known paper by A. R. Loeblich Jr. and Helen Tappan (4) on "Correlation of the Gulf and Atlantic Coastal Plain Paleocene and lower Eocene formations by means of Plankotonic Foraminifera", in favour of the idea that the Danian is certainly not part of the Cretaceous but belongs to the Tertiary, and that this conclusion is convincingly supported by detailed biostratigraphic studies based on planktonic Foraminifera in several areas. According to these investigators, it seems that in many places a pronounced and significant palaeontological 'break' in the planktonic foraminiferal succession is noticed at the close of the Maestrichtian, so profound in its nature that it can be, or *should* be, regarded as demarkating a clear-cut 'boundary' between the Cretaceous and the following Tertiary. An important point to note in this connection is that this 'break' is generally noticed only in the case of the planktonic Foraminifera and not always in the other co-existing faunal groups. This naturally raises the question, why this "selective catastrophism" in the case of the planktonic Foraminifers alone? The answer to this has itself been the subject of much speculation, and various theories have been put forward. We are, however, not concerned with this here; but there is one general question which we may well ask at this stage about these 'palaeontologic breaks'; when we draw a boundary line on this basis, are we sure, as E. H. Rainwater (7) puts it, that ". . . . the marine faunas in the sediments above and below the boundary are really as different as they have been described? Is it not probable that taxonomists, knowing where the boundary is placed on the basis of some fossils, are finding 'different forms' above and below the boundary, when in reality they are the same."

It is impossible in this short Address to go into all the details of this boundary dispute and assess their relative merits. I have dealt with some of the intricacies of this problem in my 1964, paper (8), and would only like to add a few more words to what I have already said. From an

over-all general review of the various observations and arguments put forward in this controversy, it would appear that those who favour the 'Danian is Tertiary' view are rather overstating their case, relying only on one very restricted part of the available palaeontological evidence,—that of the planktonic Foraminifers—and giving an exaggerated importance to this evidence alone, and overlooking other collateral and relevant stratigraphical and/or palaeontological considerations. While admitting that the planktonic Foraminifers have an important part to play in biostratigraphy, it should also be remembered that they have their own limitations; and that it is not safe to rely *only* on them, overriding all other considerations, especially when dealing with beds involved in a world-wide 'boundary problem'. It is refreshing to note that this aspect is being increasingly recognised in more recent times by the foraminiferal micropalaeontologists themselves. According to Berggren (1): "Recent contributions to the knowledge of planktonic Foraminifers and their occurrence in the Upper Cretaceous-Paleocene sequences around the world have appeared with such rapidity that it appears necessary to pause and re-evaluate these and earlier works on the subject in order to clarify the taxonomic impasse to which current research is leading and to restore to these naturally useful guide fossils the integrity and proper stratigraphical value which they possess"; and there are some who have gone so far as to say that "in highly variable populations (like those of the Foraminifers) excessive splitting and resulting disagreement over nomenclature and species assignments is leading to taxonomic chaos and probably unrealistic concepts of areal distributions." A. R. Loeblich Jr. and Helen Tappan (5) have recently discussed these ideas and pointed out the 'fallacies' in such criticisms; and have tried to make out a strong case to show that the recent developments in foraminiferal systematics and classifications are all in the right direction, and are a clear indication of 'progress', and not 'chaos'.

In dealing with the present problem of the Cretaceous-Tertiary boundary in the proper perspective, the following observations made in the recent Hedberg Report (3) are of the highest value:

1. The world-wide boundary of a System cannot be defined satisfactorily as being the upper or lower limit of occurrence of some fossil form, or the upper or lower boundary of some fossil zone, or the stratigraphic position of some palaeontologic evolutionary change .... The point is that the oldest or youngest known occurrence of a certain fossil form, or the upper or the lower limit of a certain fossil zone, or the stratigraphic position of a certain palaeontologic feature, as determined in one place, does not necessarily in all other places represent the same horizon with respect to geologic time, nor does any such feature persist world-wide through all kinds of strata.

2. It should be further emphasised that a purely palaeontologic standard for a System boundary has the disadvantage of failing to provide a fixed standard of reference since the position of the palaeontologic marker may be constantly changing not only with new discoveries in fossil ranges but also with changes in taxonomic concepts.

The Report however is careful to add that these "limitations on the use of biostratigraphic boundaries as chronostratigraphic markers should in no way be considered as a 'down grading' of the role of fossils or a 'condemnation' of the palaeontologic methods, as some have feared. Rather it is an attempt to put the use of Palaeontology in chronostratigraphic classification on a sound and rational conceptual basis which will allow it to better develop its tremendous potential".

Much of what we have been discussing above is mostly in regard to the determination of a 'Cretaceous-Tertiary Boundary" in any particular area: and it is important to note that any decision that we may arrive at after considering all aspects of the available evidence can hold good for that area only, in the context of the local stratigraphical and palaeontological setting. It would not be right or proper to import these ideas bodily and use them automatically for solving similar problems in other areas. The position in the latter areas must again be considered on its own merits and a decision taken on the strength of the local evidences. Such circumspection and unbiassed judgment in each area are particularly necessary when we are dealing with a common 'boundary problem' in widely separated successions belonging to two different marine paleobiological provinces altogether, like the Tethyan and the Indo-Pacific, as in the case of the Cretaceous–Tertiary boundary. We in India must particularly remember this point and resist the temptation to jump into conclusions regarding this 'boundary' here on the basis of long distance correlations influenced by extraneous considerations imported from outside.

This brings me to the next and perhaps the most important aspect of the Cretaceous–Tertiary boundary problem in general, and that is the one dealing with the two questions—(i) does, or must a 'boundary line' really exist in all places and (ii) are all such 'boundary lines' which may be recognised in different areas bound to be strictly synchronous in geological time? The consideration of these two questions is of fundamental importance from the point of view of world stratigraphy with which alone we are ultimately concerned. I have briefly discussed both these questions in my 1964 paper (8) and will now proceed to say a few words by way of clarifying my own point of view in the matter.

Although it is true that in many places there is at some level or other some kind of a 'break' in the Upper Cretaceous-Lower Tertiary succession, the magnitude (or time span) of this break is not the same in all places; as a result of recent studies in certain areas, these 'breaks' have been narrowed down considerably almost to the point of their non-existence altogether. It is almost certain that further studies in particular areas (now known or yet to be discovered) will ultimately reveal cases where the 'change over' from the Cretaceous to the Tertiary is seen to be so gradually progressive that there is no break or boundary of any kind between the two; there is only a 'passage' leading from one to the other, a 'passage' which from one point of view belongs to both, and from another, belongs to neither. More and more discoveries of such

'no boundary' areas will be of the greatest value in world stratigraphy since the study of these what are now 'missing links' will enable us to fill the existing lacunae in our knowledge, and thus work out the complete picture of the History of the Earth.

As to the second question, whether all the boundary lines now recognised in widely separated areas are at an identical stratigraphical level and strictly synchronous in terms of the Standard Stratigraphical Scale, the answer is that they are not, and cannot be so, in the very nature of things. The border line beds—Danian, Montian, and Thanetian—were deposited in different areas under rapidly differing and varying geological facies and ecological conditions; and this is naturally reflected in corresponding variations in their relative development and mutual stratigraphical and palaeontological relationships, with the result that the 'thresholds' marking the 'cross over' from one stage to the other are not constant in their relative positions in time and/or space; they are, as it were, of a 'mobile' nature occupying different levels in different places. Under these circumstances, it is hardly possible to equate and correlate all of them to fit into a single pattern uniformly applicable to all the regions.

In conclusion, I would like to summarise the main points which I have made in this Address for due consideration in discussing the general problem of the 'Cretaceous-Tertiary Boundary'.

(1) The determination of this boundary line in any given area must be based entirely on all the evidences available in the context of the local stratigraphical setting, without importing extraneous ideas from outside, however valuable they may be *there*.

(2) This kind of circumspection is particularly necessary when we are trying to find a common boundary line in widely separated areas, and especially in successions belonging to different palaeogeographical provinces altogether like the Tethyan and the Indo-Pacific.

(3) Our main objective hereafter in studying such 'boundary problems' should be to discover more and more of the possible 'no boundary' areas, so that with their help we may eliminate all the present 'gaps' in our knowledge of Earth History, and thus ultimately fulfil the task of "Stratigraphy and Palaeontology", which is to reconstruct and present a continuous and unbroken record of geological and biological events in the course of an uninterrupted flow of geological time.

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ABSTRACTS OF PAPERS

1. BIOSTRATIGRAPHIC ZONATION OF THE UPPER CRETACEOUS FORMATION OF TRICHINOPOLY DISTRICT, SOUTH INDIA

M. V. A. SASTRY, B. R. J. RAO AND V. D. MAMGAIN
(Geological Survey of India, Calcutta)

An attempt is made in this paper to compile the available data, published and unpublished along with the authors' observations, in the form of biostratigraphic zonation of the Upper Cretaceous formations of Trichinopoly district, Madras. Based on the distribution of the commonly occurring ammonite species, nine biostratigraphic zones are recognised in the Upper Albian-Maestrichtian sequence. Data available on other fossil groups such as *Inoceramus* and planktonic Foraminifers have been compared and the stratigraphic ranges of these fossils indicated with reference to ammonite species. Certain important Indo-Pacific ammonites with limited biostratigraphic ranges are listed. The data is provisionally compiled for the purpose of interregional correlation of parts of the Indo-Pacific region.

2. TERTIARY DEPOSITS OF NEYVELI LIGNITE FIELD

N. K. BALASUNDER
(Neyveli Lignite Corporation, Neyveli)

The topography, boundaries, structures, etc., of the Tertiary deposits of the Neyveli Lignite Field and their associated formations like Archaeans, Cretaceous, Alluvium, etc., are dealt with together with their mineralogical, palaeontological and other characteristics.

This is followed by a fairly complete analysis of sequence of deposition of the Tertiaries, their subsurface structure, areal extent, and thickness together with a descriptive account of these deposits with reference to their quality, quantity, utilisation, etc.

The geo-hydrological aspects of Tertiaries with reference to their aquifer characteristics and behaviour on a regional basis are also covered in this paper.

3. ON THE BASIN STUDY PROGRAMME OF THE CRETACEOUS AND TERTIARY SEDIMENTS OF CAUVERY BASIN*

V. V SASTRI AND V. RAIVERMAN
(Research & Training Institute, O. N. G. Commission, Dehra Dun)

Authors draw attention to the different types of investigations required for a comprehensive basin study programme from the point of view of Oil

exploration in Cauvery basin. Surface, sub-surface, geophysical, geomorphological and geochemical data are considered to interpret certain important aspects of petroleum geology and suggestions are made for future lines of study. The following points are given priority in discussion :

1. Basin architecture, its evolution and the influence exerted by it on sedimentation pattern.
2. Location of fossil coral reefs and their influence on sedimentation.
3. Drainage pattern in the area surrounding the basin and its control on litho-facies.
4. Source rock characters of some of the formations.

