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WORKSHOP: COMPARISON OF THE CUDDAPAH BASIN, INDIA
AND THE ADELAIDE GEOSYNCLINE, AUSTRALIA

Report of overseas visit - January, 1981

by

K.A. Plumb

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CONTENTS

TABLES

FIGURES

APPENDIXES

1. Seminar on Integrated Resources Survey and Evaluation, Programme.
2. 4th Workshop on Status, Problems and Programmes in Cuddapah Basin, Programme.
3. The Cuddapah Basin. Highlights of its Geology and Mineral Resources, by C. Karunakaran.
4. The Cuddapah Basin - A Review of Basin Development and Basement Framework Relations, by Y.G.K. Murty.
5. A Bird's Eye View of some Recent Geological and Geophysical Work in the Cuddapah Basin and Related Conceptualisations, by V.S. Krishnaswamy.

INTRODUCTION

Three Australian scientists* visited India in January, 1981, to attend the "4th Workshop on Status, Problems and Programmes in Cuddapah Basin", at the National Geophysical Research Institute (NGRI), Hyderabad, and to participate in a field trip to the Cuddapah Basin, with a view to comparing the Cuddapah Basin with similar Proterozoic basins in Australia.

The program is summarized in Table 1.

The visit was funded under the India/Australia Science and Technology Agreement. This involved the provision of return air-fares from Australia to India by the Australian Department of Science and Technology, and the provision of all accommodation and internal travel within India by the Indian Government.

TABLE 1 - PROGRAM

January	6	-	Canberra - Melbourne - Singapore - Madras
"	7	-	Madras - Hyderabad
"	8	-	NGRI, GSI, Hyderabad
"	9	-	Hyderabad - Anantapur
"	10-16	-	Fieldwork in Cuddapah Basin
"	16	-	Anantapur - Bangalore
"	17	-	Bangalore - Mysore - Bangalore
"	18-19	-	Bangalore - Hyderabad
"	20-21	-	Seminar on "Integrated Resources Survey and Evaluation"
"	22-23	-	4th Workshop on "Status, Problems and Programmes in Cuddapah Basin"
"	24-26	-	In Hyderabad
"	27	-	Hyderabad - Madras
"	27-28	-	Madras - Singapore
"	28-29	-	Singapore - Sydney - Canberra.

*Dr B. Daily, The University of Adelaide
K.A. Plumb, BMR
D. Clark, Division of Mineral Physics, CSIRO

SEMINAR - INTEGRATED RESOURCES SURVEY AND EVALUATION

... We were invited to attend this seminar before the Cuddapah Basin workshop. The program of papers is attached.

The seminar was multidisciplinary and covered all resources. Most papers involved the use of remote sensing, particularly Landsat. India possesses its own receiving and processing facility, and the main aim seemed to be the encouragement of integrated regional surveys for several resources so that 1) the interrelationships of various resource needs could be seen; 2) duplication of effort could be reduced by concurrently utilising those routine aspects of remote sensing data analysis which are common to several types of survey.

This theme was excellently stated by the Director of the National Remote Sensing Agency (Wg. Cdr. Rao; a non-scientist), but seemed to be ignored by many of the scientists who spoke later in the program. Most speakers were academics and tended to be theoretical rather than practical. Many rehashed elementary well-known principles. Others presented abstract models which seemed to have little application.

4TH WORKSHOP ON STATUS, PROBLEMS AND PROGRAMMES IN CUDDAPAH BASIN

... The original proposal specified a special workshop to compare the Adelaide Geosyncline and Cuddapah Basin. In practice, it turned out to be the above meeting. The program of papers is attached.

The meeting was conducted by the Institute of Indian Peninsular Geology. The Institute seems to comprise simply a management committee, charged with integrating all of the research by NGRI, Geological Survey of India (GSI), and universities, on the Precambrian of Peninsular India. There is a similar Institute of Himalayan Geology in Delhi. There is no permanent staff or building. Day-to-day management is carried out by NGRI through its Director, who is also Hon. Director of the Institute.

The main activity of the institute seems to be these annual workshops, which are designed to review progress, consider new research proposals, and solicit government support.

The meeting was simply a formal presentation of numerous very short papers; lack of time prevented many being presented at all. Even as specially invited speakers, time was short for our reviews, and time for discussion almost nil. We were the only people to try to compare the Australian and Indian data.

A very large proportion of the Indian papers, particularly the major reviews, were almost identical to those presented at previous workshops. The others were largely of local interest only and difficult to absorb.

All papers will be published in full.

FIELD TRIP TO CUDDAPAH BASIN

This was a special trip for the Australian delegation. The program is detailed in Table 2, the stratigraphy in Table 3, and localities in Figure 1.

The Cuddapah Basin is about 350 km south of Hyderabad; about 8 hours drive. We stayed throughout in Anantapur, which is about 40 km WSW of Tadipatri, just outside the area covered by Figure 1. This involved considerable travel each day and severely restricted effective work. Important areas east of Cuddapah were quite out of reach. The aim of the field trip was to allow Brian Daily and myself to see the stratigraphy of the basin, and to allow David Clarke to collect palaeomagnetic samples.

TABLE 2 - DETAILED PROGRAM, CUDDAPAH BASIN FIELD TRIP

January	10	-	Archaean basement and dykes, basal conglomerate of Cuddapah Basin succession, near Anantapur.
"	11	-	Chitravati and Papaghni Groups in Tadipatri area.
"	12	-	Chitravati and Papaghni Groups near Pulivendla.
"	13	-	To Cuddapah. Some Papaghni Group. Attempt to see contact Nallamalai Group with Chitravati/Papaghni Groups.
"	14	-	To Banganapalle. Chitravati, Papaghni, and Kurnool Groups.
"	15	-	Detailed section through Vempalle Formation, Chitravati Group, near Pulivendla.
"	16	-	Kimberlite pipes near Anantapur.

GEOLOGY OF THE CUDDAPAH BASIN

The Cuddapah Basin is a mildly to moderately deformed Proterozoic platform cover, overlying the Archaean basement rocks of the Peninsular Shield. It covers about 35 000 km^2, in an arcuate structure 360 km long by up to 150 km wide. The maximum thickness at any point is about 6 km.

The stratigraphy is summarized in Table 3 and the general geology in Figure 1. We spent most time in the Papaghni and Chitravati Groups, and did not see the Nallamalai Group at all (Table 2).

A remarkably accurate geological survey of the basin by Oldham, Foote, and King in the 1860's, and published by William King in 1872, has provided the main geological framework of the basin. Subsequent surveys have really not changed the picture very much; King's map has still been the basis of most of NGRI's work. GSI commenced a new survey in 1967, with the aid of air photos, and presented a new map at 1:250 000 scale in December, 1979 (10 years for the equivalent of 5 of our 1:250 000 sheets). This map is still in press and, although it has revised the stratigraphic correlations and relationships in places, has changed King's map remarkably little.