It is indicated that Cauvery basin is formed by block subsidence along different fault lines activated during different periods. Jurassic depressions (U. Gondwana) were mainly of NE–SW trend; so also the depressions of lower part of upper Cretaceous (Uttatur and Trichinopoly). But N–S axis was established during upper part of upper Cretaceous (Maestrichtian), which continued during Tertiary periods.

By superposing the blocks of periodic subsidence, it is brought out that certain areas remained relatively more positive during the formation of the basin, which now appear as basement ridges. It is also shown that while the main direction of subsidence changed from NE–SW to N–S, basin axis as a whole shifted gradually from west towards east. Maximum depth of the basin is recognised to be of the order of 3 to 3.5 km., which is made up mostly by the Cretaceous sediments in the western part and by the Tertiary sediments in the east. This is illustrated along an east-west profile.

From the reef outcrops in Uttatur stage and inferred ancient drainage pattern, an attempt is made to infer their subsurface extension along structural hinge lines. A restricted environment with development of black shales is predicted for the central part of such basins surrounded by fringing reefs.

From geomorphological considerations, existence of two rivers fringing the western margin of the ancient basin (fore-runners of Cauvery and Ponnaiyar) are recognised and their influence in distributing clastics into the basin is pointed out. Based on drainage, structural pattern and location of reefs on the surface, a litho-facies map for Uttatur stage is prepared.

Bio-facies of different formations are considered to indicate favourable locations of prolific organic growth. Geochemical studies, still under progress, on a few shales from a well near Karaikal indicate favourable quantities of organic content for source-rock possibilities.

Importance of the hinge-lines, which often localise reservoir rocks and influence oil migration from the basin centre, is stressed in the search for oil in Cauvery basin. Study of the exposed and subsurface reefs from paleontological, petro-physical, petrological and chemical points of view are among some suggestions offered for future work.

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* The views expressed are of the authors and not necessarily of the O. N. G. Commission.

4. A RE-STUDY OF THE PONDICHERRY FORMATION

N. RAJAGOPALAN
(Geology Department, Annamalai University)

A re-examination of the planktonic foraminiferal faunas of the Pondicherry lithologic unit indicates that it is of Paleocene age only. The Lower Eocene appears to be absent in this section. *Heliolithus riedeli,* a very characteristic Thanetian nannofossil, is present in the upper marlstone unit. (Bramlette: personal communication). The discocyclinid limestone unit appears to be a facies variant of the upper marlstone in part.

5. FORAMINIFERAL BIOSTRATIGRAPHY OF THE LOWER ARIYALUR STAGE OF PONDICHERRY AND VRIDHACHALAM AREAS

RANJIT K. BANERJI [1]
(Oil & Natural Gas Commission, Dehra Dun)

The foraminiferal biostratigraphy of the marine Cretaceous strata near Pondicherry has been described in detail. The Cretaceous succession in Pondicherry, as a whole, is correlated with the Lower Ariyalur Stage of Trichinopoly, the type area, and Vridhachalam. Five minor lithologic units (named as P_1, P_2. . . . P_5) are recognised which are approximately equivalent to the lower five horizons of Warth's subdivisions (1895).

These minor litho-units are correlated with the biostratigraphic zones and subzones of the Lower Ariyalur Stage of Vridhachalam. These zones and subzones, as established by the author are: Zone A. Unfossiliferous sandstone zone (Upper Turonian) the lowermost; Zone B. *Globotruncana linneiana coronata* zone (Coniacian); Zone C. *Globotruncana concavata* zone (Santonian); Zone D, *Globotruncana globigerinoides* zone, divisible into two subzones—D_1. *Globotruncana marginata* subzone (Lower Campanian) and D_2. *Globotruncana ventricosa* subzone (Middle to Upper Campanian), and Zone E. *Globotruncana linneiana tricarinata* zone (Upper Campanian to Lower Maestrichtian). In Pondicherry, the lower two zones (A and B) appear to be absent and five litho-units (P_1—P_5) are equivalent to upper three biostratigraphic zones of Vridhachalam and they are similarly designated.

A reference has been made to the palaeo-environmental interpretation of the basin of this stage, which indicates a rather uniform open sea condition of shallow to intermediate depths in a warm tropical sea, and there is every indication of shallowing of the basin during later stage of the Lower Maestrichtian times.

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[1] This work was carried out by the author during the years 1960-64 at the Department of Geology and Geophysics, Indian Institute of Technology, Kharagpur.

6. STRATIGRAPHY OF THE CRETACEOUS ROCKS OF VRIDHACHALAM, SOUTH INDIA

D. A. RASHEED AND A. GOVINDAN
(Geology Department, Madras University)

Two lithological units namely Patti and Palkollai formations in the Vridhachalam Cretaceous area, corresponding to Blanford's older fossiliferous and younger unfossiliferous series of rocks, have been recognised. On the basis of about 60 foraminiferal species reported from the Patti formation, two foraminiferal assemblage zones—*Frondicularia-pattiensis* zone and *Globotruncana tricarinata-fornicata* zone—have been established. The age of the former is Santonian to Upper Campanian and that of the latter is Upper Campanian to Lower Maestrichtian. The age of the Palakollai formation may be Upper Maestrichtian.

7. THE AGE OF THE YOUNGEST MARINE HORIZON PRESENT IN PONDICHERRY, SOUTH INDIA

BIMAL K. SAMANTA
(Department of Geology, Calcutta University)

The Discocyclina limestone reported by Furon and Lemoine from a boring in the Pondicherry area contains abundant microfossils including several index planktonic foraminiferal species such as *Globigerina hornibrooki* Bronnimann, *Globigerina linaperta* Finlay, *Globorotalia acuta* Toulmin, *Globorotalia aequa* Cushman and Renz, *Globorotalia convexa* Subbotina and *Globorotalia imitata* Subbotina. A detailed account of these forms is provided in the present paper. On the basis of the presence of these forms the Discocyclina-bearing limestone is considered to be Upper Palaeocene-Lower Eocene in age. The previous age determination, on the basis of the occurrence of a species of *Discocyclina*, is not reliable because the identification of the discocyclines as *D. pratti* (Michelin) is not correct. The late Cuisian Nummulitic limestone, known from subsurface only, is supposed to represent the youngest marine horizon in the Pondicherry area.

8. OCCURRENCE OF MARINE PALEOCENE SEDIMENTS IN THE VRIDHACHALAM AREA, SOUTH INDIA

N. RAJAGOPALAN
(Geology Department, Annamalai University)

A siltstone from near Nachchiarpettai, about ten miles north of Vridhachalam has yielded the following foraminiferal fauna: Planktonics: *Globigerina* cf. *trivialis, G. triloculinoides, Globorotalia imitata. G.* cf. *chapmani, G. angulata, G.* sp. *Chiloguembelina midwayensis.* Benthonics:

Cibicides, Gyroidina, Eponides, Robulus, Dentalina, Osangularia, Tappanina, Buliminella, and *Pseudouvigerina.* The fauna indicates an early Paleocene age. The siltstone beds underlie the Cuddalore formation with an intervening bed of conglomerate and appear to extend for a distance of about four miles in the NE direction grading into claystones in places. The water-slaking property of this siltstone is great.

9. THE NINIYUR GROUP OF TRICHINOPOLY, SOUTH INDIA

V. D. MAMGAIN, B. R. J. RAO AND M. V. A. SASTRY
(Geological Survey of India, Calcutta)

The paper traces the development of the concept leading to the recognition of the upper fossiliferous Ariyalur beds of Blanford into a distinct unit, the Niniyur Group. These beds, considered by earlier workers as the topmost horizon in the Cretaceous corresponding to Danian, contain quite a distinct fauna whose importance in the study of the Cretaceous-Tertiary boundary problem in this area is discussed. The geographical extent and the geological boundary of this group have been delineated on 1 : 63,360 scale. Data collected from three traverses run across the formations from Nanniyur, Sendurai and Anandavadi have been presented in the form of lithostratigraphic columns and correlated.

A critical examination of the chert occurrences at Vilangudi and Kilnattam shows that these cherts are not *in situ* outcrops as considered by earlier workers which have a bearing on the extent of the Niniyurs. Some observations on the rock types of these formations are also presented in the paper.

10. THE UPPER CRETACEOUS & TERTIARY FORMATIONS OF PONDICHERRY

N. G. K. MURTHY
(Geological Survey of India, Madras Circle)

The Upper Cretaceous rocks of the Pondicherry area mark the northern limit of the sediments laid during the great Cenomanian marine transgression along the east coast of South India. They comprise hard and massive limestone, marl, sandy and calcareous shale, shell limestone and calcareous sandstone. They may be grouped into three lithological units depending on their occurrence and association, corresponding to the classification adopted by Kossmat for the Cretaceous rocks of the Pondicherry region as Anisoceras beds, Trigonarca beds and Nerinea beds. The lithology of the three units has been discussed. The Tertiary formations represented by the Cuddalore sandstones which overlie the Cretaceous beds have been described.

11. SURFACE & SUBSURFACE GEOLOGY OF THE AREA AROUND DALMIAPURAM, TRICHINOPOLY DISTRICT

J. V. SUBBARAMAN
(Dalmia Cement, Dalmiapuram)

In the quest for more limestone deposits around the Dalmiapuram Cement Factory, prospecting work carried out with the help of Calyx Core drills has brought to light many interesting geological features.

(1) The coral limestone bed found at the base of the Uttatur stage is an irregular body although it shows distinct stratification.

(2) Succeeding the coral limestones are alternating beds of low grade limestones and marls.

(3) The marls imperceptibly grade to barreen clay.

(4) Succeeding the barren clays are the gypsum clays.

(5) The limestone and gypsum beds are not directly resting upon the Archaean rocks but they lie unconformably on a bed of grey shale. A north-south trending fault has exposed this shale in one of the quarries. The exact age of this grey shale can be fixed only after studying the fossils in detail, although stratigraphically the bed may be considered as pre-Uttatur in age.

12. SOME OBSERVATIONS ON THE FLORA OF THE CUDDALORE SANDSTONE SERIES

C. G. K. RAMANUJAM
(Botany Department, Osmania University)

The plant fossils preserved in the Cuddalore sandstones of the South Arcot district, are almost exclusively represented by silicified woods. The flora on the whole is predominantly angiospermous; coniferous (Podocarpaceous) woods, however, are particularly abundant at a few localities.