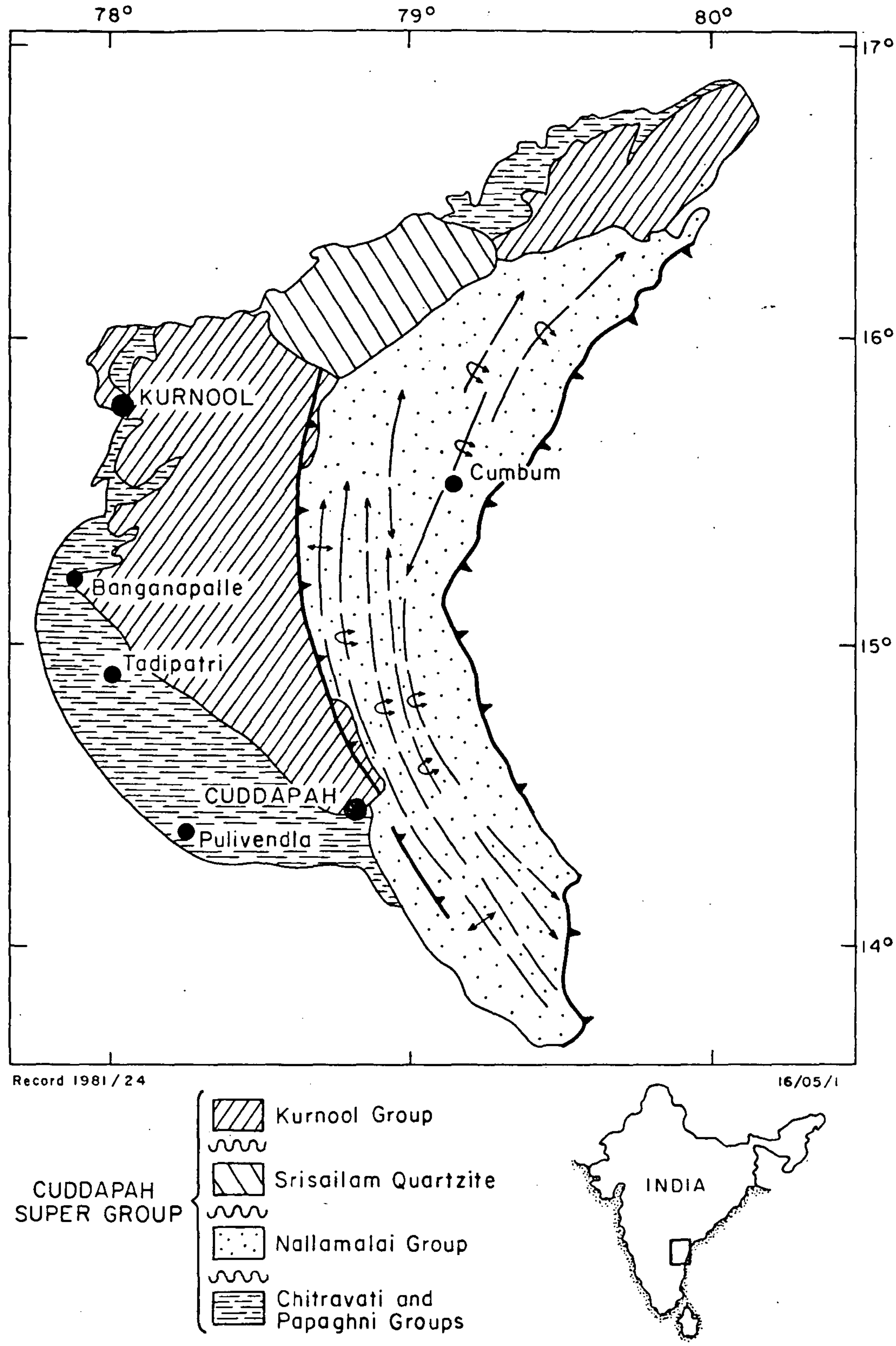

Fig. 1 Locality sketch map, Cuddapah Basin

TABLE 3 - SUMMARY OF STRATIGRAPHY, CUDDAPAH BASIN

Unit & Thickness			Unit	Description
KURNOOL GROUP 500 m			Nandyal Shale 50-100 m	Not seen
			Koilkuntla Limestone 15-50 m	Not seen
			Paniam Quartzite 10-35 m	Cross-bedded orthoquartzite
			Auk Shale 10-35 m	Laminated black & grey shale
			Narji Limestone 100-200 m	Black stylolitic limestone
			Banganapalle Quartzite 0-57 m	Pebble conglomerate & sandstone
			UNCONFORMITY	
CUDDAPAH SUPERGROUP 6000 m±			Srisailam Quartzite 600 m+	Not seen
			UNCONFORMITY	
	NALLAMALAI GROUP	2500 m	Cumbum Formation 2000 m	Not seen. (Shale, phyllite, quartzite, dolomite)
			Bairenkonda Quartzite 1500 m	Not seen
			UNCONFORMITY	
	CHITRAVATI GROUP		Gandikota Quartzite 1200 m	Alternating glauconitic sandstone & red-brown siltstone
			Tadipatri Formation 4600 m	Grey-green shale. Flaggy sandstone, stromatolitic limestone 4600 m includes thick dolerite sills
			Pulivendla Quartzite 1-75 m	Fluviatile cross-bedded sandstone. Some amygdaloidal basalt
			DISCONFORMITY	
	PAPAGHNI GROUP		Vempalle Formation 1500 m	Stromatolitic dolomite; flaggy buff dolomite, red siltstone, red-brown sandstone
			Gulcheru Quartzite 28-250 m	Fluviatile cross-bedded sandstone & conglomerate
			EPARCHAEAN UNCONFORMITY	
ARCHAEAN BASEMENT			Dolerite dykes	Several ages
			"Eastern Ghats"	Charnockite, khondalite, schists, granite, migmatite; 3100-450 m.y
			Dharwar Supergroup	Greenstone belts; 2600-2500 m.y.
			Peninsula Gneisses	Felsic gneiss, granite; 3000-2600 m.y.
			Sargur Schists	High-grade greenstone belts; >3000 m.y.

Age

Crawford and Compston (J. geol. Soc. Aust., 19, 1973) have dated lavas from the Papaghni Group as older than 1555 m.y., and possibly as old as 1700 m.y. An isotopic resetting occurred at about 1360 m.y.; perhaps associated with the major pre-Nallamalai unconformity. Post-Nallamalai diatremes and granites place a minimum age on that group of about 1225-1140 m.y. The widespread dolerites intruding the Cuddapah Supergroup are 980 $\pm$ 110 m.y. old, which places a lower limit on the base of the Kurnool Group. Absence of tillites from this group suggest a minimum age of about 800 m.y. or more for this group.

Thus, the main part of the Cuddapah Basin sequence is much older than the Adelaidean, and the Papaghni-Chitravati Groups fall in the same general "ball-park" as the McArthur Basin. The Kurnool Group is equivalent to only the lower part of the Adelaidean, at best.

The Cuddapah Basin does not seem to correlate directly with other major Indian sequences, such as the Vindhyan.

Tectonic Setting

The Cuddapah Basin is an epicontinental platform cover overlying an Archaean basement. The basement contains two major tectonic zones. To the west is a cratonic zone, comprising the Peninsula Gneisses and several greenstone belts of the Dharwar Supergroup and older Sargur Schists (Table 3). To the east is a mobile belt, the "Eastern Ghats"; part of the well-known charnockite belt of India and Ceylon. This belt is a polymetamorphic belt, subjected to successive episodes of medium to high-grade (granulite) metamorphism between 3100-450 m.y. ago.

In the basement, we only saw representatives of the Peninsula Gneisses, and younger intrusive granites. The most impressive feature is the extreme compositional uniformity of the gneisses over hundreds of kilometres; it is difficult to imagine them being metasedimentary. The other feature is very well-developed and exposed dolerite dykes, several ages of which intruded the craton before the Cuddapah Basin was developed.

The Cuddapah Basin itself contains two distinctive tectonic belts (Fig. 1); the boundary between them corresponds to that between the underlying basement belts, just described. The western block is mildly deformed, with flat-lying Kurnool Group unconformably overlying gently-dipping Chitravati and Papaghni Groups. The eastern belt contains tightly overfolded and overthrust Nallamalai Group rocks. There is almost no overlap between the depositional belts of these sequences; they virtually represent quite separate basins, with the younger thrust over the older (Fig. 1).

Stratigraphy

The Gulcheru Quartzite is a typical basal fluvial conglomerate and sandstone, in which pebbles may be identified from Archaean greenstone belts. It passes up into the carbonate-rich Vempalle Formation.

The Vempalle Formation is the best exposed sequence we saw, and occupied most of my interest. It comprises interbedded stromatolitic dolomites, bedded buff dolomites, and red-bed-type siltstones and sandstones; typical of the facies of much of the McArthur Group. In fact, it resembles the McArthur Group much more closely than any other sequence I have ever seen outside of North Australia. I spent considerable time examining the stromatolites which, superficially, are very like some typical McArthur forms, but expert study is required for confirmation. We discovered evaporites for the first time: halite casts, cauliflower cherts, and solution-collapse breccias. I suspect that gypsum is there too, but we could not locate any.

The overlying Chitravati Group, in turn, resembles the Roper Group. Pulivendla Quartzite may be compared with Limmen Sandstone. Tadipatri Formation grading up into the glauconitic Gandikota Quartzite resembles the Mainoru Formation-Crawford Formation-Abner Sandstone, although limestone is more prominent in the Indian sequence and mica, so typical of the Roper Group, is absent.

These analogies need not imply time correlation; I have noted similar parallels in basin evolution in the much older Transvaal Basin of South Africa.

The Kurnool Group is a fairly normal sandstone-shale sequence, with little of note. Daily carried out a search for fossils, which might have allowed correlation with the Adelaidean, but without success.

Stratigraphic Relationships

The Nallamalai Group is much more deformed than the older Papaghni and Chitravati Groups, and has widespread cleavage development. This is apparently anomalous to some people, but can be explained by the fact that the Nallamalai Group overlies the eastern mobile zone, while the older units overlie a craton. The stratigraphic relationship is crucial, so we attempted to confirm it.

From Figure 1 it can be seen that a straight stratigraphic contact apparently occurs only in a short belt near Cuddapah. There is clearly a marked angular discordance between the units here, but the question arises whether it is an unconformity or flat-dipping thrust.

Attempts to reach the contact on the ground were thwarted by time. Several efforts to interpret air photos of the contact were foiled by government policy which restricts access to air photographs, apparently a defence policy, and a considerable hindrance to both our work and the local geologists.

One can only assume that the relationship is correct. It is certainly the easiest interpretation of the available 1:250 000 map, assuming that the mapping is correct. The interpretation requires that the increase in deformation and metamorphism takes place rapidly, over a short distance.

Mineral Deposits

The Cuddapah Basin contains a variety of mineral deposits, most of them small. We did not actually see any of them.

Barytes: This is the principal resource. A recently discovered deposit at Mangampeta (near Cuddapah) has reserves of 75 million tonnes (not stated whether tonnes $BaSO_4$ or tonnes ore) of bedded barytes in tuffs of the Cumbum Formation.

Many small deposits occur in veins and fractures at the contact between dolerite sills and Vempalle Formation.

Asbestos: Chrysotile is mined at several localities from veins formed at the contact between dolerite sills and dolomites of the Vempalle Formation.

Base metals: Several small deposits of Pb-Zn or Cu are known from the Cumbum Formation and, to lesser extent, the Vempalle Formation. Individual deposits are a couple of million tonnes or less. Grades are mostly less than 1%. Deposits are generally strata-bound, but also seem to have some structural input as well.

Diamonds: This region was the major gem producer of the world for centuries before the South African pipes were discovered. The Kohinoor stone immediately comes to mind. Most were recovered from gravels, but there was some ancient mining of kimberlites. A more interesting occurrence is from fluvial conglomerates in the Banganapalle Quartzite (Table 3). Banganapalle employed thousands of miners centuries ago, and virtually none of the rock has been left in situ. This occurrence indicates a Precambrian diamond source, confirmed by 1225-1140 m.y. isotopic dates of pipes.

GSI is carrying out active exploration for kimberlite pipes; mostly geophysical search for non-outcropping pipes. We saw both exposed pipes and totally covered discoveries. Pipes occur both within the Cuddapah Basin and within the basement. Results of tests of diamond content are not known.

Limestone: As well as being a popular building stone (regular flaggy parting), the Narji Limestone is a source of both cement and blast-furnace-grade lime. Flux-grade limestone is also developed secondarily from dolomite, where dolerite sills intrude Vempalle Formation.

GEOPHYSICS

With NGRI involved, geophysics has formed a major part of Cuddapah Basin studies since about 1960. BMR Geophysical Branch is probably familiar with much of it, from exchange contacts over several years. Studies involve routine methods such as gravity, magnetics, resistivity etc. Standard M-T techniques are being applied; this was the subject of a visit by Dave Kerr a couple of years ago, and an Indian worked in McArthur Basin in 1978.

The geophysical highlight is the Kavali-Udipi Deep Seismic Profile (Kaila et al., J. geol. Sci. India, 20, 307-333, 1979). This 600 km-long profile crosses right across Peninsula India, from the Arabian Sea to Bay of Bengal, and was carried out jointly with USSR Academy of Sciences during 1972-75. The major crustal blocks are identified and there is remarkable structural detail right down to the Moho. Major faults extend right to the base of the crust. The major thrusts in and along the eastern boundary of the Cuddapah Basin are readily identified.

COMPARISON OF ADELAIDE GEOSYNCLINE-CUDDAPAH BASIN

David Boyd of University of Adelaide has been involved with work in India and in contacts with NGRI for many years. This, therefore, is the origin of this comparative project.

Except in very general terms, there is little comparison. Both are fairly thick Proterozoic epicratonic basins. But every basin is unique.

Most of the sequence (Cuddapah Supergroup) is closer in age to the McArthur Basin than to the Adelaide Geosyncline. Only the Kurnool Group is Adelaidean, and then only early Adelaidean. The sedimentary facies, lateral continuity of units, and stability of the platform of the Papaghni/Chitravati Groups, is very similar to the McArthur-Roper Groups of the McArthur Basin. It lacks the lateral facies changes typical of much of the Adelaide Geosyncline. We did not see enough of the Nallamalai Group to draw comparisons.

The tectonic setting of the Cuddapah Basin could be likened to the McArthur Basin, being situated well within a shield area, while the Adelaide Geosyncline lies more near the craton margin. Alternatively, the western stable platform passing into the eastern mobile belt could be likened to the Stuart Shelf-Adelaide Geosyncline relationship. The difference is, however, that sequences of different ages are involved in the Cuddapah Basin, whilst sequences of the same ages cross all zones in the Adelaidean. Then again, intracratonic grabens or aulacogenes, which characterise the McArthur Basin and Adelaide Geosyncline, are not apparent in the Cuddapah Basin.

In summary, each basin is unique. For comparison with rocks of the same age and similar stratigraphy, the McArthur Basin may be more appropriate. The Adelaide Geosyncline has some tectonic features in common but, perhaps, a more valid comparison in terms of tectonics and setting could be in Central Australia, i.e. Officer-Amadeus-Georgina Basins.

GENERAL IMPRESSIONS

The standard of scientists in India varies far more than in Australia. Different universities have widely differing standards. The leading researchers and administrators are very impressive, but a large proportion of the working scientists we met seem to lack drive, initiative, or adequate understanding of even very basic principles of their science.

There was little to gain from discussions in terms of techniques or concepts. The real value of such a visit lies in the fieldwork and comparing the geology of India to that of Australia and other continents. At the same time, the fieldwork is the most difficult part to organise.

The Cuddapah Basin is a typical Proterozoic epicratonic basin. Stratigraphically, it has more analogies with the McArthur Basin than with the Adelaide Geosyncline; in fact it resembles the McArthur-Roper Group succession more closely than any other sequence I have ever seen outside of northern Australia. Structurally or tectonically, the best comparison might be with Central Australia. In detail, however, the Cuddapah Basin is unique.

Geophysically, the basin has been studied quite extensively; perhaps comparable to any other Proterozoic basin in the western world. Geologically, there is a great need for sedimentological analysis.

APPENDIX 1

SEMINAR ON
INTEGRATED RESOURCES SURVEY AND EVALUATION
(January 20-21, 1981)

Sponsored by:	UNIVERSITY GRANTS COMMISSION
Jointly organised by:	OSMANIA UNIVERSITY, HYDERABAD
	NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Venue:	Conference Hall, National Geophysical Research Institute, Uppal Road, Hyderabad-500 007.

PROGRAMME

January 20, 1981

10.00 a.m.	INAUGURATION OF THE SEMINAR

Vamdemataram

Welcome:	Dr S. Balakrishna, National Geophysical Research Institute.
Greetings from UGC:	Prof. B. Ramachandra Rao, Vice-Chairman, University Grants Commission.
President's Remarks:	Prof. G. Ram Reddy, Vice-Chancellor, Osmania University.
Opening Address:	Prof. Hari Narain, Vice-Chancellor, Banaras Hindu University.
Inaugural Address:	Shri K.C. Abraham, His Excellency the Governor of Andhra Pradesh.
Vote of Thanks:	Prof. N. Ramana Rao, Head, Department of Geology, Osmania University.

National Anthem

11.00 a.m. SESSION - I

1. Wg. Cdr. K.R. Rao,
   Director,
   National Remote Sensing Agency,
   Secunderabad.

   REMOTE SENSING AS AN INTEGRATED SURVEY TOOL

2. Shri B.D. Pathak,
   Chief Hydrogeologist & Member,
   Central Groundwater Board,
   New Delhi.

   &

   Shri K.C.B. Raju, Director,
   Central Groundwater Board,
   Southern Region, Hyderabad.

   MULTI-DISCIPLINARY APPROACH FOR GROUND WATER RESOURCES EVALUATION IN THE HARD ROCK AREAS OF SOUTHERN INDIA

3. Dr S.R. Udas,
   Director,
   Atomic Minerals Division,
   Hyderabad.

   CRITERIA FOR EVALUATION AND EXPLOITATION OF MINERAL DEPOSITS

4. Dr Baldev Lahai,
   Head, AGPD/RSA,
   Space Applications Centre,
   Ahmedabad.

   RESOURCES SURVEY OF IDUKKI DISTRICT (KERALA) THROUGH REMOTE SENSING TECHNIQUES

5. Prof. B.K. Sahu,
   Professor of Geology,
   Indian Institute of Technology,
   Bombay.

   STOCHASTIC MODELLING FOR MINERAL DEPOSIT EVALUATION

2.00 p.m. SESSION - II

1. Prof. V. Bhaskara Rao,
   Professor of Geophysics,
   Andhra University,
   Waltair.

   INTEGRATED GEOPHYSICAL SURVEYS

2. Shri Y.S. Murthy,
   Scientist-in-Charge,
   NEERI Zonal Laboratory,
   Hyderabad.

   KARIMNAGAR PROJECT

3. Dr R.C. Sinha,
   Professor of Geology,
   Patna University,
   Patna.

   INTEGRATED GEOPHYSICAL-GEOLOGICAL-GEOCHEMICAL INVESTIGATION PERTAINING TO RESOURCE SURVEY OF A TYPE MODEL

4. Prof. S. Acharya, Professor and Head, Department of Geology, Utkel University, Bhubaneswar. — INTEGRATED RESOURCES SURVEY OF BOLANGIR DISTRICT, ORISSA FROM LANDSAT IMAGERIES

3.15 p.m. **SPECIAL LECTURE**

January 21, 1981

10.00 a.m. **SESSION - III**

1. Prof. R. Jagadeswara Rao, Head, Department of Applied Geology & Special Officer, S.V. University P.G. Extn. Centre, Cuddapah. — INTEGRATED SURVEY AND EVALUATION OF THE NATURAL RESOURCES OF INDIA BY BARE-FOOT SCIENTISTS

2. Dr N.G.K. Nair, Head, Resources Analysis Division, Centre for Earth Science Studies, Trivandrum. — METALLOGENIC STUDIES AND MINERAL RESOURCES SURVEY IN THE KERALA REGION

3. Prof. B.L. Deekshatulu, Head, Technical Division, National Remote Sensing Agency, Secunderabad. — IMAGE BASED INFORMATION SYSTEMS

4. Prof. Ashok Mookerjee, Professor of Geology, Indian Institute of Technology, Kharagpur. — ULTIMATE AVAILABLE AMOUNTS OF SCARCE METALS - A GEOCHEMICAL PROGNOSTICATION

5. Shri V. Venkatesh, Director, Geological Survey of India, DORIS, Southern Region, Hyderabad. — PHOSPHORITE POTENTIAL OF THE CUDDAPAH BASIN

6. Prof. V.V.J. Sarma, Professor and Head, Department of Geophysics, Andhra University, Waltair. — EVALUATION OF GROUND WATER RESOURCES

7. Shri S.K. Guha, Director, Geological Survey of India, Quaternary Division, Southern Region, Hyderabad. — PARAMETERS OF SURVEY AND EVALUATION OF WATER RESOURCES - A BASIC COMPONENT OF ENVIRONMENT

2.00 p.m. SESSION - IV

1. Dr S.C. Sarkar, Department of Geological Sciences, Jadavpur University, Calcutta. — BASE METAL SULFIDE DEPOSITS OF INDIA - AN OVERVIEW

2. Dr S. Murali, Department of Geophysics, Osmania University, Hyderabad. — DIRECT METHODS OF GEOPHYSICAL PROSPECTING FOR OIL AND GAS DEPOSITS

3. Dr G. Shankar Narayana, Department of Geology, Osmania University, Hyderabad.

   &

   Shri V. Ravindra, Groundwater Department, Hyderabad — CHEMICAL QUALITY OF GROUND WATER AROUND KALVARNADI STREAM, HYDERABAD DISTRICT

APPENDIX 2

Institute of Indian Peninsular Geology
Hyderabad

4TH WORKSHOP ON
STATUS, PROBLEMS AND PROGRAMMES IN
CUDDAPAH BASIN

22-23 JANUARY, 1981

Co-sponsored by
NATIONAL GEOPHYSICAL RESEARCH INSTITUTE

PROGRAMME

January 22, 1981

9.30 a.m.	INAUGURATION
Welcome	Dr S. Balakrishna, Hon. Director INSTITUTE OF INDIAN PENINSULAR GEOLOGY
Presidential Address	Prof. C. Karunakaran, Chairman INSTITUTE OF INDIAN PENINSULAR GEOLOGY
Inaugural Address	Shri P. Venkatasubbiah, Hon'ble Minister of State for HOME & PARLIAMENTARY AFFAIRS GOVERNMENT OF INDIA
Opening Address	Shri V.S. Krishnaswamy, Director-General GEOLOGICAL SURVEY OF INDIA CALCUTTA
11.00 a.m.	COFFEE BREAK

Session I	INVITED TALKS
11.15 a.m.	
President	Dr M.V.N. Murthy, Deputy Director-General GEOLOGICAL SURVEY OF INDIA, A.M.S.E. WING, BANGALORE
Evolution of an Intracratonic Basin. The Cuddapah Basin, India - A Case History.	Prof. Somdev Bhattacharji* Department of Geology BROOKLYN COLLEGE OF THE CITY UNIVERSITY OF NEW YORK BROOKLYN, NEW YORK, U.S.A.
A discussion of the Geochemical problems presented by the Cuddapah Basin Barytes deposits.	Prof. George W. Devore* Department of Geology THE FLORIDA STATE UNIVERSITY, TALLAHASSEE, FLORIDA, U.S.A.
Tectonic Significance of Dyke Swarms	Prof. R.B. Hargraves, PRINCETON UNIVERSITY, (U.S.A.), VISITING PROFESSOR, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD.
Session II	INVITED TALKS
2.00 p.m.	
President	Shri J. Swami Nath, Deputy Director-General GEOLOGICAL SURVEY OF INDIA SOUTHERN REGION, HYDERABAD
The Late Precambrian (Adelaidean) of the Adelaide 'Geosyncline' South Australia	Dr B. Daily* Department of Geology & Mineralogy THE UNIVERSITY OF ADELAIDE, SOUTH AUSTRALIA
Tectonic setting of the Carpentarian and Adelaidean Intracratonic Basins of Australia	Mr K.A. Plumb* BUREAU OF MINERAL RESOURCES, CANBERRA AUSTRALIA
Geology and mineralisation of South Australia	Mr B.P. Thomson SOUTH AUSTRALIAN DEPARTMENT OF MINES, ADELAIDE, SOUTH AUSTRALIA
Review of Geophysical studies of the Adelaide 'Geosyncline'	Mr D.A. Clark*, Division of Mineral Physics C.S.I.R.O. NORTH RYDE, NEW SOUTH WALES, AUSTRALIA.