Among the angiosperms, dicotyledonous families are profusely represented, the monocots consisting only of a few species of *Palmoxylon*. In the majority of cases the Cuddalore fossils are strikingly similar xylotomically to many of the modern genera.

Comparisions with the Lower Eocene intertrappean flora of the Deccan, and the Mid-Tertiary flora of Assam and W. Bengal indicate that the fossil flora of the Cuddalore series is closely related to the latter. The common occurrence of the moist loving Dipterocarpaceae and the woods referable to *Mesua, Gluta* and *Cynometron* etc., would conclusively signify that the climate during the Mio-Pliocene of the South Arcot and its surroundings was tropical with plenty of rainfall. Concomitantly the absence of these elements in the present day flora of the area indicates that since the Mio-Pliocene, the area has become drier.

A probable migratory route of the Dipterocarpaceae from Malayasia into South India via Burma, Assam, Bengal and thence southwards along the east coast, has been discussed in the paper.

13. NANNOPANKTONS FROM THE UPPER CRETACEOUS AND LOWER TERTIARY FORMATIONS OF PONDICHERRY, SOUTH INDIA

T. NARASIMHAN
(Department of Applied Geology, Indian School of Mines, Dhanbad)

With a view to gain more information regarding the chronostratigraphy of the nannoplanktons (Discoasteridae and Coccolithophoridae) from the Cretaceous-Tertiary Formations of Pondicherry, South India the present study has been undertaken. We have now available for this region, a good stratigraphic succession of characteristic planktonic foraminiferal zones which is of immense use in pinpointing the occurrence of these nannofossils in regard to their exact geologic age. Preliminary investigations of a set of twelve samples from the three important formations of the Pondicherry area, namely Valudavur, Mettuveli and Pondicherry Formations, ranging in time from Late Cretaceous to Late Paleocene have yielded the following well known forms: *Discoaster barbadiensis*, *Tetralithus gothicus*, *Tetralithus copulatus*, *Trochoaster cruciformis* and several small specimens of *Coccolithus* sp., all from Valudavur Formation *(Globotruncana gansseri* zone*); Braarudosphaera bigelowi, Coccolithus grandis, Coccolithus reticulatus, Zygolithus dubius,* and *Lucianorhabdus cayeuxi,* from the Pondicherry Formation *(Globorotalia uncinata* and *G. Whitei* zones). Detailed investigation is under progress.

14. STATISTICAL STUDY OF THE FORAMINIFERAL FAUNA FROM THE LOWER ARIYALUR STAGE OF VRIDHACHALAM AREA

RANJIT K. BANERJI[2]
(Oil & Natural Gas Commission, Dehra Dun)

Statistical analysis and interpretation are found to be useful in the study of foraminiferal fauna from the Lower Ariyalur Stage (Upper Cretaceous) of Vridhachalam. This stage has been subdivided by the author into five biostratigraphic zones and two subzones, ranging in age from the Upper Turonian to the Lower Maestrichtian. In the present work, the number of specimens constituting each species, genus, family and the total fauna has been graphically plotted to express the variation in the distribution of these forms in the different zones and sub-zones of the Lower Ariyalur Stage. The variation of the intraspecific character such as the diameter/thickness ratios of some of the commonly occurring species of *Hoeglundina* and *Cibicides* are studied. This illustrates the fact that the variation of an individual species depends mainly on its own ontogenic behaviour rather than on the environmental conditions or on its stratigraphical distri-

bution. Both the analysis of population distribution and intraspecific characters corroborate the biostratigraphic zones and subzones worked out by the author on the basis of the distribution of the planktonic and benthonic forms from this locality.

This type of statistical work is considered useful for such biostratigraphic zoning when the reliable index fossils are either meagre or absent.

The percentage distribution of several commonly occurring species of Foraminifera is found useful in the interpretation of the palaeoenvironment and the depth of the basin.

[2] This work was carried out by the author during the years 1960-64 at the Department of Geology and Geophysics, Indian Institute of Technology, Kharagpur.

15. UPPER CRETACEOUS FORAMINIFERA OF VRIDHACHALAM, SOUTH INDIA

D. A. RASHEED AND A. GOVINDAN
(Geology Department, Madras University)

Sixty foraminiferal species (of which 3 are new) belonging to 27 genera and 9 families, are reported from the Upper Cretaceous rocks of Vridhachalam. Their staratigraphical importance and distribution are discussed.

16. TRIGONAL *DISCOCYCLINA* SP. FROM THE PONDICHERRY FORMATION, PONDICHERRY, SOUTH INDIA

M. G. ANANTHA PADMANABHA SETTY
(Geology Department, Bangalore University)

A rare and unusual type of 'trigonal' *Discocyclina* sp. is noticed in the uppermost Discocyclinid limestone and the Upper marlstone units of the Pondicherry formation (F horizon—Nerinea beds—of Pondicherry area). The faunal association of this species is chiefly planktonic, and transitional from the Discocyclinid limestone unit to the Upper marlstone unit, as seen by its lesser degree of abundance. The 'trigonal' shape of the test may be due either to specialisation or degeneration in the changed conditions of the regressive phase of the Cretaceous transgression in South India. The faunal assemblage indicates a middle to outer neritic environment.

17. *GLOBOTRUNCANA* IN ARIYALUR GROUP OF TRICHINOPOLY CRETACEOUS, SOUTH INDIA

B. R. J. RAO, V. D. MAMGAIN AND M. V. A. SASTRY
(Geological Survey of India, Calcutta)

The paper briefly reviews the occurrence of the planktonic foraminiferal genus *Globotruncana* in the Cretaceous formations of Trichinopoly

district, South India. Fourteen species of *Globotruncana* have been described and illustrated from the Ariyalur beds. Based on *Globotruncana* species, two distinct bio-stratigraphic assemblage zones have been recognised. The lower zone is characterized by *G. lapparenti lapparenti, G. tricarinata, G. linneana* assemblage, whereas the upper zone is characterised by *G. contusa, G. gansseri, G. stuarti stuartiformis* assemblage. The larger Foraminifers of the Ariyalur group viz., *Lepidorbitoides, Siderolites,* etc. are restricted to the upper zone. The lower *Globotruncana* assemblage zone corresponds to the Campanian and the upper zone to the Lower Maestrichtian. The upper sandy beds of Ariyalur group containing dinosaurian remains and devoid of other invertebrate fossils, probably represent the upper Maestrichtian.

18. FORAMINIFERA FROM THE BOREHOLE SAMPLES NEAR UDAYARPALAIYAM, S. INDIA

A. K. CHATTERJI
(Geological Survey of India, Calcutta)

Certain borehole samples from near Udayarpalaiyam, Trichinopoly District about ten kilometers east of the Niniyur outcrops were examined for their foraminiferal contents. All the samples are of marlstones and contain *Discocyclina ramaraoi* Samanta, *Operculina* sp., and some miliolids which are figured and described. The assemblage suggests the age of the beds as upper Paleocene to early Eocene (Landenian-Ypresian) and are comparable to the upper marlstones of the Nerinea beds of the Pondicherry formations. This supports the view that the Niniyurs here are succeeded by beds equivalent to the Nerinea beds, and confirms the extension of the upper Paleocene-early Eocene sea south of Pondicherry, at least upto Udayarpalaiyam.

19. FOSSIL BRYOZOANS FROM THE CRETACEOUS ROCKS OF TRICHINOPOLY, SOUTH INDIA

HONNAPPA
(Geology Department, Central College, Bangalore)

The paper deals with the bryozoan species occurring in the rocks of all the four stages of the Trichinopoly Cretaceous. Fifteen forms belonging to two Orders (five belonging to Cyclostomata and ten belonging to Cheilostomata) are identified on the basis of the zooecial characters as seen in thin sections of the rock. The stratigraphic distribution of these forms in the sediments of the area confirms the existing classification based on other groups of fossils.

The forms studied are also used to interpret palaeo-ecological conditions as they existed during Uttatur-Niniyur period.

20. STRATIGRAPHY OF CAUVERY BASIN WITH REFERENCE TO ITS OIL PROSPECTS

S. RAMANATHAN
(Oil & Natural Gas Commission, Dehra Dun)

The stratigraphy of Cauvery Basin, with particular reference to the rock unit of the Tertiary sediments, as understood from the two deep wells and three structural wells drilled so far, has been dealt with. The prospects of oil, particularly in the Tertiary sediments, is likely to be more on stratigraphic traps than purely on structural traps.

The sedimentation and the distribution of sediments have been controlled probably by tectonic forces, active till middle Tertiary period.

It will, therefore, be necessary to study the trend of the ancient shorelines, as well as the stratigraphy of the sediments in the deepest parts of the various sub-basins, before sizable commercial stratigraphic pools can be located. Structural prospects, if any, are likely to be in small structures in the regional synclines.

21. STUDIES ON CRETACEOUS-TERTIARY SEDIMENTS OF CAUVERY BASIN, SOUTH INDIA

P. V. DEHADRAI AND MADAN MOHAN
(Oil & Natural Gas Commission, Dehra Dun)

Published works on Cretaceous and Tertiary sediments of Cauvery basin are available in literature. The present paper is based on an attempt to evaluate the data obtained recently as a result of extensive work carried out by the Oil & Natural Gas Commission in connection with the oil exploration programme in the region. Apart from the geological mapping of the Cretaceous-Eocene exposures in the districts of Trichinopoly and Pondicherry, two deep wells in Karaikal, one structural well at Tiruppundi and two structural wells at Pattukkottai have added much information regarding the subsurface Cretaceous-Tertiary sediments and the configuration of the basement as was unknown before. The geophysical studies have revealed the presence of four "basement highs" which controlled the deposition in this region from the early stages of the sedimentation cycle. Certain evidences point out the faulted nature of the basement which in all probability remained active at least till the close of Palaeogene period. The information obtained from two structural wells drilled at Pattukkottai has supplemented the results of geophysical work in the region and suggests that a basement ridge existed in between these two locations and this ridge, although covered with sediments, acted as a barrier even during the lower Miocene period.

22. OSCILLATORY MOVEMENTS IN THE CRETACEOUS-TERTIARY BASIN OF SOUTH INDIA

S. VENKATARAMAN AND M. K. RANGARAJU
(Oil & Natural Gas Commission, Dehra Dun)

In this paper, oscillatory movements of the entire basin during the past geological period and up to the present day have been discussed.

In the light of the above it is surmised that there is a general regression due to marginal uplift of the continent, save for two minor transgressional periods, viz. one at the close of Uttatur period and another during Ariyalur time, in the basin north of Coleroon river.