4.30 p.m.	
SPECIAL LECTURE	Dr M.V.N. Murthy*, Deputy Director-General GEOLOGICAL SURVEY OF INDIA A.M.S.E. WING, BANGALORE
January 23, 1981	
Session III	PRESENTATION OF PAPERS
9.30 a.m.	
President	Prof. M.N. Viswanathiah DEPARTMENT OF GEOLOGY, MYSORE UNIVERSITY, MYSORE
Geophysical Investigations in Cuddapah Basin	Dr S. Balakrishna* NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Reconnaissance Gravity and Magnetic investigations across Cuddapah Basin between Parnapalli and Tummalapenta	Prof. V. Bhaskara Rao* DEPARTMENT OF GEOPHYSICS ANDHRA UNIVERSITY, WALTAIR
Pre-Nagari Barite Mineralisation in the Cuddapah Basin. A new prospect.	Dr K.K. Mukherjee* DORIS, GEOLOGICAL SURVEY OF INDIA, EASTERN REGION, CALCUTTA
Deep Geology of Cuddapah Basin	Shri S.H. Mehdi* GEOLOGICAL SURVEY OF INDIA, A.M.S.E. WING, HYDERABAD
The Basemetal potential of the Nallamalai Group Cuddapah Basin	Shri Srinivasa Rao* GEOLOGICAL SURVEY OF INDIA, A.M.S.E. WING, HYDERABAD
Airborne Magnetic anomalies in Udayagiri and adjacent areas of Andhra Pradesh	Shri B.K. Sharma* GEOLOGICAL SURVEY OF INDIA, A.M.S.E. WING, HYDERABAD
Basemetal Mineralisation between Gollapalli and Ghantapuram, Prakasam District, Andhra Pradesh	Shri K.K. Raju GEOLOGICAL SURVEY OF INDIA, A.M.S.E. WING, HYDERABAD
Origin of high grade limestone of Malkapuram area, Dhone Taluq, Kurnool District, Andhra Pradesh	Shri A.M. Gautam GEOLOGICAL SURVEY OF INDIA A.P. CIRCLE, HYDERABAD

Session IV	PRESENTATION OF PAPERS (Contd.)
2.15 p.m.	
President	Prof. V. Bhaskara Rao DEPARTMENT OF GEOPHYSICS, ANDHRA UNIVERSITY, WALTAIR
Interpretation of Gravity data along DSS profile in the Cuddapah Basin and inferences about the Eastern Ghat Orogeny	Dr K.L. Kaila* NATIONAL GEOPHYSICAL RESEARCH INSTITUTE HYDERABAD
The possibility of tapping groundwater in Cuddapah Basin, A.P.	Shri K.C.B. Raju* CENTRAL GROUND WATER BOARD, HYDERABAD
The recent palynological findings on the Cuddapah rocks	Dr M.N. Viswanathiah* Department of Geology, UNIVERSITY OF MYSORE
The initiation of Proterozoic intracratonic basins	Dr S.M. Naqvi* NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Red sanders as a Geobotanical indicator in the Classification of the Cuddapah Supergroup	Prof. R. Jagadishwara Rao* Department of Applied Geology S.V.U. POST-GRADUATE CENTRE, CUDDAPAH
Some aspects of Groundwater Exploration in Kurnool system of rocks	Shri M.V.R. Chandrasekher* GROUNDWATER DEPARTMENT, CUDDAPAH
A study of the Barytes deposit of Mangampeta, Cuddapah District, South India	Dr A.V.R. Sastry* Dept. of Geology ANDHRA UNIVERSITY, WALTAIR
Inferences on the anomalous upper mantle beneath Cuddapah Basin from gravity anomalies	Dr T.K.S. Prakasa Rao, Dept. of Geophysics ANDHRA UNIVERSITY, WALTAIR
Trace Elemental distribution in Palnad limestones	Dr A. Narasinga Rao, Department of Geology ANDHRA UNIVERSITY, WALTAIR

Elemental Resistivity Investigations in Bukkapatnam Tank, Anantapur District	Shri A. Sundar, INSTITUTE OF INDIAN PENINSULAR GEOLOGY, HYDERABAD
Petrographic Studies on a Bukkapatnam Dyke Swarm, Anantapur District	Shri P. Chitra Swaroop, INSTITUTE OF INDIAN PENINSULAR GEOLOGY, HYDERABAD
Vertical Magnetic Surveys in Gugudu region, Anantapur District, A.P.	Shri K. Subrahmanyam, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Geological Studies of basic intrusives of Malyavantam region, Anantapur District, A.P.	Dr B. Venkatanarayana, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Groundwater Investigations in Chitravati river basin of Dharmavaram region, Anantapur District, A.P.	Shri T. Venkataswara Rao, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Bedrock Investigations at Buggavanka damsite, Cuddapah District, A.P.	Dr K.R. Ramanujachary, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Magnetic Investigations across basic intrusives occurring in Dharmavaram region, Anantapur District, South India.	Shri K. Subrahmanyam, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Th/U Ratio as an aid in studying the Genesis of Barytes of Mangapeta, Cuddapah District	Shri G.V.S. Rama Rao, Department of Geology, S.V.U. POST-GRADUATE CENTRE, CUDDAPAH
Geological Setting of the Intigullapadu Minor Irrigation Project Region and its implications	Dr A.V. Ramana Rao, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Basic Magmatism and Evolution of the Cuddapah Basin	Dr M.N. Rao, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Results of a Telluric Profiling Survey Across the western Margin of Cuddapah Basin	Dr S.V.S. Sarma, NATIONAL GEOPHYSICAL RESEARCH INSTITUTE, HYDERABAD
Possibilities of Groundwater Development in Vempalli Limestone Belt, Dhone Taluk, Kurnool District, Andhra Pradesh	Shri P. Lakshmana Swamy, GROUND WATER DEPARTMENT, CUDDAPAH

APPENDIX 3

THE CUDDAPAH BASIN
HIGHLIGHTS OF ITS GEOLOGY AND MINERAL RESOURCES

by

C. KARUNAKARAN

Presidential Address delivered at the 4th Workshop on Status, Problems and Programmes in Cuddapah Basin, Organised by Institute of Indian Peninsular Geology, Hyderabad, January 22-23, 1981.

THE CUDDAPAH BASIN
HIGHLIGHTS OF ITS GEOLOGY AND MINERAL RESOURCES

BY

C. KARUNAKARAN*

INTRODUCTION

The Institute of Indian Peninsular Geology after its creation in 1974 took up various components of geological and geophysical studies in the Cuddapah Basin. The Institute has already conducted three Workshops where emphasis was given to the problems of the Cuddapah Basin. Today we are inaugurating the Fourth Workshop which is meant exclusively for dealing with Status, Problems and Programmes in Cuddapah Basin. Such an emphasis on a particular geological domain is not without strong scientific reasons. As I have been called upon to deliver the Presidential address I thought it would be pertinent to mention some of these reasons.

If you look at the geological map of India, a crescent shaped feature in the Indian Peninsula draws our immediate attention. This feature stands out prominently amidst the expanse of Archaean Crystalline rocks. To explain the geological jargon to uninitiated I may mention that the rocks of the Cuddapah Basin are younger than those of the crystalline rocks surrounding the basin. Moreover, these rocks are not as deformed and as strongly metamorphosed as the crystalline rocks. This is one of the features which makes the Cuddapah Basin one of the interesting areas of study in the Indian Peninsula.

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* Presidential address delivered at the 4th Workshop on Status, Problems and Programmes in Cuddapah Basin, organised by Institute of Indian Peninsular Geology, Hyderabad, Jan. 22-23, 1981.

The Cuddapah Basin covers an area of nearly 44,000 sq. km. It extends in the north-south direction for about 440 km, and it has a maximum width of nearly 145 km. The basin includes 10 districts of Andhra Pradesh. These are Krishna, Guntur, Nalgonda, Mahaboobnagar, Kurnool, Prakasam, Anantapur, Cuddapah, Nellore and Chittoor districts. The basin constitutes about 16% of the total areas of the state of Andhra Pradesh, but geologically and mineral wealth-wise the basin is an important segment of the state.

GEOLOGICAL FRAMEWORK:

The geological uniqueness of the Cuddapah basin was realised in the last century. The first geological investigation in this basin was initiated by the Geological Survey of India in the 1860's through the work of Oldham, Robert Bruce Foote, and William King. This early work, especially the systematic investigations by King, delineated the basin configuration and established the broad stratigraphy of the Cuddapah and Kurnool group of rocks. After this initial investigation in parts of the Cuddapah basin, a revival of detailed surveys for economic mineral deposits in 1930's and later have resulted in a better understanding of the geological situation of the Cuddapah basin. This work was mainly carried out by the Geological Survey of India and other research institutions of the country.

In course of geological investigations in later years it was found that the stratigraphy of the Cuddapah group of rocks as worked out by King needs revision. It was justifiably felt that the stratigraphic positions of certain formations like Gondikota quartzites, Pullampet and Kolamnala shales etc., need to be refixed. A modified stratigraphic sequence of the Cuddapah rocks has been suggested recently by the G.S.I. The older Cuddapah sequence comprises a succession of quartzites or quartzitic sandstones, slates or shales with associated limestone bands. The alternating sequences of arenaceous, pelitic and carbonate associations persist through the lower into the upper Cuddapah sequence. However, the carbonate content of the lithology decreases up the sequence. The total inferred thickness of the sedimentary rocks of the Cuddapah sequence is about 6 km. However, the depth to the basement is quite variable within the basin. Generally, the thickness of the strata increases in the easterly direction.

The stratigraphy of the Cuddapah basin and the correlation of the individual formations across the basin are complicated due to frequent facies changes, stratigraphic overlaps and discontinuity of strata. A careful and methodical geological mapping, including establishment of type lithological sections and their correlations, were considered necessary for a clear understanding of the stratigraphy of the Cuddapah basin.

One of the most interesting features of the Cuddapah basin is the occurrence of various types of volcanic rocks and other igneous rocks that were emplaced primarily in the lower Cuddapah period. The main rock types of the volcanic sequence comprise picrite, olivine dolerite, amygdaloidal basalts, felsite and suspected flows of intermediate to acid composition. Interestingly, these rocks are confined to the western and southern margin of the Cuddapah basin. It is possible that the igneous activity of the Cuddapah basin has a protracted period of development. In recent years, several workers have suggested widespread volcanic activity within the Cuddapah basin. There has been attempts to relate the mineralisations like barite with widespread volcanism during the Cuddapah period. It is likely that the kimberlite of Vajrakrur, although outside the Cuddapah basin in the west, and recently reported carbonatite bodies in the northeast, are temporally related to the igneous activity of the Cuddapah basin. Undoubtedly these igneous rocks, and especially the volcanics of the basin, provide important clues to the development of this intracratonic Cuddapah basin.