On the other hand a prominent transgression during Tertiary is noted in the basin south of Coleroon. However, during the later part of Tertiary, regressional aspect came into play in the northern part of the basin.

Areas where continuous transgressional facies is likely to have developed are the Devipatam-Rajasingamangalam basin and Cauvery graben. These areas deserve full investigation for their oil prospects.

The oscillatory movements along the Andhra Coast have also been discussed.

23. FAUNAL ASPECTS AND THE EVOLUTION OF THE CAUVERY BASIN

A. K. DUTTA AND T. S. BEDI
(Oil & Natural Gas Commission, Dehra Dun)

The present paper deals with the evolution of the Cauvery Basin with special reference to the total faunal aspects of the region. It is shown that the distribution of sediments and fauna was controlled by the topography of the basin which was not a continuously sloping floor. Details of the several transgressive and regressive phases in the sedimentary succession have been worked out. On the basis of these studies the authors favour the drawing of the Mesozoic-Cenozoic boundary at the base of the Niniyur Stage.

24. EOCENE-OLIGOCENE PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY OF CAUVERY BASIN, SOUTH INDIA

D. S. N. RAJU
(Oil & Natural Gas Commission, Dehra Dun)

Sixty species or subspecies of Eocene-Oligocene planktonic Foraminifera from the subsurface rocks were encountered in wells drilled by Oil and Natural Gas Commission near Karaikal, Thiruppundi, and Pattukkottai.

The following planktonic foraminiferal zones are established. They are in ascending order: *Globorotalia rex* zone, *Globorotalia palmerae-Globorotalia formosa formosa* assemblage zone for the Lower Eocene; *Globigerina frontosa-Globigerinoides higginsi* assemblage zone, *Trucorotaloides topilensis-Globorotalia lehneri* assemblage zone, *Porticulasphaera mexicana* zone, *Truncorotaloides rohri* zone for the Middle Eocene; *Globigerinathecka barri* zone, *Turborotalia carroazulensis* zone for the Upper Eocene and *Globigerina ampliapertura ampliapertura—Chiloguembelina cubensis* assemblage zone for the Lower-Middle Oligocene.

The coiling characteristics of common spacies of planktonic Foraminifera are also studied.

The environmental conditions of deposition of sediments have been inferred on the basis of both benthonic and planktonic foraminiferal populations.

25. CRETACEOUS MICROFLORA FROM SOUTH INDIA

D. BANERJEE AND C. M. MISRA
(Oil & Natural Gas Commission, Dehra Dun)

While studying samples from a well drilled near Karaikal, a vast amount of Cretaceous palynomorphs have been recorded. A brief account of these is given in the paper. Some of the important forms recorded are *Osmundacidites* sp., *Trilobatur* sp., *Lygodiumsporites* sp., *Cicatricosisporites* sp., *Callialasporites* spp., *Alisporites* sp., *Podocarpidites* sp., *Abietinaepollenites* spp., *Microcachryidites* ap., *Aquillapollenities* sp., *Palmaepites* sp., *Nymphaeaceaepites* sp., *Monocolpites* sp., *Tricolporites* spp., etc. This assemblage is comparable with Upper to Middle Cretaceous forms recorded from various parts of the world, viz., Australia, Canada, Western India, etc. From the assemblage it is inferred that the vegetation was not nearshore and was of a temperate to subtropical, warm and humid nature growing in marshes as well as fresh-water lakes or ponds. Saccate grains suggest a more or less elevated topography which supported a temperate to subtropical gymnospermous vegetation. Hystrichosphaerids are very rare in occurrence.

26. YOUNG CENOZOIC MARINE OSTRACODA FROM SUBCROPS OF SOUTH INDIA

D. K. GUHA
(Oil & Natural Gas Commission, Dehra Dun)

Thirty species of Ostracoda belonging to twenty-three genera are recorded from Lower Miocene and Pleistocene subcrops of South India.

The Lower Miocene Ostracodes are described and listed from the wells drilled at Karaikal, Thiruppundi, and Pattukkottai, in the Cauvery basin. They comprise twenty-one species including one new species of *Hemicythere cauveriensis* and one new variety, *Aurila chaasraensis robusta*. Nineteen of these Lower Miocene Ostracodes have been described earlier from Lower Miocene (Gaj beds) of Kutch, Western India.

Nine species of Ostracoda from a marine sequence in the Thiruppundi well referred to Pleistocene are illustrated and listed. The species are comparable to Plio-Pleistocene and Recent Ostracoda described from Sumatra, Java and Philippines.

The primary purpose of this paper is to present the rich Cenozoic Ostracoda from South India of which very little is known. The stratigraphy and Foraminifera from these beds have been presented in separate papers. The yield of Ostracoda from the Paleogene sequence of the wells studied is very poor, and only a few specimens of *Paracypris*, *Bairdia*, *Schizocythere* and *Brachycythere* are recorded.

27. THE TERTIARIES OF KERALA COAST

K. V. POULOSE AND S. NARAYANASWAMI
(Geological Survey of India, Kerala Circle)

The Tertiaries of Kerala coast comprise chiefly: (1) the 'Quilon Beds' consisting of fossiliferous limestones, carbonaceous clays, sandy clays and sands, and (2) the 'Warkalli Beds' consisting of variegated sands and clays, white plastic clays and carbonaceous clays with lignite, succeeded by sub-Recent shell-bearing sands, clays and silts.

The geographical distribution of the formations reveals two major basins of deposition (1) from Trivandrum to Ponnani, and (2) from Cannanore to Manjeshwar, with a protrusion of the gneissic platform between Calicut and Tellicherry. From faunal evidence, the age of the 'Quilon Beds' has been considered by previous workers to be Lower Miocene (Burdigalian) to Upper Miocene (Vindobonian), though the upper age limit of the overlapping hitherto unfossiliferous 'Warkalli Beds' may be doubtfully Mio-Pliocene.

The general lithology, stratigraphic overlaps and spatial distribution of the beds suggest that the 'Warkallis' are shallow water littoral deposits, semi-contemporaneous with the marine lagoonal deposits of the 'Quilons' under somewhat oscillating stable shelf conditions.

28. STRATIGRAPHY AND SEDIMENTATION OF MIOCENE RAJAHMUNDRY FORMATION, ANDHRA PRADESH, WITH SPECIAL REFERENCE TO SEDIMENTARY STRUCTURES

C. NARASIMHA RAO
(Dept. of Geology and Geophysics, Indian Institute of Technology, Kharagpur)
AND
D. S. N. RAJU
(Oil & Natural Gas Commission, Dehra Dun)

The Miocene Rajahmundry formation is exposed near Rajahmundry, Andhra Pradesh. On the basis of lithology the formation has been divided into five distinct members in order of age: Basal conglomerate and sandstone; Pidungoyya ferruginuous sandstone; Bommuru intercalated sandstone and clay stone; Dowleswaram sandstone, and laterite. The sedimentary structures encountered in the various members include prolific cross-bedding, channel cuts and fills, ripple marks, mud cracks, contemporaneous deformational structures, intricate intertonguing of various lithological units, which are in themselves lenticular in character.

The basal conglomerate is oligomictic; the individual sandstones are coarse grained, well sorted orthoquartzites. Evidences have been put forward to consider the basal conglomerate as a deposit formed during marine transgression. The rest of the members are thought to have been deposited under valley flat conditions nearer to the delta. A statistical study of the cross-bed directions indicates a southerly direction of the transport system.

29. CRETACEOUS-TERTIARY BOUNDARY IN THE PANGADI AREA WEST GODAVARI DISTRICT, ANDHRA PRADESH

S. N. BHALLA
(Geology Department, Muslim University, Aligarh)

The Cretaceous-Tertiary boundary in the Pangadi area, Andhra Pradesh, is discussed in the light of foraminiferal evidence obtained from the infra-trappean beds exposed in the region. The Foraminifera, though poor in number and frequency of species, indicate the prevalence of a shallow marine inner-neritic condition of sedimentation. The assemblage favours a Palaeocene age for these infra-trappean beds. On this basis, the overlying flows of the Deccan Traps are regarded to be of early Eocene age.

30. SOME SIGNIFICANT FEATURES OF THE DECCAN TRAP

L. V. AGASHE AND R. B. GUPTE
(Geology Department, Engineering College, Poona)

During recent geological field work and engineering geology investigations in some of the Deccan Trap areas, the basalts and associated formations were found to possess many hitherto unsuspected characteristics. The ideas of horizontality, uniformity and extensive lateral extent of the basalt flows are found to be true to a limited extent. Irregular flows with considerable local dips, flows covering small areas, and lateral variation in the lithological character of a flow are frequently seen. These features along with the volcanic vents, ropy lava and volcanic breccias found at many places suggest that central type of volcanic activity also took place in the Deccan Trap period. Some unusual types of basalt like porphyritic basalt with giant phenocrysts of plagioclase up to 6 cm. in size were also noticed.

Basic dykes were found to be common in many areas supposed to be dyke-free. The red boles considered upto now to be formed by baking of soil by the heat of the upper flow, show many features that suggest that they are products of atmospheric weathering, and baking is not essential for their formation.

31. FAUNA & FLORA OF THE INTERTRAPPEAN BEDS OF GURUMATKAL AREA, GULBARGA DISTRICT, MYSORE STATE

D. RANGAIAH
(Geology Department, Central College, Bangalore)

A preliminary study of the inter-trappean beds around Gurumatkal covering an area of 260 sq. km. has revealed the occurrence of rich fauna and flora. The beds, consisting of conglomerates, sandstones, clays and cherts, vary in thickness (maximum being 16 metres) and are exposed all along the 2000 ft. contour.

The floral assemblage consists of seeds of *Magnolia linnaeus, Nipa burtini* (internal casts with a groove corresponding to an infold of the endocarp), *Ginkgo* and *Pithonella;* flower remains of *Magnolia linnaeus* and the stem of Cycadeoidea (the last varying in size from a foot in diameter to about 5 ft). Algal remains of *Lithothamnion, Chara* and *Batrocospermum* are also found.

The faunal assemblage consists of the following gastropod species: *Lithobius* sp. *Conus adversarius, Rimella* sp. *Neritina compacta, N. carolina,* and *Physa pleuromatis.*

From the above mentioned fauna and flora it is concluded that (1) the inter-trappean beds were deposited in fresh water, (2) that these sediments are of Eocene age and (3) that the inter-trappean beds of both the Gurumatkal and Nagpur-Chhindwara areas are of the same age.

32. SOME RESULTS OF GEOPHYSICAL EXPLORATION OVER THE CRETACEOUS-TERTIARY FORMATIONS OF THE MADRAS COAST

L. N. KAILASAM
(Geological Survey of India, Calcutta)

The results of recent gravity, magnetic and seismic investigations conducted by the Geological Survey of India in the coastal sedimentary belt of Madras State are presented in relation to the Cretaceous-Tertiary deposits of this region.

The geophysical data indicate a thickness of the order of eight to ten thousand feet of sediments near the sea coast and have brought out some prominent structures associated with the basement in the Porto Novo, Karaikal and Tirutturaipundi areas. The data further suggest that the sedimentary belt of the Madras Coast consists broadly of three basins designated as the South Arcot, Tanjore (Cauvery) and Ramnad Basins, respectively, which are separated by buried ridges of the pre-Cambrian crystallines branching out towards the sea coast from the main peninsular mass.

In the South Arcot Basin, the seismic data clearly bring out the unconformity between the surface Cuddalore (Mio-Pliocene) formations and the underlying Eocene strata. The Cuddalores have a synclinal base with a maximum thickness of the order of 2000 feet in the central portions of the South Arcot Basin, as indicated by the seismic data.

In the Tanjore basin, the Cretaceous rocks are apparently restricted to the western parts of the basin, to the west of the shallow north-south Adiramapatnam-Mannargudi ridge indicated by the gravity data. This appears to be corroborated by the results of drilling recently carried out by the Oil and Natural Gas Commission in the Pattukkottai and Karaikal areas.

In the Ramnad Basin further to the south, the seismic data indicate a shallow basement in the western and central parts of the basin with a thicker sedimentary section over the shores of the Palk Strait. A thin Miocene section is indicated, underlain presumably by Eocene strata in the coastal parts of this basin.

The results of some bore holes drilled for ground water in these areas are also appended.

33. A GRAVITY PROFILE ACROSS THE NORTHERN PART OF CAUVERY BASIN

D. DAS AND S. N. SENGUPTA
(Oil & Natural Gas Commission, Dehra Dun)

The bouguer anomaly along a profile in the northern part of Cauvery Basin has been analysed in the light of probable basement relief, the

differences in densities of different basement blocks, as well as variations of densities within the sediments.

Qualitatively, all the gravity 'highs' and 'lows' appear to be due to uplifts and depressions in the crystalline basement. The sharp gravity gradients are suggestive of faults in the basement which might or might not have affected the overlying sediments. In the quantitative interpretation, the method of gravity-stripping has been applied. Laboratory measurements were made of densities of different types of crystalline and sedimentary rocks exposed on the west and also those found in Karaikal Well Nos. 1 and 2. The base of the Neogene and Paleogene sediments along the profile has been assumed by projecting the seismic data in the neighbourhood of the profile. Assuming that there are two crystalline basement blocks on the parts of the basin crossed by the profile, the western block consisting of charnockite, gneiss and schist of density 2.84, and the eastern block of granite with density 2.62, the gravity effects due to variations of thicknesses of Neogene (density 2.00) and Paleogene (density 2.26) sediments have been computed with the help of two dimensional graticule. From the residual anomalies, the thickness variations of the Cretaceous sediments (density 2.48) have been computed using the formula for infinite slab and the probable geological cross-section is presented. A more rigorous method involving the use of graticule is then applied for computing the thickness of Cretaceous sediments and the resulting cross-section is also shown.

In interpreting the gravity data of the Cauvery Basin, in addition to the basement relief, account has to be taken of the possible density differences of the basement blocks and the variations of densities within the sediments.

34. GRAVITY AND MAGNETIC ANOMALY PATTERN ON THE CRETACEOUS AND YOUNGER FORMATIONS OF THE GODAVARY VALLEY, ANDHRA PRADESH

V. N. DEEKSHITULU
(Oil & Natural Gas Commission, Dehra Dun)

The salient features of the gravity and the magnetic anomalies of the Godavary valley situated in the area bounded by latitudes 16° 0′ N and 17° 15′ N and east of longitude 81° 0′ E up to the coast and their disposition have been described. The coincidence of the anomaly zones with the geological features and formations is pointed out. It has been shown how some features on the gravity and the magnetic maps of the Godavary delta can be attributed to the tectonics and the geological movements of the region,

The extension of the Deccan Trap, the possibility of finding the Cretaceous and the Tertiary formations in the subsurface near the coast and off-shore, and the prospects of the area for hydrocarbon accumulations are discussed.

35. CONFINED TERTIARY AQUIFERS OF NEYVELI LIGNITE FIELD

N. K. BALASUNDER
(Neyveli Lignite Corporation, Neyveli)

An account of the Tertiary formations of this area with special reference to the confined aquifers associated with them is given.

This is followed by a detailed description regarding the aquifers, their geological and hydrological characteristics, nature, behaviour, etc.

The recharge and discharge phenomena of the confined aquifers and their behaviour on large scale pumping operations are also dealt with to the extent the present investigation has revealed.

36. ON THE MINERAL RESOURCES AND GEOLOGY OF THE CRETACEOUS AND TERTIARY ROCKS OF SOUTH INDIA

A. K. DEY
(Planning Commission, New Delhi)

In South India, the Cretaceous and Tertiary sediments have undergone extensive erosion and little deformation since their deposition. The sediments, so far as could be judged from superficial examination, do not hold much promise of yielding significant oil or gas production. The possibilities of finding commercial accumulation of oil and gas in the offshore regions cannot be known without geophysical investigation.

Apart from the Deccan Trap lava flows there has been no igneous activity permitting deposition of ore bodies in South India while the lavas themselves present little evidence of differentiation to produce magmatic ore deposits. They, however, provide excellent building stones and road metals.

The phosphatic nodules, gypsum, etc. found associated with the Cretaceous rocks in the Trichinopoly-Pondicherry sector are not sufficiently concentrated into large economically workable deposits.

With the retreat of the Eocene sea, the coastal regions of Madras and Kerala, were extended during the Miocene epoch, producing swampy flats on which coal-measure forests spread. These have given rise to lignite, which in the absence of any other suitable mineral fuel, is exploited only at Neyveli.

As Tertiary marine deposits are found only along the coast, the present outline of South India had been pretty well established during the late Tertiary period. The deposits are, however, scattered and difficult to align stratigraphically.

In the Quilon Limestone bed in Kerala, the percentage of living molluscan species is about 33.55. The fauna has been assigned to the Vindobonian age mainly on account of the discovery of *Taberina mala-*

barica (Carter), the most characteristic fossil of the Quilon bed, at the type locality of the Gaj series. This species may have a little wider range than hitherto known as it has also been found in fossiliferous strata apparently underlying the Quilon Limestone. M. Cossmann referred Karaikal fauna to the Pliocene; but the fauna contains about the same percentage of Recent molluscan species as the Quilon bed. It would be interesting to know if the Oil and Natural Gas Commission have found *Taberina malabarica* in their exploratory bore holes.

37. ROCK PHOSPHATE DEPOSITS IN THE CRETACEOUS ROCKS OF SOUTH INDIA

B. LASKAR AND A. S. NARASIMHAN
(Geological Survey of India, Calcutta)

The paper records the results of detailed investigations for the location of phosphatic deposits within the Cretaceous-Tertiary succession of Pondicherry, South Arcot and Trichinopoly districts. These studies have revealed the occurrence of important deposits in the Trichinopoly district only; the deposits in the other two districts are found to be unworkable.

In the Trichinopoly district, in an area of 27.52 sq, km. extending from Neykulam in the south to Sirukambur in the north, and including in it the lower and middle substages of Uttatur, a distinct zone of phosphatic nodules is recognised. Detailed prospecting upto a depth of 50 feet has revealed that the occurrence of nodules does not bear any relation to depth.

The probable reserve of phosphatic nodules in the Trichinopoly district is estimated to be about 127,000 tons to a depth of 50 feet; and the P_2O_5 content varies from 21.14 to 26.50% (44 to 57% B. P. L.).

38. EOCENE BITUMINOUS LIMESTONE FROM THE PONDICHERRY AREA AND ITS SIGNIFICANCE

S. SAMBE GOWDA
(Pool Officer, C. S. I. R., Department of Mines & Geology, Bangalore)

The Eocene limestone, met at depths between 150 and 180 metres in a well in the region of Usteri tank, is found to be bituminous. Since bituminous Eocene limestone is known to occur in the Cauvery Basin at shallow depths as in the Pondicherry area, the present discovery is considered as of some importance in the exploration for hydrocarbons in the Cauvery as well as Pondicherry Basin. After taking into consideration the nature of occurrence of bitumen in the limestone from Pondicherry, all the questions relating to its origin and association are considered and discussed.

The reasons for assuming the limestone to be reservoir rock are given.

The changes in the development of sedimentary succession in the area north of Coleroon river during Eocene are deduced from the study of the limestone.

39. PHOTOGEOLOGICAL CHARACTERS OF THE CRETACEOUS TERTIARY SEDIMENTS OF TRICHINOPOLY DISTRICT, MADRAS STATE

K. VARADARAJAN AND P. N. JAGTAP
(Oil & Natural Gas Commission, Dehra Dun)

The paper is based on the observations and interpretations made on the aerial photographs. Different aerial photo characters like tonal differences, drainage and erosion patterns, vegetation and soil characteristics were taken into consideration to determine the different rock types and to subdivide the sedimentary strata into nine distinct photogeological units. They correspond roughly to the well known subdivisions of the Cretaceous-Tertiary sediments of the Trichinopoly area.

Linear trends, mostly in East-West to North East-South West directions, are clearly seen in the air photos. These linears indicate that there are many basement faults in the down-dip area to the east where they may act as fault traps for oil accumulation.

Subsurface ridges in the East-West and North-South directions have been detected by the photogeological study. These subsurface ridges might have controlled the sedimentation in general and the reefoidal growth in particular. It is normal to expect such ridges in the deeper part of the basin also where stratigraphic pinch-outs against them might trap hydrocarbons.

40. *HERCOGLOSSA DANICA* AND THE CRETACEOUS-TERTIARY BOUNDARY IN SOUTH INDIA

S. S. SARKAR
(Geological Survey of India, Calcutta)

Hercoglossa danica is known as an important index fossil of Danian in Europe, Asia and Africa. Many palaeontologists and field-geologists have so long depended entirely on the evidence of this species occurring in India to establish an international stratigraphical correlation or to draw a Cretaceous-Tertiary boundary. The author however felt the need for critically examining the Indian specimens of this species before following the traditional practice.