It is well-known that the intensity of deformation as well as of metamorphism increases towards east within the Cuddapah basin. This feature was recognised as early as 1872 by William King who reported broad folds and low-dipping beds in the west, and strongly folded and over-thrust rocks along the eastern margin. Apart from the eastern margin fault there are several faults in the southwest of the basin like the Gunnygull fault near Ramallakota and the Piduguralla fault in Palnad. Later work particularly by the GSI has identified a series of low amplitude folds that trend NNE-SSW, and NNW-SSE. Several asymmetric folds and domal structures have been recognised. It appears that the structural and tectonic development of the Cuddapah rocks have been multiphasal. Undoubtedly, the deformation was unhomogeneous in space. Judging from the angular unconformable relationship between the Kurnool group of rocks and the Cuddapah sequence, it appears that a phase of deformation and basin inversion must have taken place prior to deposition of the next sequence of sediments of the Kurnools. Although a consensus of opinion as to the timing of the major phase of deformation within the Cuddapah basin has not yet been achieved, it is probable that this deformation resulting in intense folding and thrusting along the eastern margin took place after the deposition of the youngest Kurnool formations. Detailed structural events are necessary to decide this important issue.

The tectonic situation of the Cuddapah basin has been worked out by the geophysical surveys, including the first DSS Profiling carried out in India which was conducted by the National Geophysical Research Institute. From Bouguer anomaly interpretation, it has been inferred that the Moho discontinuity below the basin lies at a maximum depth of 38 km, and the crust itself thins towards the east. Several gravity lows and highs have been identified within the Cuddapah basin. This feature may have some causal relationship with the basement configuration and the emplacement of igneous rocks within the basin. The results of the DSS Profiling indicate interesting tectonic configuration where several blocks are identified which are separated by deep-seated faults. The Cuddapah basin thus presents a unique geological and geotectonic situation where the complex processes of origin and development of Proterozoic intracratonic basins can be studied.

IMPORTANT MINERAL DEPOSITS OF THE CUDDAPAH BASIN

Apart from the geological interest, the Cuddapah basin has in recent years emerged as an important area of valuable mineral deposits in India. Andhra Pradesh is indeed fortunate in having the basin within its territory, because this part of the country not only has a great reputation in the recovery of famous diamonds like Kohinoor, Regent and Pitt, the basin holds a dominant position in respect of many industrial minerals. I shall not go into much detail of the distribution of these mineral deposits of the Cuddapah basin, but instead, I think it will be in place to mention briefly some of the most important mineral occurrences of the basin.

The first economic mineral that comes to my mind, and this is for reasons of my association with its exploration, is barytes. The GSI has proved the largest single deposit of barytes (estimated reserve nearly 75 million tons) in the western and southwestern part of the Cuddapah basin. Apart from the economic importance of this important mineral in the Cuddapah basin the origin is of exceptional interest. In recent years it has to become a topic of great and continuing debate. I am sure the forthcoming deliberations in the Workshop will throw light on this aspect in which I am personally interested.

The basemetal occurrences within the basin are situated in two major belts in the eastern Cuddapah basin, and also in subsidiary belts in the northern part of the lower Cuddapah basin. The Gani-Kalva belt contains copper occurrence in discontinuous lenses along and in the vicinity of prominent lineament. The Agnigundala belt comprises both copper and lead-zinc deposits. The lead prospects of Bandalamottu are under exploitation.

Two medium sized lead-zinc deposits have been demarcated in Zangamra jupalle-Varikunta belt. These major basemetal mineralisations and several other minor occurrences within distinct stratigraphic horizons of the Cuddapah sequence are interesting in the sense that they provide scope for studying the environment of basemetal mineralisation in intracratonic basins. It is also interesting to work out the possible relationship between basemetal mineralisation and volcanic activity within the Cuddapah basin.

The Cuddapah basin contains vast resources of limestone, particularly in the Kurnool and Palnad basin areas. The limestone prospects of the basin have catered to the needs of several cement factories in the State. As a matter of fact 75% of the limestone bands are found to be of flux grade, suitable for the iron and steel industry particularly in Jaggayyapeta and Ankireddipalle areas. These limestone deposits will assume great importance in the event of establishing steel plants within the state. Apart from limestones, a few dolomite deposits are also present within the Cuddapah rocks.

Asbestos and steatite are important non-metallic mineral deposits of the Cuddapah basin. These normally occur at the contact zone between lower Cuddapah limestones and the associated basic igneous rocks. A minor occurrence of iron ore in the form of hematitic supergene ore bodies occur in Veldurti region of Kurnool district.

The Cuddapah basin is also an area where geological studies have achieved a major break through in medicine. The dread and hitherto incurable disease of Fluorosis, caused by an excessive intake of fluorine found in the waters of parts of eastern Cuddapah, is prevalent in this area. Studies in the Geological Survey of India showed that the excess of fluorine in the ground waters of this area is caused by the mineral fluorite and further researches proved that another mineral serpentine formed also in the Cuddapah basin has the capability of removing excess fluorine from the living human system.

Senior physicians working in collaboration with scientists in the Geological Survey of India who supplied the mineral for the treatment and carried out the control chemical analysis, were able to cure cases considered hopeless till then. Physicians have told me that this is as great a medical breakthrough as Penicillin with the difference that the disease is not widespread. What is remarkable and interesting is that the disease caused by a mineral found in this area, is cured by another mineral also found in the Cuddapah Basin.

As a part of detailed stratigraphic studies of the Cuddapah basin studies on evidence of ancient life on earth, palynological research has been taken up, particularly by the Department of Geology, Mysore University, under the auspices of the Institute of Indian Peninsular Geology. The Papaghni group of rocks of the lower Cuddapah sequence have yielded 42 different palynomorphs that can be classified under specific and non-specific taxonomic categories. The microbiotic assemblages have been suggested to indicate a pre-Riphean-Lower Riphean (1800 m.y. to 1400 m.y.) age for the Lower Cuddapah rocks. It appears that a considerable scope exists for establishing the biostratigraphy of the Cuddapah rocks through palynological studies, including systematic analysis of stromatolites in limestone in the basin. This will also help correlation of the Cuddapah rock with other Proterozoic basins of India and the world.

CONCLUSION:

In this brief review I have tried to highlight the geology and mineral resources of the Cuddapah basin. In this context I stress that the Cuddapah basin is a very important geological entity in the whole of India which needs proper geological, geophysical and metallogenic studies. These studies, I am sure, would yield very significant results. These results are not only useful for understanding the evolution of the Cuddapah basin itself, but these would have significant bearing on the understanding of intracratonic basins elsewhere in India and in other parts of the world.

These studies would also lead to delineation of suitable environments of mineral locations and to their subsequent discoveries. One of the most important aspects of the Cuddapah basin is the occurrence of nearly undeformed and unmetamorphosed Precambrian rock sequences. This situation is indeed very rare in the geological record of the world. Therefore, the studies of the Cuddapah basin would throw significant light on the crystalline basement-cover relationship, the magmatism and the sedimentation patterns of Precambrian times. To this I must add the development of crustal fracture systems during the Precambrian times, that controlled the sedimentation and magmatism in intracratonic basins like the Cuddapah basin.

The Institute of Indian Peninsular Geology has initiated a number of projects that would aim at tackling some of these problems. Various other institutions and agencies of the country are also actively engaged in these investigations. I am sure the Workshop which has been inaugurated today to deal with Status, Problems and Programmes in Cuddapah basin would discuss some of these problems, and would identify course of studies in this very interesting basin.

APPENDIX 4

THE CUDDAPAH BASIN - A REVIEW OF BASIN DEVELOPMENT AND BASEMENT FRAMEWORK RELATIONS

by

Y.G.K. MURTY

Abstract

The discussion deals with the broad features of the basin development and an outline of the tectonic setting of the basement which formed the depositional area for the basin.

Revision mapping and correlation of the Cuddapah Supergroup rocks in the last few years by officers of Geological Survey of India led to a revised stratigraphy. The corresponding rock group distribution and structure enabled an understanding of the depositional history and tectonics of the basin rocks.

The basin evolved through the development of a series of shifting depositional areas or sub-basins within an overall period of over 1,000 m.y., from about 1700 m.y. to 6-700 m.y. ago.

1) The Western sub-basin containing the Papaghni and Chitravati Groups.

2) The Nallamalai (or eastern) sub-basin consisting of the Nallamala Group.

3) The Srisailam sub-basin in the north consisting of the Srisailam Formation.

4) The Kurnool/Palnad sub-basin(s) consisting of the rocks of the Kurnool Group.

The Western and Nallamalai sub-basins were land-enclosed on three sides with connection with the open sea probably on the northeast, the subsequent Srisailam basin was a transition to open-sea type. The Kurnool-Palnad was largely of open-sea deposition.

Transition from the western to the Mallamalai and from Nallamalai to Srisailam sub-basins is conceived as having taken place by shifting of depositional areas across crustal hinge zones; north-south between the Western and Nallamalai, and ENE-WSW between Nallamalai and Srisailam/Palnad.

Frequent oscillations of land/sea levels, and other varying depositional environments in restricted-basin conditions are indicated in the litho-types of the Western and Nallamalai basins. The shore lines of these basins should be expected to have correspondingly migrated to and fro during the different phases of deposition.

Intensive and extensive volcanic activity of basic to acid character accompanied deposition in the lower Cuddapah (Western sub-basin). In the major southern part of this basin progressive shift of basin trough axis towards ENE and NE is interpreted as due to tilting of the basin floor. It may be possible to correlate the igneous activity of the basin with the tilting which must have caused basin floor fractures.

Progressive phases of Nallamalai basin are - initial deposition in the Eswarakuppam dome and Nallamalai hill range area; later extension to south to the Nagari outliers area; and extension to northeast with an arm to northwest in the Cumbum times. Volcanic activity during Nallamalai is identified by large prevalence of tuffs and other volcanogenic beds like baryte, dolomite-chert-carbon phyllite and synsedimentary sulphides.

Main folding of the Nallamala took place in the Pre-Srisailam times. This was accompanied by formation of domal structures. Late phase of this folding and much later compressional movements from east caused overturning of beds and thrusting of basement rocks over these sediments along eastern margin.

The Bairenkonda (Nagari) at the southwest and Cumbum (Irlakonda) Quartzite in the northwest arm escaped folding owing to high level of basin floor. The eastern margin of the Western basin rocks escaped folding due to faulting along the hinge line.

Srisailam sub-basin has its basin axis close to its southern boundary with the Nallamalai.

Kimberlite emplacement in the Nallamalai (and in the Wajrakarur area) took place in the time gap between Nallamalai folding and Srisailam deposition. Post-Srisailam erosion exposed the kimberlites which formed source for the diamond content of the Banganapalle conglomerate with which Kurnool sedimentation commenced.

The Kurnool rocks indicate steady and undisturbed deposition in open sea conditions. Absence of igneous activity and extensive low-magnesia limestone deposition among the Kurnool contrast with formation of dolomite in the Cuddapah sediments which are associated with igneous rocks.