The author has reviewed the literature on this subject and compared the Indian specimens of *'danicus'* with the European figures of *danicus* as supplied by Lyell (1835) and does not consider the Indian specimens to be *danicus*. They might belong to an allied species. Therefore, to base the

Cretaceous-Tertiary boundary any further, on the evidence of this Indian '*danicus*' is not sound.

41. A NOTE ON THE CRETACEOUS-TERTIARY BOUNDARY IN SOUTH INDIA

G. W. CHIPLONKAR
(Poona)

In view of the mixture of Cretaceous and Tertiary aspects of the fauna found in the Danian strata in many regions, they were considered as constituting 'passage beds' between the Cretaceous and the Tertiary systems. With increasing attention that is being devoted to the microfossils, such as foraminifers, algae and ostracods, there has been a tendency to treat the Danian as the lowest member of the Tertiary and to push back the Cretaceous-Tertiary boundary to the top of the Maestrichtian.

It has, however, to be borne in mind that though some important elements of early Tertiary foraminifers are present in the Danian, the general aspect of the fossil assemblages is such that the Cretaceous elements cannot be overlooked. One has also to keep an open mind to see if any strata yet younger than the Danian as hitherto known but not quite Paleocene are identifiable, and see what evidence is available in support of Rama Rao's idea of Creocene.

While investigating the position of such border line strata, one should be on guard against the possible mistakes in the correlation of strata across inter-continental distances on the basis of only some foraminiferal key species.

So far as South India is concerned, the author feels that exposures of the Niniyur beds and the apparently conformable Mettuveli-Pondicherry Limestone succession need careful and dispassionate investigation.

42. PALYNOLOGICAL EVIDENCES ON CRETACEOUS-TERTIARY BOUNDARY

A. K. GHOSH
(Calcutta University, Calcutta)

The Upper Cretaceous represents a period of time covering the transition as it were from the Mesozoic Gymnospermous flora to the modern Angiospermic types. Considerable data is available on the evidences of algae from South India; and in recent times, some beds on the Cretaceous-Tertiary boundary not only of South India but also of other parts of India have been dated on palynological evidences.

From the point of view of phytogeography, common elements have been traced in the Mesozoic and Cenozoic of Western Siberia, Australia and

New Zealand. Lack of palaeobotanical data from Mesozoic of India does not permit the establishment of the probable migration of the floral elements from some intermediate tropical region in order to explain the existence of common elements in the flora of Western Siberia and Australo-New Zealandian region.

The role of *Classopollis, Podocarpus, Nothofagus,* pollen of Palm and *Proteacae, Pediastrum* (alga), *Microthyriaceae* (fungus), etc., in elucidating some of the interesting problems in stratigraphy, phytogeography, and palaeoecology is discussed.

43. STANDARDIZATION OF STRATIGRAPHIC NOMENCLATURE OF THE CRETACEOUS AND TERTIARY SEDIMENTS OF SOUTH INDIA

S. SAMBE GOWDA
(Pool Officer, C. S. I. R., Department of Mines & Geology, Bangalore)

After a brief reference to the internationally accepted modern definitions of stratigraphic units of different orders, some stratigraphic units of the South Indian Cretaceous and Tertiary sediments have been examined to know whether they are valid or not in terms of those definitions. The scope and limitations of following the standard procedures such as the selecting of type localities and stratotypes, and adhering to the rule of priority in the classification of the sediments of the region are pointed out. Some suggestions are made to make the nomenclature more rational and acceptable.

Based on the earlier field observations made by Blanford and also on the recent observations made by the author, appropriate new names for some stratigraphic units are proposed for consideration.

44. HEAVY MINERAL STUDIES OF THE CRETACEOUS-TERTIARY FORMATIONS OF PONDICHERRY, SOUTH INDIA

G. VICTOR RAJAMANICKAM
(Geology Department, Annamalai University)

A study of the heavy minerals of the three lithologic units—Valudavur, Mettuveli and Pondicherry, shows that there is a distinct change in the heavy mineral suite from the Mettuveli to the Pondicherry lithologic unit. Zircon and rutile which are characteristically present in the Pondicherry Formation are totally absent in the Valudavur and Mettuveli. The Cretaceous-Tertiary boundary is thus definable in terms of the heavy mineral assemblages.

Garnet which is common in all the above three formations is absent in the overlying Cuddalore Sandstones.

45. BAGH BEDS—THEIR FAUNA AND AFFINITIES WITH THE SOUTH INDIAN CRETACEOUS FORMATIONS

K. K. VERMA
(Geological Survey of India, Hyderabad)

The paper records the results of the detailed study of a rich assemblage of fossils, invertebrates and vertebrates, recently made by the author from the Bagh Beds exposed at and in the neighbourhood of Limdi, Moti Chikli, Mongra and Khasru in the Amba Dongar area, south of Baroda District, Gujarat State.

A notable feature of this collection is the rich assemblage of fossil shark fauna which is either identical or closely related to that occurring in the Uttatur and Ariyalur stages of the Cretaceous of South India. On the basis of this study it is suggested that there is a close faunal relationship between the Bagh Beds and Cretaceous rocks of South India. The probable passage for intermingling of the two faunas has been suggested.

The classification and the faunal studies of the Bagh Beds are also reviewed in the light of the present studies. The age relationships and affinities of Bagh Beds with the Cretaceous of South India and other parts of the Gondwanaland are discussed in detail, with the help of palaeogeographic maps.

A tentative correlation of the Bagh Beds with South Indian Cretaceous, with reference to the Standard (European) Scale, is also given.

46. SOME OBSERVATIONS ON THE CRETACEOUS DINOSAURS OF INDIA

K. N. PRASAD
(Geological Survey of India, Hyderabad)

The occurrence of dinosaurian remains from the Lameta beds of Jubbalpore, Pisdura, Takli and Ariyalur has been reviewed. Among them is found *Titanosaurus* which is found in India, Madagascar and Europe only. Results of the study of recently discovered sauropodian remains from Umrer, Nagpur district are also presented.

The age of the dinosaurian remains from Jubbalpore and Pisdura and those of the Ariyalur stage of the Trichinopoly area is discussed. A picture of the then existing dinosaurian provinces of India is attempted. The Jubbalpore and Ariyalur fauna may represent two different life provinces, the former showing affinities with the fauna of Madagascar and the latter probably with Australia. Reasons for the mass mortality of the dinosaurs in the Indian region are given.

Charts showing correlation and distribution of the Cretaceous fauna are also included. Suggestions are made for future planning of the studies of dinosaurian remains in India.

47. MARINE TRANSGRESSIVE SEDIMENTARY FORMATIONS OF SOUTHERN INDIAN PENINSULA AND THEIR RELATION TO THE DECCAN TRAP IGNEOUS ACTIVITY

S. V. L. N. RAO
(Indian Institute of Technology, Kharagpur)

The Archaean formations are well represented in the southern part of peninsular India. These are all formed in different geosynclinal basins. The Paleozoics are not observed, and in the Mesozoic era (also in the Cenozoic era) along the coastal belt, outcrops of sedimentary formations are to be noticed primarily deposited in a marine transgressive environment.

The author is of the opinion, that the marine transgressions were a result of intense crustal activity which has by itself resulted in Deccan trap volcanism towards the end of the Mesozoic era.

48. THE UPPER CRETACEOUS-PALEOCENE SUCCESSION OF MADAGASCAR

M. COLLIGNON
(France)

The paper deals with the study of the Upper Cretaceous of Madagascar and the present state of our knowledge regarding its passage to the Paleocene.

A detailed description is given of the Maestrichtian, Danian and Paleocene formations of Madagascar, together with the list of characteristic macro- and microfossils found in each and compared with those of India. The paper concludes with a tabular statement showing the correlation of the Upper Cretaceous and Lower Tertiary succession of Madagascar with that of India based on these studies.

The problem of the passage from the Cretaceous to the Tertiary in Madagascar is most interesting, and in the present state of our knowledge, it has not been entirely solved inspite of extensive recent researches.

49. THE TERTIARY/CRETACEOUS BOUNDARY

F. E. EAMES
(England)

The consideration of the stratigraphy and stratigraphical palaeontology of the Danian stage in its type area in N. W. Europe indicates that the Danian stage belongs to the Cretaceous system and that the fauna of the Danian has strong Cretaceous affinities. Successions covering the interval, top Maestrichtian to Upper Paleocene in India are referred to briefly from the point of view of the ages of the various beds concerned.

50. THE PROBLEM OF THE CRETACEOUS-TERTIARY BOUNDARY

T. MATSUMOTO
(Japan)

In recent years, the problem of the Cretaceous-Tertiary boundary has been discussed from various lines of evidence obtained in different areas of the world. Many of the specialists have concluded or at least been inclined to conclude, that the Danian is to be ascribed to the lowest Time-Stratigraphic Unit of the Tertiary and the Maestrichtian to the uppermost Cretaceous. The problem, however, has not been thoroughly solved. There are several points requiring further careful scrutiny; and these have been indicated in the paper.

The Indian region occupies the critical position in correlating the sediments of the Indo-Pacific with those of the Tethys marine realm, the marine ones with the continental, and also the sediments with the igneous rocks.

51. LATE CRETACEOUS AND EARLY TERTIARY CORRELATIONS IN THE INDO-PACIFIC REGION

B. MCGOWRAN
(Australia)

The occurrence of Maestrichtian and Paleocene strata in an arc extending from West Pakistan to New Zealand is reviewed. A general correlation is attempted using relatively well established planktonic foraminiferal zone sequences as the main standard. Some new data are incorporated, mainly from a Maestrichtian to Lower Eocene section on the Gaj river, West Pakistan, and the Paleocene of Australia. Maestrichtian and middle to upper Paleocene faunas are more widespread than faunas of intermediate age; the Danian appears to have been a time of general regression in this region.

INVITED ADDRESSES

Summaries

TECTONICS AND PETROLEUM POSSIBILITIES OF SOUTH INDIA

N. A. EREMENKO
(Dehra Dun)

The sedimentary areas occupy only a small portion of the Indian peninsula and measure 32,000 sq. km. in the south-eastern and about 10,000 sq. km. in the south-western parts (lying to the south of the latitude of Bangalore). The major part of the peninsular region is occupied by highly metamorphosed rocks and cannot be considered favourable for oil and gas prospects. There is, however, no doubt that the peninsula is girdled by sedimentary basins, having sufficiently thick sequence, like, for example, the Cauvery basin. The sedimentary sequence in the Cauvery basin consists of Mesozoic, Paleogene, and Neogene rocks. The occurrence of Mesozoic rocks in the west coast basin is still an open question.