The margins of Kurnool rocks on the side of Nallamalai fold belt were involved in post-Kurnool compressional movements.

Tectonic setting of the basement:

The striking tectonic feature of the Cuddapah Basin versus the basement is that the Nallamalai fold belt lies in the collision zone between two major cratonic segments of the Peninsula: (1) On West, the relatively stable craton of the Dharwar Supergroup, granites, gneisses, and greenstone belts; (2) on the East, the mobile craton of the charnockite-kondalite suite, high-grade schists, greenstone, migmatite, granites etc.

As already known, the Eastern Ghat regime, which is through running along the southeast and southern parts of the Peninsular has in general, a discordant, tectonically over-riding relationship with the adjoining cratonic segments of the Peninsula. The collision zone was welded prior to the Eparchaean Unconformity. At the south, the inter-craton boundary approaches the Kalahasthi area along the Sevathur lineaments. In the north, the boundary goes into the Khammam district and swerves across the Godavari by west of the Eastern Ghats.

The inception of the western basin is conceivably due to a depression in the western craton caused by a slight revival of crustal or sub-crustal instability in the collision zone. The Nallamalai folding represents a resurgence of the collision movements which waned off in pre-Srisailam times, but repeated in post-Kurnool ($\pm$ 500 m.y.).

Arcuate configuration of the Nallamalai is partly due to pre-Cuddapah basement structures of the Charnockite-Kondalite craton. The curvature is accentuated by differential movements during Nallamalai folding and later compression.

The western sub-basin floor contains the extensions of greenstone belts from NNW to SSE. Sediments earlier to the Gulcheru are likely to be present in the median part of the basin with material, and possibly metals, derived from the greenstone belts.

Loci for volcanicity of the Western basin are likely to be concealed within the basin's axial areas.

The western craton part of the Cuddapah Basin suffered only block faulting. Major fault tectonic zones are identified which join with the western and northwestern marginal zones of the Nallamalai fold belt. These zones are of importance from 'Deep Geology' point of view, including location of kimberlites.

Thus the contrast in the tectonic pictures of the western and eastern parts of the Cuddapah Basin is relatable to the basin falling in the collision zone between two major, dissimilar cratonic segments, one stable, the other active.

APPENDIX 5

A BIRD'S EYE VIEW OF SOME RECENT GEOLOGICAL AND GEOPHYSICAL WORK IN THE CUDDAPAH BASIN AND RELATED CONCEPTUALISATIONS*

by

V.S. KRISHNASWAMY

Director General
Geological Survey of India

Prof. Karunakaran, Hon'ble Minister, Dr Balakrishna,
Distinguished Scientists and Invitees

Introduction

I feel greatly honoured to have been called upon to address you all for a second time in 3 years, on the same subject of the geoscientific problems and programmes of the Cuddapah Basin. In my last address, given at the First Workshop on the theme, I had touched upon some problems, concepts and interpretations relating to the geological aspects of Peninsular India, but with special reference to the Cuddapah basin. I had then touched upon the results of the latest geological work by the GSI scientists working on several aspects of the Cuddapah basin and, I had put forward the new concepts they had evolved on the structures and stratigraphy of the Cuddapah basin, as derived from their painstaking work of a decade and more. I will not repeat these in this address; but, I will confine my attention to what I consider to be some of the significant steps we had taken on the studies of the Cuddapah Basin and the present results of the significant work done in the recent years - particularly in the last 3-4 years that this Workshop has been in vogue, and develop some conceptual geological models, not with a finality but merely with a view to provoke further thinking.

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*Inaugural Address delivered at the IVth Workshop on Cuddapah Basin, held under the auspices of the Indian Institute of Peninsular Geology, NGRI, Hyderabad, on 22nd January, 1981.

2. Some recent contributions and related concepts

After the classical work of Oldham, Bruce Foote & King in the 1860's, the most significant event has been the GSI's remapping of the Cuddapah basin on modern toposheets on the scale of 1:50 000. An exposition of this map was made under the auspices of the Institute of Peninsular Geology, about a year ago, when I had the pleasure of being associated with the exposition of this great achievement of GSI. This was put forward by the younger and the older geologists of the Survey who had given their sweat and blood to the completion of the endeavour. I am happy to inform you that the revised, modern, geological map of the entire Cuddapah Basin, which was presented about a year ago, is under final stages of printing now and that, God willing, we expect to release it for sale by May this year - along with an accompanying aeromagnetic map of the Cuddapah basin, putting together the results of foreign and totally indigenous efforts at aerial geophysical surveys.

I feel that as effective companions to these two Leader - Maps of the Cuddapah basin, we should also bring out, on the same scale, the Gravity Map and, if possible, the Ground Magnetic Map (or at least part map and part magnetic profiles) of the Cuddapah basin. I suggest for your consideration, that the Indian Institute of Peninsular Geology, during this session, if feasible, may nominate a Committee of Compilers, based on relevant contributions, for preparing these two maps, with a designated coordinator who can bring together the efforts of GSI, NGRI and some of the Universities who had accomplished this job. Even though these two maps may not yet be totally complete, I think in such cases, partial truth is better than no truth. The GSI would indeed be willing to support this endeavour in every possible and reasonable way, and also help, if necessary, in getting these two companion maps published. After all, this is a National endeavour in which several agencies have contributed and, as a National Organisation, it will be our pleasure to be of some service in fulfilling the National objective of bettering the geological knowledge, which will, ultimately, lead to the enhancement of the knowledge of the mineral resources of the Cuddapah basin.

Turning now to the Cuddapah basin itself, the rocks of this great sedimentary basin, deposited after the Eparchaean interval, cover 12% of our total land area and encompass 10 districts of the State of Andhra Pradesh. The basin is rather unique in its crescentic shape, the outer length of which is 440 kms, and the maximum width of which, in the central portion, is 145 kms. There is a great anomaly in the total thickness of the sediments of the Cuddapah Supergroup and the Kurnool Group, as inferred from geological mapping at the surface, which is 6500 m and the geophysically determined thickness of the sedimentary column, which averages around 9000 m. This anomaly needs some thinking and explanation, even if it be termed as highly conceptualised or resting on slender grounds at this stage.

The western margin of the basin as we see now, has so far been believed to be largely representing the original shoreline of deposition and, only slightly modified by later erosion - for, there are no significant outliers beyond this margin to the west - and ipso-facto the lowest stratigraphically mappable formation, the Gulcherus, ought to represent the true base of the sedimentary pile. However, recent studies by the GSI, undertaken as part of an All India GSI Geo-Chemical-Geophysical Mapping Project, started near the southwestern margin of the basin, near the town of Cuddapah, have brought out a 15 m thick conglomerate at the base of the Nagari formation which shows rock fragments derived from the quartzites and shales of Gulcheru's which is not surprising; but also baryte in the matrix and, probably, celestite, which is indeed surprising. Spectrochemical analysis of the matrix material gives more than 3000 ppm of strontium. While the localisation, true nature, extent and significance of this interesting find are under further study and evaluation by the GSI, the possibility of an older sedimentary sequence, having barytes in its litho-assemblage, is intriguing as a concept.

The results of the 1972-DSS Surveys along the Kavali-Udipi profile - published by the NGRI in 1978 - covers the Cuddapah basin in 6 blocks viz. block 3 to 8, of the 18 blocks encompassing this sub-continental profile. In the six blocks covering the Cuddapah basin, the basement of the Cuddapah sediments is interpreted, from reflectors recorded, to be at the depth range of 3 to 10 km. In the central block 6, which encompasses the maximum thickness of the sediments, including the Kurnool Group, the basement, as interpreted from reflectors, gives a depth of 9 to 10 kms. If one were to accept these reflectors to truly represent the Archaean basement - <u>not including the infolded remnants of Dharwarian metasediments</u> - the difference of 1500 m in the geological and geophysical estimates of the total thickness of the sedimentary column requires a plausible explanation.

I might attempt at one of the many such possible explanations. As part of the All India GP/GC Mapping Project of GSI, launched in 1979-80, some resistivity soundings were taken close to the southwestern margin of the Cuddapah basin. These appear to indicate a sedimentary thickness for the Gulcherus, greater than what can be sustained by a measured geological section from the basement to the point of geological observation. This difference is being rechecked with seismic depths and we have to wait for the correct answer. But, in the total context of the evidence that we have, viz. i) the DSS data on total thickness of Cuddapah basin; ii) the occurrence of baryte in the matrix of the conglomerate forming the base of the Cuddapah sedimentary sequence and iii) the Gulcheru thickness as obtained for resistivity data, it may not be straining credulity to suggest that what we see in the Gulcherus as mapped is probably the apparent base of the Cuddapah sequence and not the true base, this probably having been overlapped by the Gulcherus. Further work alone can establish the credibility or otherwise of this conceptualisation - including the need for Deep Electrical Sounding to verify the picture as portrayed by the DSS work.

In regard to the eastern margin of the Cuddapah basin, this is generally admitted to be a tectonic dislocation; but, in some of the Cuddapah outliers stated to be resting non-tectonically on the overthrust basement block, there is a difficult-to-explain-riddle, of underthrust rocks occurring as outliers on an overthrust mass. Leaving this riddle apart, the earlier geological surmise of low-angled thrusting of the crystallines over the sediments has been substantiated by the 1978-DSS data. From the DSS data, the Cuddapah sediments are interpreted to extend, eastwards, under the overthrust block, to as great a distance as 20 kms, and Bhaskar Rao et al., in 1979, have in fact, considered this extension of sediments under the crystallines to be represented by a steep fall in the gravity value in this section. To the best of my recollection, the DSS data have revealed the eastern margin thrust to be a very deep-seated feature, even displacing the "Moho" in its down-dip extension.

Let us now consider the lateral extension of this thrust. The ONGC Tectonic Map encompasses the eastern margin dislocation in a sweeping, deep-fault trace, that extends up to Orissa in the North and Karnataka/Kerala in the south, along a line which defines the Charnockite-Khondalite province. When one considers the great lateral extent of this tectonic dislocation, which replicates the present continental boundary and, its great vertical extent down to the "Moho", one is tempted to visualise the eastern margin of the Cuddapah basin as a now welded, old subduction zone of a plate-tectonic configuration of the Proterozoic. To what extent this visualisation is real or is imaginary, can be brought out only by further studies of Deep Geology and by petro- and minero-genetic studies of the belt of alkaline magmatism as discovered in recent years, which seems to be closely related to the ONGC demarcation line. To what extent such a conceptualisation under a Plate Tectonic Model can account for the missing volcanoes that are believed to have contributed to the formation of the unique, 75-million ton reserve-bearing Mangampeta baryte is a further question to be resolved by future studies - but, then, the Plate Tectonic concept applied to the Cuddapah basin raises many other inconvenient questions, which we are unable to answer now.

In my last address, I had mentioned the need for making concerted geophysical and geological efforts in the field of Deep Geology, as related to the vast cover of Deccan traps - which, like a thin dress worn by a lady - appears to conceal more than what it reveals! I am happy to convey to this audience that the GSI will be taking the lead - as in fact, it should do, as the premier Earth Science Institution in the country, employing 2500 geoscientists - by launching, from the next field season 1981-82, a systematic programme in deep geological appraisals, which will include the Deccan trap basement visualisation as well as the Cuddapah basin basement visualisation. Such deep geological visualisations can be, not merely academic exercises, but can also serve as the foundation for new conceptual approaches in resources evaluation programmes. For example, in the case of the Cuddapah basin, one can think of syngenetic ore deposits associated with the euxinic sediments laid down at the beginning of the cycle of Proterozoic sedimentation and, not far above the crystalline basement, as, I am told, is the case with the Zambian basement and the related base metal deposits. About a similar situation stated to exist in the Adelaide basin of Australia, I am awaiting with great interest, to hear, in the course of the Workshop, expositions from our earth-science colleagues from Australia.

I must now surface from deeper waters and turn to some highlights of the results of the work relating to the shallow levels of the crust in the Cuddapah basin.

3. Palaeontological studies of the Cuddapah basin

3.1 Stromatolites

Referring to the recent work in this field, the studies of stromatolites and microbiota entombed in the Cuddapah sediments deserve mention. As a part fulfilment of the Project for studies on stromatolites and the microbiota of some of the Precambrian formations of Southern India, comprising the Cuddapah, Kaladgi and Pakhal basins, the GSI carried out work in the Cuddapah basin during 1977-78 and 1978-79.

This work, done by the Palaeontology Division of the Southern Region, has revealed the widespread occurrence of columnar stromatolites in the Lower Cuddapahs. The stromatolitic assemblages of the Vempalle and Tadpatri Formations are also morphologically distinct. In the Lower Cuddapahs, the columnar stromatolite 'Kussiella' is recognised for the first time. The occurrence of 'Conophyton' and 'Collenia symmetrica' have been recorded from the Vempalle and Tadpatri Formations, respectively. In paranthesis, I must add that the genera Collenia and Conophyton are also known from the Vindhyan formations of Mirzapur.

The microbiota, yielded by the cherty stromatolite of the Cumbum Formation of Zangamrajupalle area, is stated to have an affinity resembling that of the Gunflint assemblage of Canada with an age of 1900 million years. In conformity with similar thinking elsewhere in the world, the syngenetic basemetal mineralisation in the Zangamrajupalle area has been attributed to the biotal activity of the cherty stromatolites.

During 1979-80, the palaeontological studies made by the GSI were restricted to the Kaladgi basin. The studies of the Cuddapah basin will be revived in 1980-81, i.e. the present field season.

3.2 Ichnofossils

Ichnofossils have been recorded for the first time from the Gulcheru Quartzites. These fossils indicate a fairly evolved animal activity, hitherto unknown from an early to middle Proterozoic sequences. Quite apart from the help these fossils can give in solving the problems of local correlation, the basic question raised is, have we really seen the earliest trace of biogenic activity in the Cuddapah? or, judging from the stage of evolution of the ichnofossils of the Gulcherus, are there still some, as yet, unrevealed pages of the book of early sedimentary history of the Cuddapah, hidden by a large overlap of the older formations? I had referred to this conceptualisation, earlier in this address.

3.3 Palynofossils

Studies on palynofossils collected along the DSS profile line by the NGRI, taken across the Cuddapah basin, were carried out by the Mysore University. These have yielded 42 different polymorphs, classifiable under specific and non-specific, taxanomic categories. Biostratigraphic analyses of the forms have resulted in the recognition of two assemblages, viz. a pre-Riphean to Lower Riphean assemblage with an age of 1800-1400 m.y., as assigned to the entombing the palynomorphic assemblages and individual taxa. This has been collaborated by K/Ar dating and, the age assigned to the Gulcheru quartzite, from this approach is 1800-1600 m.y., which takes it to pre-Riphean times and closely agrees with the age as surmised from palynofossil evidence.

4. Phosphorite in the Cuddapah basin

I would now like to refer to some recent work of GSI, which resulted in the discovery of phosphorite beds in the Cuddapahs. In the area NW of Peddasettipalle two stromatolitic phosphorite horizons have been reported, for the first time, within the Cumbum Formation. The role of algae in the deposition of phosphorite has been well recognised, by other investigators. The phosphorite deposition in shallow water, in intertidal to sub-tidal zones, with intermittent phases of high energy conditions, seems to have been helped by the stromatolitic colonies which trapped and precipitated the phosphorous from the sea water, assuming that the other favourable chemical conditions prevailed.

Turning to another area in the Cuddapah basin, pelletal and fragmental phosphorites have been discovered, in the course of geochemical surveys, in the Chelima ($15^{\circ}25'$:$78^{\circ}42'$:57 I/11) - Pacherla ($15^{\circ}24'$:$78^{\circ}40'$) area of the Kurnool district during 1978-79. This area exposes quartzites, shales and dolomites of the Cumbum Formation intruded by kimberlitic dykes.

The phosphorite at Chelima occurs in association with the quartzites and the khaki-green shales, both as intercalations and at the contact of the basemetal mineralised dolomite and the khaki-green shale sequence. In this area, a band of phosphorite has been traced for a length of about 3 km with a width varying from 0.5 to 2 m, all along the shale/dolomite contact, from 2 km SSE of Chelima to 2 km west of Pacherla. The grab samples collected from this band analysed around 23% P_2O_5 on an average; samples from the Pacherla area gave a higher P_2O_5 content.

With the discovery of phosphorite in the Chelima area, the search for locating new phosphorite occurrences within the same stratigraphic unit was intensified by way of regional geological traverses. A number of occurrences have recently come to light, as briefly described below; all these are in the process of evaluation:

(i) I have already mentioned about the Peddasettipalli area ($14^{o}43'$:$78^{o}43'$); here, pelletal and fragmental phosphorite occurs embedded in the dolomitic matrix, often concentrated along the inter-columnar spaces within the stromatolites. While the thickness of the dolomite is about 250 m the phosphatic horizons have a thickness of only 1 to 5 m. This horizon is being traced. The field vanado-molybdate tests for phosphate have indicated about 20-25% P_2O_5.

(ii) In the Vanipenta area ($14^{o}47'$:$78^{o}47'$; 57 J/13) the dolomites/limestones, having intercalations of chert, showed the presence of phosphorite.

(iii) In the Chinnalputti area ($14^{o}57'$:$78^{o}45'$; 57 J/13) a pelletal and fragmental, phosphorite-rich zone has been located within a shaly dolomite horizon.

(iv) In the Chinna Ahobilam area, pelletal and fragmental phosphorite has also been located within the quartzites, about 3 km northeast of Chinna Ahobilam ($15^{o}08'$:$73^{o}40'$; 57 I/12); the vanado-molybdate tests indicated P_2O_5 up to 15%.

(v) Two flat pebbles of phosphorite (10 cm dia. and 1.5 cm thick) have been noticed in the Srisailam quartzites west of .1531 peak ($16^{\circ}19':79^{\circ}28'$; 56 P/7). The source rock of these pebbles is under search.

We will take some more time to consolidate all these current efforts in our search for phosphorite, so that tangible prospects can be outlined for further detailed work by the exploitation agencies.

5. Some Base-metal deposits of Cuddapah Basin

Turning to the base-metal occurrences and deposits in the Cuddapah basin, the main base-metal occurrences of the Cuddapah basin are: the well-known Agnigundala belt; and the less known Zangamrajupalle-Varikunta belts within the Cumbum Formation and the least - known Gani-Kalva belt within the Tadpatri Formation. Recently, the work of the AMSE Wing of GSI has identified a possible base-metal belt in the Markapur area of Prakasam district, whose economic significance has yet to be assessed. Besides the above, minor shows of base-metals are reported from Karampudi-Pappyapalem area (extension of Agnigundala belt); Chelima area, Ahobilamam area, Vontimetta and Vempalle areas. I will not deal with either the well-known or better-known deposits, like Agnigundala nor even the minor occurrences as stated above - but, I will mention some facts about the Gani-Kalva, the Zangamarajupalle and Markapuram areas.

5.1. Gani-Kalva area

This area deserves mention because of GSI's renewed interest in this area during this field season. The copper occurrences in the Gani-Kalva area are in the Tadpatri shale sequence, which is folded into an asymmetric syncline. The occurrences are situated in the vicinity of the well-known Ramallakota-Kalva fault lineament. The mineralisation is controlled by fractures and faults that cut across the axial portion of the regional anticline. Chalcopyrite occurs within quartz veins, in the form of small, discontinuous lenses.

Although the work done earlier by the GSI revealed only a low, total reserve of 0.43 million tonnes of copper·ore, over a length of 550 m and in a vertical depth of 100 m with 1.37% copper, we are hopeful of doing better, if we can get a more complete visualisation of the geophysical, geochemical and geophysical setting of this area. With this objective, this area has been chosen, this year, for work under the All India Project for Regional Geophysical and Geochemical mapping.

The structures favourable for copper-ore localisation within the Tadpatri shales run into the underlying Pulivendla Quartzite and Vempalle limestone Formations. Therefore, we have yet to prove whether or not richer mineralisation exists within these rocks at greater depths than what had been probed in this area; some deeper drilling is also contemplated for this purpose.

In this connection, some conceptualisations are worth mentioning. The area had earlier been covered by aero-magnetic-cum-electromagnetic surveys. The results indicated the lithological trends of all the formations to be divergent from the trend of the magnetic patterns, the latter including a system of elongate, narrow, positive and negative anomalies, trending east-west. The electro-magnetic, conductive zones, also coincided more or less with the trend of the magnetic contours. Parsons of USA, who interpreted the earlier aero-survey data, felt that the strong magnetic pattern, coincident with the conductive EM-zones, may be a pointer to the likelihood of hydrothermal activity in the area and that the linear pattern of the magnetic anomalies are suggestive of a structural control for mineralisation probably related to the fault systems of the area. Ground check up by AMSE field parties have confirmed the structural control as surmised by Parsons. But, his concept of hydrothermal activity has yet to be fully substantiated by careful study of all the analytical data on soil samples collected so far, and, by related petro-chemical studies on the rock samples to be collected under the recently launched Project of All India GP/GC Mapping.

Viswanathan, T.V., four years ago, had reported the occurrence of a peculiar "specularite" (fault breccia) near Remallakota, along the Kalva fault, similar to the "rodbergite" described elsewhere in the world, associated with carbonatite. On the basis of this identification, the postulation of the possibility of occurrence of carbonatite at depth along the Srisailam-Ramallakota-Gani-Kalva lineament has been taken up for verification. If this postulate is proved, there could be a probable inter-relationship between the carbonatite at depth and the basemetal mineralisation in the Gani-Kalva area. All the relevant hypotheses will be tested by detailed geophysical/geochemical surveys and by the pattern of drilling now visualised for the Gani-Kalva area.