The tectonic framework of these sedimentary basins cannot be explained without the knowledge of the main (shield) part of the Indian peninsula. Uptil now, unfortunately, the work regarding the tectonic frame work of the Indian peninsula including the sedimentary basins has not been completed. The first stage of work only has been initiated in this direction in the Cauvery basin based on all available seismic, gravity, magnetic, geological survey and drilling data. This tectonic scheme has got important significance in deciding the plan of exploration-development for oil and gas in the basin. The time of movements of these different basement blocks is of maximum importance. Practical application of these questions will lead to the decision of the time of formation of the structures in the overlying sedimentary sequence, the traps, and oil and gas pools.

The famous geologists of India, like Krishnan and others postulated the time of development of continent-forming fault along the east coast of India at the end of the Gondwana times. This supposition seems sufficiently convincing. There is at the same time, no doubt, that the movements also took place during later as well as earlier periods. The geological data from the exposed part of the basement corroborate the evidences of the earlier movements, whereas those of the later movements are supported by the geological investigations from the sedimentary part of the basin and geomorphological considerations from all over the southern part of the peninsula, including the off-shore regions. It is easily noticed that the system of fractures, delineated on the exposed part of the basement and continuing into the sedimentary basin, has some definite trends. The reactivation of movements along these differently trending fractures, undoubtedly, seems to have taken place at different times. It is interesting to note that the time of development of continent-forming faults along the eastern and western coasts is considered to be different.

If along the east coast, as stated earlier, it developed during the end of the Gondwana times, the west coast fault is dated to be Neogene.

Thickness and the facies of the sedimentary sequences and the tectonic peculiarity of the sedimentary basins flanking the Indian peninsula confirm their petroleum prospects. Besides, there are oil and gas shows in these regions; unfortunately the data are very scanty. Only doubtful occurrence of seepages is known along the western coast.

Summing up, it can be stated that there is good hope for finding some oil and gas fields in the sedimentary basins girdling the southern part of the Indian platform.

GEOPHYSICAL ASPECTS OF THE CRETACEOUS-TERTIARY BASIN OF SOUTH INDIA

M. B. RAMACHANDRA RAO
(Bangalore)

I deeply appreciate the opportunity given to me to speak in this Seminar. My active interest in the Cretaceous-Tertiary region of South India started in the year 1954 when the Government of India decided to undertake Oil Exploration. Dr. Krishnan set a task for Shri L. P. Mathur and myself in Geological Survey of India to draw up on the large scale Geological Map of India, the limits of the several areas where Oil Exploration has to be carried out and suggest their relative importance. We did this in a preliminary way, indicating a low priority for the Cauvery basin. My feeling was that Dr. Krishnan was not too happy that we relegated such a low priority to thls area. Perhaps he had a hunch that Tertiary sediments could be of considerable extent there. Very soon, he directed that we should take up a gravity survey there using the new Worden Gravimeter we had received then. Shri L. N. Kailasam was deputed for this survey and he initiated the investigations in the lignite area and made some progress. He did commendable work even with such limited equipment and resources available in that Department. In fact, his contribution brought to light the magnitude of the sediments there and the indications of structure which are likely to be favourable for oil prospects.

Although the Russian, German, French and other foreign experts visited this region and recommended oil exploration by ONGC, the Commission had committed its resources to the then priority areas viz. Rajasthan, Punjab, Ganga Valley and Assam. Even the exploration of Cambay basin came in later, after the geophysical results obtained by Geological Survey of India in the previous years, were verified by drilling. A few years later, the Commission decided to take up work in the Cauvery basin; and Shri Kailasam's results had, in the meantime, forcibly focussed attention in this area.

It would be vain for me to dwell at length on the progress of geophysical surveys in this region as I am out of date with information. Shri Sen Gupta is giving some results of a Gravity profile study. Messrs. V. V. Shastri, Dehadrai, Ramanathan and others of the ONGC are presenting papers comprehensively dealing with the geological aspects absorbing also the import of the geophysical studies. The offshore seismic investigations in the Bay of Bengal and Palk Strait are said to have furnished some interesting indications and that the subsurface structure near Karaikal is likely to extend to about 25 kms. into the sea. The first deep test well drilled at Karaikal has revealed only traces of oil. The results of the drilling of other wells in the area are to be watched with interest. It is to be borne in mind that apart from basement heights or anticlinal structures, there are possibilities of finding stratigraphic traps and reefoidal features in the region which may be explored for oil. A detailed exploration of this basin may take many years. An accelerated programme of exploration and development will naturally follow when a commercially workable oil or gas field is found. It is very difficult for anyone to foretell the prospects of finding workable quantities of oil in this region. Some think that this basin, being a continental type, the prospects may not be bright. My own belief is that such pre-conceived notions are not always valid. In any case, those notions do not cheer up those whose responsibility it is to put in the money and the effort needed for a proper assessment of the prospects based on tangible drilling. The Cambay basin is a standing example of how preconceived notions came in the way of that region being tackled properly for many years. There is no substitute to drilling, taking calculated risks. Anyway, if success comes in the Cauvery basin, we shall all be happy; otherwise there is the satisfaction that the prospects have been ascertained and valuable geological information has been gained.

Reverting to the geophysical aspects, I recollect that when I had a look at the gravity and magnetic maps of the Cauvery basin, I was struck by the manner in which they indicated three old embayments of the sea into the crystallines, though on the surface a vast continuous stretch of sediments is seen. A gravity high was also indicated at Karaikal. The seismic work done later has further strengthened this feature. In Cambay also, the gravity and magnetic results gave us the first indications of the subsurface structure. The Nahorkatiya structure in Assam was also originally indicated in the gravity surveys. I am stressing this not because gravity indications mean specifically oil bearing structures, but that we have found in India how the preliminary reconnaissance gravity-cum-magnetic surveys are useful in oil exploration. Gravity studies by themselves cannot furnish answers to the subcrustal features. Coupled with deep seismic investigations, we are likely to get more reasonable data. United States of America and U. S. S. R. especially, are carrying out such deep seismic investigations. A beginning in this direction is yet to be made in India. Perhaps, it is difficult to find the resources, financial and equipment, for such a project at present.

I may add a few words regarding the Cretaceous-Tertiary unconformity. In the results of the seismic surveys, and of the subsurface data, I have seen relating to West Bengal, Assam, Cambay and the Cauvery basin, there is no unconformity stratigraphically, which is marked or clearly identifiable. In West Bengal, the passage from the Tertiary to the Cretaceous below is almost imperceptible. I am not much acquainted with the palaeontological and palynological evidences. This Seminar will undoubtedly help throw light on this question which has become of world-wide interest. Certain ideas get entrenched as scientific gospels, but when fresh evidences or new discoveries turn up, they become untenable. This has happened many a time. Anyway, the data provided by geophysical surveys and drilling have added a new dimension, viz. of subsurface data, which can bring a little light on some of the broader aspects of our stratigraphic problems. The progress of such subsurface investigations has to be watched and integrated by geologists who have comprehensive knowledge of Geology as a Science, apart from the specialised branches. Geologists of this type who have all-India comprehension, are already scarce in our country, and it is greatly to be hoped that some of the younger geologists will take up this trend and maintain India's reputation.

AGE OF THE DECCAN TRAPS OF KUTCH

W. B. METRE
(New Delhi)

Wynne who carried out the earliest geological work in Kutch (1872) in association with Fedden, had originally assigned an Eocene age to the stratified traps and the associated intertrappean beds of Kutch. However, in the "Manual of the Geology of India" (1879) the stratified traps were given an Upper Cretaceous age and the overlying sub-Nummulitic and Gypseous shales were correlated with the Ranikot series of Kutch. Since then, very strong evidence for the early Eocene age of the Deccan Trap has been put forward by B. Sahni, L. Rama Rao, Raj Nath, Hora and others. Since various workers still seem to be inclined, following earlier publications, to refer to the Deccan Traps of Kutch as being of Cretaceous age, it seems necessary to draw the attention of this Symposium to the additional evidence which has since become available to indicate that the bulk of the Deccan Trap in Kutch is probably of early Eocene age.

On general considerations we may assume that the Cretaceous/Trap junction in Kutch is unconformable. From recent studies in the Kutch and Cambay areas, it seems quite clear that the lava flows in Kutch and Gujarat were deposited during the pre-Laki period. No beds similar to the Lower Ranikot of Sind are represented in Kutch. However, from the available evidence it is clear that the stratified traps show consider-

able thickening in the southern direction, from the Laki range to Kutch, and that the latter are the homotaxial representatives of Lower Ranikot of Sind. It can be presumed that the strong eruptions which probably started simultaneously over a large area continued in Kutch over a longer period. It seems most likely that the bulk of the Deccan Trap in Kutch and also the northern part of Gujarat was erupted and deposited during early Eocene period (mainly Lower Ranikot or Early Paleocene).

CONCLUDING SESSION

The Concluding Session of the Seminar was held at 6-30 P.M. on 9th June 1966, with Sri B. Rama Rao, President of the Society, in the Chair.

At the outset, Prof. L. Rama Rao, Chairman of the Seminar, gave a brief account of the proceedings of the session and expressed his thanks to the members of the Steering Committee for all the help they had rendered in organising the Seminar, He specially referred to the valuable surface and subsurface studies being conducted in these regions by the officers of the Geological Survey of India and the Oil and Natural Gas Commission, many of whom were actually present to communicate their papers and participate in the discussions—thanks to the kindness of the Heads of the two organisations who were good enough to depute their officers for this purpose. These recent investigations, he said, have yielded excellent material for further studies, the results of which would be most valuable both from the economic and scientific points of view, and expressed the hope that these studies will soon be actively undertaken.

A number of the visiting delegates then gave their impressions of the work of the Seminar, and all of them were unanimous in their appreciation of the arrangements made for the conduct of the session, and the high standard of the papers presented at the meetings. The delegates who spoke are (i) Sri M. V. A. Sastry (Geological Survey of India, Calcutta), (ii) Sri V. V. Sastri (Oil and Natural Gas Commission, Dehra Dun), (iii) Dr. Budhadeb Biswas (Esso Oil Co., Calcutta), (iv) Dr. B. K. Samanta (Calcutta University) and (v) Sri V. Gopal (Madras State Geological Survey).

Dr. B. P. Radhakrishna, Secretary of the Society then reviewed the work of the organisation of the Seminar and expressed the sincere thanks of the Society to all those who had individually or collectively extended their whole-hearted co-operation in making all the arrangements in regard to the accommodation for the visiting delegates and their comfortable stay here, as also for the conduct of the Seminar meetings and public lectures everyday.