5.2 Zangamrajupalle-Varikunta area

I would now like to deal with the base metal mineralisation in the Zangamrajupalle- Varikunta belt, not only because it is not so well known as the Agnigundala belt, but also because of suspected volcanogenic associations with the mineralisation. As is perhaps known to some of you, the Zangamrajupalle-Varikunta base metal belt was explored jointly by the Southern Region and AMSE Wing of GSI. This belt extends over a distance of about 50 km and is situated near the west-central margin of the eastern part of the Cuddapah Basin.

The rocks of the area belong to the Cumbum Formation. The shale-dolomite-quartzite sequence in the Zangamrajupalle area appears to be intercalated with tuffs and tuffaceous dolomite, Three separate horizons of dolomite are found associated with the shales. Two small deposits of lead and zinc are found in the above-listed rocks, in the Zangamrajupalle and Gollapalle blocks. The shales are intruded by a micaceous kimberlite dyke, which is very much similar in nature and composition to the kimberlite dykes recorded from the Chelima area.

The structure of the Zangamrajupalle area consists of broad and shallow synforms with intervening antiforms. Second order synclinal and anticlinal rolls are seen associated with the first order folds.

The top horizons of the dolomite host-rock are generally cherty in nature. The intensity of mineralisation within the cherty dolomite and, at the contact of this dolomite with the overlying shale, is relatively greater, wherever the latter is carbonaceous. The mineralisation is found associated with the quartz-carbonate veins traversing the dolomite and this is attributed to the remobilisation of the syngenetic galena, the original base-metal mineralisation being related to biogenic activity, as inferred from the microbiota present in the black cherts associated with the dolomitic host rock.

The sulphide minerals found are galena, sphalerite, pyrite and chalcopyrite. The lead-zinc mineralisation is confined to the dolomite and associated chert, while the copper mineralisation is seen confined to the bottom beds of dolomite. No direct relationship between the thickness of the dolomite and the concentration of mineralisation could be established.

Over a total length of about 40 km, the mineralisation, in reasonable concentrations, is noticed only at a few isolated places, namely, at Gollapalle, Zangamrajupalle and Varikunta. The marginal grade reserves, as estimated in the following two localities of the belt are:

i) Zangamrajupalle Central part - about 1.3 m.t. with 5% Pb+Zn
ii) Gollapalle Block - about 1.3 m.t. with 5% Zn+Pb

8 to 12 ppm for Ag, and 45 to 90 ppm for Cd.

5.3 Markapuram area

I would now like to refer to one of our recently revived interests for locating base metal prospects in the Markapuram area of the Prakasam district. This area is currently under investigation by AMSE Wing. The basemetal mineralisation in this area is recorded between Gollapalle ($15^{\circ}36'$:$79^{\circ}13'$; 57 M/2) and Ghantapuram ($15^{\circ}25'$:$79^{\circ}10'$; 57 M/3) - again, significantly from the point of view of the Plate Tectonic concept I had put forward earlier, along the eastern margin of the Cuddapah basin. The mineralised belt extends from Badapuram to Konapalle over a distance of 70 km. Old workings for iron and manganese ores and barytes are present in a 3 m-wide and 3 km long zone. Stratabound occurrences of copper and lead are recorded in the same alignment as that of the old workings.

The mineralised belt lies close to a shear zone and the multi-instrumental airborne surveys, carried out under Project "Operation - Hard Rock", picked up a linear electromagnetic zone, which was, however, located on the ground, about 500 m west of the mineralised belt. In the course of the recent work the GSI parties have so far covered 17 km of the 70 km long belt by soil sampling and 20 km of the 70 km belt by channel sampling. The work done so far has resulted in the delineation of a 3.5 km long and 3 m wide zone of copper mineralisation, with subordinate lead mineralisation. The oxidised outcrops have, however, indicated only 0.1 to 0.56% copper and 0.11 to 0.43% lead. Deeper explorations are being planned by the GSI teams.

6. Barytes in the Cuddapah basin

In consonance with the trend of my address, I have now to refer to the well known deposits of Barytes in the Cuddapah basin. The Barytes deposits of the Cuddapah Basin are genetically classified as "vein type" and "bedded type". The former occurs in most of the lithostratigraphic units of the Cuddapah Supergroup and is considered to be of hydrothermal origin. The latter, viz. the bedded barytes, is known only from the Mangampeta area, within the tuffaceous sequence of the Pullampet Formation. I will not deal with vein barytes of the Vempalla formation, which is well known to most of you in this audience. I must however, make special reference to the bedded barytes, whose origin is still unresolved.

The Mangampeta deposit has a reserve of about 74 million tonnes and is the World's biggest deposit, containing about 28% of the known world barytes reserves. The deposit contains beds of granular barytes overlain by those of lapilli barytes, all within the carbonaceous and tuffaceous sequence of the Pullampet Formation.

In regard to the genesis of the bedded barytes, the GSI's thinking has been that the granular barytes is a product of exhalative volcanic activity while the lapilli-barytes represents the pyroclastic phase of the same volcanism. Electron microprobe studies have indicated the presence of barium-rich felspar within the laths of barytes rosettes. The sulphur isotope analyses have indicated that the sulphur in the barytes could have been derived from sea-water by bacteriogenic reduction, while the source for barium could be volcanic. The presence of excess sulphur in elemental form in the granular and lapilli types has also been identified as magmatic in origin.

The real problem in regard to Mangampeta barytes is its relative abundance here as compared to the other coeval basins in the Indian Peninsular Shield and, the very low concentration of barytes in the crustal rocks. While this suggests a localised concentration of the element, the mechanisation of its concentration is far from clear. The granites and gneisses occurring in the provenance area cannot account for such a huge localised concentration of barium. Further, i) the occurrence of vein barytes, within the various formations of the Cuddapah Supergroup, representing a wide range in time and lithology; and ii) the absence of basic intrusives in the vicinity of the vein barytes occurrences that are confined to the younger formations of the Cuddapah Supergroup, rule out the view of some of the earlier workers that the barium bearing solutions were the products of differentiation of a parental basic magma, which had earlier given rise to the intrusive, dolerite dykes and basaltic sills. Hence, the barytes in Cuddapah basin, both of the vein and the bedded types appear to be a product of extremely barium rich volcanism that may have prevailed at the time of their formation.

The above postulation is based on the local evidence of barium rich volcanism in the Mangampeta area and the indirect geochemical evidence of the computed low-barium content of the entire sedimentary pile of the Cuddapah basin and of the nearby granitic rocks on the basis of the average barium content of the crustal rocks, in general, and of the granites and shales in particular, vis-a-vis the total barytes reserves as estimated. Thus, for example, it can be easily admitted that with a maximum known content of 0.12% barium in granitic rocks and with a crustal average of 0.04% barium, no amount of remobilisation and/or reworking of the barium in the provenance-rocks can explain the presence of such a large volume of the massive barytes deposits of the Cuddapah basin.

In connection with these views of the GSI, I was very happy to learn from Prof. Karunakaran that one of our foreign guests, Dr Devore, has approached this puzzle of barium concentration from a thermo-dynamic angle. His paper, I presume, will come up for discussion in this Workshop and I await, along with others, with bated breath, to hear of his findings.

7. Concluding observations

I have titled this address as a Bird's eye review of some recent geoscientific work in the Cuddapah basin. It is a small bird, attempting a huge overview. Before the bird comes to land, it is useful to refer to three approaches with new techniques in the study of the Cuddapah basin. I wish to refer to these because such new technological applications can rapidly advance the frontiers of our knowledge of the rocks of the Cuddapah basin.

The first of these is the Telluric Survey carried out by NGRI in 1979 on an experimental basis - across the western part of the Cuddapah Basin and along two traverses, each 40 km long; one from Tadpatri to Anantapur and the other from Bhogasamundram to Gooty. The studies were taken up as a part of multi-disciplinary investigations in the belt encompassing the DSS profile and under the programme sponsored by IIPG, which is the theme of this 4th Workshop. These surveys were expected to reveal the structure of the different litho-units. The results of the surveys indicated a distinct telluric response from individual litho-units. A thickening of the sedimentary column from the west to the east along the profile taken has also been indicated. Such surveys need intensification, together with related geological appraisals of the results.

The second new technological application is the Helium Survey attempted by the Centre for Exploration Geophysics, Osmania University in 1978. I am told that the Helium Surveys were done using a borrowed Russian equipment and along the Guntakal-Tadpatri-Badvel-Duttaluri profile, with a view to map deep fault zones through which helium normally escapes. The helium anomalies mapped along this profile, indicate a 30 km wide, permeable zone, comprising at least three faults bordering the eastern marginal areas of the Cuddapah basin. Another deep fault, based on the helium anomalies, is indicated about 3 km west of Badvel.

We have to develop our own equipment for helium surveys. I would suggest that the NGRI and Universities teaching Geophysics can come together on this useful endeavour. The GSI will be willing to sponsor such an effort, as we need the technology of helium surveys badly for detecting buried kimberlite pipes under our All India programme of Diamond Exploration. Experience in Siberia, USSR, indicates that helium can be a useful pathfinder element for detection of hidden pipes. After developing our own equipment, we have to establish how far this will be useful in the known kimberlite bearing areas of our country in detecting them, before we can deploy them in unknown areas that are suspected to contain hidden or buried kimberlite pipes.

Lastly, the survey using Transient Pulse Method, generated recently by the NGRI, deserves mention as a new technological aid for effective exploration. Such ground surveys, in some cases, have been found to be helpful in delineating the areas of base-metal mineralisation from areas of carbonaceous shale, where the latter is either difficult to identify due to bleaching caused by alteration or where it lies under soil or deep rock cover. It will be a great support to mineral exploration, if the transient pulse method could be effectively used in filtering out the effects of carbonaceous shale, which often gives spurious anomalies that can be mistaken for base-metal mineralisation. In the Gani-Kalva belt, the NGRI is presently supplementing the GSI's geophysical work, by adopting the transient pulse induction method, and later on, it is proposed to try this type of work in the Zangamarpulle-Varilumba belt as well. We await the results of this new technological input with interest.

Gentlemen, I have done my Bird's Eye Survey of some of the recent geoscientific work in the Cuddapah basins. As I had stated earlier, it is a feeble and inadequate bird for such a large area coverage in a short time. If the review generates some new enthusiasm to tackle old problems of the Cuddapah basin in a new light and with new technological applications, I would feel amply rewarded in having done this review, however, inadequate it may be.