On behalf of the visiting delegates, Sri W. B. Metre (New Delhi) spoke in high appreciation of the excellent arrangements made for the Seminar throughout. He conveyed the special thanks of all the delegates to the Director, Dr. B. P. Radhakrishna and his colleagues in the Department of Mines and Geology, for their co-operation in providing all the required facilities for holding the meetings in their premises and thus largely contributing to make the Seminar a great success which it was, from all points of view.

In his concluding remarks Sri B. Rama Rao spoke about the work of the Seminar and its importance and expressed his pleasure in seeing that the entire Session had gone off so smoothly and satisfactorily, thanks to the co-operation extended by the local members and the visiting delegates alike.

The following resolutions were then moved from the Chair and carried with acclamation:

Resolution 1: This meeting of the Seminar on the 'Cretaceous-Tertiary formations of South India' wishes to place on record its deep sense of appreciation and gratitude to the Director-General, Geological Survey of India for permitting officers of the Survey to contribute papers and participate in the proceedings of the Seminar.

Resolution 2: This meeting of the Seminar on the 'Cretaceous-Tertiary formations of South India' wishes to place on record its deep sense of appreciation and gratitude to the Chairman of the Oil and Natural Gas Commission for permitting officers of the Commission to contribute papers and participate in the proceedings of the Seminar.

Resolution 3: This meeting of the Seminar on the 'Cretaceous-Tertiary formations of South India' held under the auspices of the Geological Society of India resolves to place on record its deep sense of appreciation and gratitude to the Department of Mines and Geology, and through the Department to the Government of Mysore, for according permission to hold the Seminar in its premises and providing all facilities for making the Seminar a success.

The proceedings concluded with the singing of the National Anthem.

PROCEEDINGS OF THE SEMINAR—A REVIEW

In concluding this brief account of the Seminar, we will now proceed to give a short review of its deliberations, so as to present an over-all picture of some of the interesting and significant results which have emerged from these recent studies. It may be mentioned at the very outset that the Proceedings of the Seminar were throughout at a high scientific level. This was due to the fact that many of the geologists who are actively engaged in this work were present at the session to present their papers and participate in the discussions; and it was evident that their contributions were all based on very detailed studies, both in the field and in the laboratory.

It was only natural that the three Cretaceous areas in South India—the Trichinopoly, the Vridhachalam and the Pondicherry—figured very prominently in the Proceedings. During the last few years it is becoming evident that many of the ideas put forward by Blanford more than a hundred years ago in regard to the classification and correlation of these formations have to be revised. To collect the necessary data for such a comprehensive revision, the Geological Survey of India has recently initiated a project for the regular mapping and sample collection from the main Trichinopoly area. The first results of such a study were presented to the Seminar, in a paper (1) dealing with a possible biostratigraphic zonation of the Cretaceous succession in this area based on Ammonites. Such biostratigraphic studies are welcome since they may be expected to lead to a revision of our current notions regarding the classification of these beds into the Uttatur, Trichinopoly and Ariyalur groups, and their correlation in different parts of the region. The occurrence of certain fossiliferous grey shales below the Uttaturs reported (11) from certain core samples in the Dalmiapuram area is of some interest and needs immediate attention. Further investigations may lead to more discoveries of each pre-Uttatur beds in this coastal belt affording further support to the view "that the so called Cenomanian transgression in this region commenced long before Cenomanian times". The series of papers on the foraminiferal biostratigraphy of the Ariyalur division of the Trichinopoly area and its equivalents in the Vridhachalam and Pondicherry areas (5, 6, 14, 15 and 17) with special reference to the important species of *Globotruncana*, were very valuable contributions embodying investigations on recognised modern lines; further studies of this kind will undoubtedly be of the greatest value in the regional correlation of these Campanian-Maestrichtian beds. Not much reference, however, was made in the Seminar papers to the description and importance of the Orbitoids and *Siderolites* recently noticed in these beds. There is an abundance of this excellent material now available, of which only a preliminary account has been published so far. These constitute an important part of the foraminiferal assemblages in all the three areas, and it is hoped that their study will soon receive the attention which they deserve.

The Niniyur group which was first defined and demarcated as a distinct stratigraphic unit of Danian age in the Trichinopoly succession in the year 1936, also came in for consideration in the Seminar (9), and it was mentioned that the flint and chert occurrences near Vilangudi are not *in situ* and as such have no stratigraphical bearing on the former extent of the Niniyurs. The flints and cherts of the Niniyur group including those near Vilangudi were first described as far back as 1934; and in the light of the observations recorded there, the present conclusion that the Vilangudi cherts have nothing to do with the Niniyur requires re-examination. In view of the special importance of the Danian vis-a-vis the problem of the Cretaceous-Tertiary boundary, the fossils of the Niniyur group, especially its Foraminifers, require a full examination to decide whether it really forms the youngest part of the Upper Cretaceous succession here or belongs to the Lower Tertiary, especially in view of the fact that a distinct Paleocene horizon has now been recognised in the Vridhachalam (8) and Pondicherry (4, 7) areas. The fact that some Lower Tertiary beds immediately above the Maestrichtian have been noticed in all these areas, makes it clear that in this region, we have fine opportunities for studying the transition from the Cretaceous to the Tertiary and recognising a possible boundary between the two. The Seminar has served a most useful purpose in highlighting this aspect, and it is now necessary to actively pursue further studies in this most fruitful and fascinating line of research. It was rather strange that throughout the proceedings of the Seminar, there was no reference to the fossil Algae from these rock formations. There is no doubt that of the hundreds of sections of limestones from these beds which have been examined for their foraminiferal contents, many would also contain plenty of algae side by side; but these have evidently been neglected. With such abundant material readily available, it is time that we concentrate our attention on its detailed study which will undoubtedly yield results of the highest value to the stratigraphical geologist and the palaeobotanist alike.

In a region like the South Indian Cretaceous where surface exposures of beds are thin, few, and far apart, the importance of getting to know subsurface successions cannot be over emphasised. An important step in this direction has been taken by the recent geophysical investigations and drilling operations in this region. The results of geophysical explorations over the Cretaceous-Tertiary formations of the Madras coast in general (32) conducted by the Geological Survey of India indicate that this sedimentary belt consists broadly of three distrinct basins. The more recent geophysical investigations carried out by the Oil and Natural Gas Commission (33, 34) have further added to our knowledge of these subsurface sediments and their basement configuration. The Commission has actually chalked out an extensive and comprehensive programme of studies in the Cauvery basin; and from the preliminary account of this work which was presented to the Seminar (3), there is no doubt that these investigations will ultimately yield most valuable results—especially in regard to oil finding in this area. Two of the papers presented by the geologists of the ONGC, (20, 21) were of outstanding interest from the

stratigraphical point of view. Geological mapping of the Cretaceous-Eocene exposures in the Trichinopoly and Pondicherry areas, supplemented by the succession revealed by the recently drilled deep well sections in Karaikal, Tiruppundi and Pattukkottai have added considerably to our knowledge regarding the subsurface Cretaceous-Tertiary sediments in these areas and their basement configuration.

An important point that has emerged from these and other recent studies in the South Indian region is that there is in many places quite a good succession of Paleocene-Eocene beds overlying the Upper Cretaceous series; and a large amount of excellent sample material of these rock formations is now available. It is urgently necessary to examine these collections in detail—especially from the micropalaeontological point of view. A co-operative effort in this direction is now required and this will certainly yield results of the highest scientific importance, not only in regard to our knowledge of the Cretaceous-Tertiary transition in this region, but also in regard to the general and more fundamental problem of the 'Cretaceous-Tertiary Boundary.'

The Deccan Traps also came in for a certain amount of notice in the Seminar. Attention was drawn (30) to the occurrence of some unusual types of porphyritic basalt, with giant phenocrysts of plagioclase, associated with the Traps, and to the several evidences indicating that the 'central type' of volcanic activity also took place in the Deccan Trap period. There was also a brief account of a fossil collection from the inter-trappean bed at Gurumatkal (31); and when fully studied these may be expected to throw more light on the exact age of the adjacent traps. The foraminiferal evidence indicating a Paleocene age for the Pangadi infra-trappean beds near Rajahmundry referred to in one of the papers (29) was valuable, in further supporting the view that the Deccan Trap formation as a whole is Tertiary in age.

In regard to the later Tertiary formations of South India, the flora of the Cuddalore sandstone series has been receiving attention within recent years, and the detailed description and identification of some of the fossil woods from these beds (12) add much to our knowledge of the flora of those days. The Tertiaries of the Kerala coast have been known for quite a long time, but not much work has been done so far, on their stratigraphy and fossils. The paper (27) dealing with the mode of origin and age of the 'Warkalli' and 'Quilon' beds which form important members of this succession was therefore a valuable contribution.

During the discussions on the various papers read before the Seminar, it was evident that there was an urgent need for the standardisation of stratigraphic nomenclature of the Cretaceous and Tertiary sediments of South India; and some concrete suggestions were actually made (43). The Seminar was of the view that steps in this direction should be taken as soon as possible as a co-operative project on the part of the leading geologists and geological institutions in India.

The four papers contributed by the leading overseas geologists constituted a valuable part of the proceedings of the Seminar and served to

remind us of the fact that the local studies with which the Seminar was immediately concerned had a much wider value in understanding the stratigraphical and palaeontological problems connected with the Cretaceous-Tertiary transition as a whole. The papers by Collignon (France) and McGowran (Australia) on the " Upper Cretaceous-Paleocene succession of Madagascar" and "Late Cretaceous and Early Tertiary correlations in the Indo-Pacific region" respectively were of stimulating interest; and the contributions by Eames (England) and Matsumoto (Japan) on the problem of the Cretaceous-Tertiary boundary in general, threw further light on the discussion of this most controversial problem of world-wide interest, in the study of which India is in a position to make a positive contribution.

Another valuable feature of the Seminar was the series of three "Invited Addresses" given by the senior geologists of the country with a wide knowledge and experience of the concerned rock formations—one on "Tectonics and Petroleum possibilities of South India" by N. A. Eremenko, the second on "Geophysical aspects of the Cretaceous-Tertiary basin of South India by M. B. Ramachandra Rao, and the third on "Age of the Deccan Trap of Kutch" by W. B. Metre. These addresses presented an over-all review of the present position in the relevant fields of study, which would serve as a useful background in planning further programmes of work.

On the whole, it was evident that the Seminar was a very useful "get-together" of all the active workers in the field on the Cretaceous-Tertiary formations of South India and provided an excellent opportunity for them to compare notes and exchange ideas. The numerous papers read before the Seminar have provided the most valuable 'raw material', as it were, which after proper integration and processing, will undoubtedly provide plenty of new ideas for rewriting one of the most interesting chapters in the geological history of India—dealing with the Cretaceous-Tertiary period.

L. Rama Rao.

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