THE PERSPECTIVE PLAN FOR TAMIL NADU

TOWARDS OPTIMUM UTILISATION OF OUR MINERAL WEALTH

REPORT OF THE TASK FORCE

ON

MINERAL RESOURCES

1972-1984

STATE PLANNING COMMISSION
EZHILAGAM, MADRAS-5

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,91

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587C-63—A

August 1972, Planning Commission

Note : *This report of the Task Force sets forth its recommendations on Mineral Resources and is not to be taken as the Perspective Plan for that sector which the Planning Commission will issue in* 1973.

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STATE PLANNING COMMISSION

D. BRIGHT SINGH,
MEMBER,

"Ezhilagam", Madras-5,
Dated 29th November 1972.

My dear Chairman,

Sub : Letter of Transmittal—Perspective Plan on Mineral Resources for Tamil Nadu—1972—84.

I have the honour to transmit to you the report of the Task Force on Mineral Resources which commenced work in November, 1971. The report embodies the Perspective Plan for the development of the Mineral Resources of Tamil Nadu for the period 1972—84. In the main, the proposals relate to the attainment of the following objectives :

* By 1984 or at the end of the proposed twelve year plan the entire State would have to be systematically covered by scientific geological surveys.

* The possibility of utilising the low grade ores will be explored by research and pilot testing.

* The policy of conservation and proper utilisation of mineral reserves would be enforced.

On the basis of a critical study of the mineral potentials of Tamil Nadu 82 schemes are suggested pertaining to about 20 minerals available in the State. These schemes are categorised under the following heads :—

(1) Explorative Schemes.

(2) Exploitation Schemes.

(3) Research and Development Schemes.

(4) Pilot Testing Schemes.

(5) Marketing Schemes.

(6) Administrative Schemes.

A radical change in the techniques of survey is suggested. The preliminary ground survey should be supplemented by continued exploration with the aid of Geophysical, Geochemical surveys and mapping on aerial photographs. Due emphasis is laid on the air-borne survey. Further discoveries of Bauxite, a realistic estimation of apatite and rock phosphate in Tiruchirappalli district, Geophysical exploration along the shear zones (Mineralized zones) delineated by the United Nations Development Programme team, a complete assessment of various grades of Limestone and surveying of Pachamalai, Kollimalai regions are the specific programmes of the Explorative Schemes.

The key note of the exploitation programme is the conservation of Mineral Resources. The problem of conservation of mineral resources arises particularly because they are irreplaceable wasting assets. The commercial exploitation of Graphite of Sivagangai, Clay, Vermiculite of Sevathur are some of the salient programmes of the exploitation schemes. The profitable winning of metals and industrial minerals involves one or more steps within the sphere of mining and metallurgical operations such as proper method of mining, ore dressing, smelting and refining. Hence, it is suggested that the wasteful method of mining of the two important minerals magnesite of Salem and gypsum of Tiruchirappalli—should be stopped immediately and a suitable

blend of mechanised and manual mining should be adopted. To ensure that the mining companies adopt a proper method of mining and to avoid the wasteful method of mining, formation of Vigilance Cell under the headship of a mining engineer is suggested. The reservation of all the flux grade limestone available in the State for the future utilisation in the proposed steel plant at Salem and other mini plants in other parts of the State is another important programme of the exploitation scheme.

The establishment of a well-equipped research laboratory is recommended in the Mineral Sector. This is considered as quite essential for the proper development of the mineral sector. Investigations on the utilisation of low grade ores of Apatite, Bauxite, extraction of Sodium dichromate from Chromite, study of period and rate of replinishment of Ilmenite in the Vaipar-Kallar Delta, successful utilisation of rock phosphates contaminated with carbonaceous matters by using nitric acid instead of hydrochloric or sulphuric acid, in situ gasification of Neyveli Lignite, mechanisation and modernisation of Granite Polishing Unit at Krishnagiri, study of the possibility of utilisation of Thiruvannamalai ores for manufacturing sponge iron, research on the possibility of manufacturing high-temperature forsterite bricks out of Magnesite of Salem are the important progammes of the Research and Development schemes.

During the Perspective Plan period greator emphasis will have to be laid on Pilot Plant studies with a view to proving the commercial viability of the process developed in the laboratories so that these would be readily accepted for utilisation by industry. As a first step towards this, an establishment of Mineral Treatment Laboratory is suggested. The extraction of alumina from sources other than bauxite, like nepheline syenite, anorthosite and aluminous clay, preparation of clay chrome-magnesia-forsterite bricks out of the raw materials available in Salem, separation of ilmenite from the beach sands, concentration of iron ores of Thiruvannamalai are to be studied on a pilot scale during the Perspective Plan period.

With a view to enhance the earnings of the Mineral Sector which will help in executing the policy and programmes of mineral development without any impediments for want of finance, certain trading schemes to be undertaken by the State are suggested for the Perspective Plan period. Accordingly, a Vitreous Glazed Mosaic Tiles Industry, two Crockery Units, a High-tension and Low-tension Insulator Units, a Graphite Crucible Plant, small units for manufacturing precipitated calcium carbonate, modern mechanised kilns for the manufacture of industrial lime, plant for the preparation of magnesium metal are proposed to be set up during the plan period, besides a number of other production and marketing units.

Streamlining and strengthening of the Geology Branch, upgrading the branch into a Directorate and setting up of a Mineral Development Corporation, enforcement of the policy of conservation and proper utilisation of minerals and prevention of illicit mining of major and minor minerals in the State are the main features of the Administrative Schemes suggested for the Perspective Plan period.

All these schemes will contribute to the establishment of mineral, metal and chemical-based industries in the State. It is needless to say that industrialisation would accelerate the growth of the economy and contribute to the well being of the people.

I am presenting this report on behalf of the Task Force on Mineral Resources which comprises the following members :—

(1) Thiru V. Karthikeyan, I.A.S.

(2) Thiru N. A. Vemban.

(3) Thiru M. K. Srinivasan (came in the place of Lt. Col. A. P. Sharma).

(4) Thiru R. Swaminathan, I.A.S. (Thiru T. Lakshminarayanan, I.A.S., has recently taken his place).
(5) Thiru V. Aravamuthan.
(6) Thiru V. Gopal.
(7) Thiru T. S. Paramasivan.
(8) Thiru P. R. Varma.
(9) Dr. S. Saravanan (Member-Secretary).

The Members of the Task Force have placed at the disposal of the Planning Commission their valuable experience and expertise and I like to place on record my deep sense of gratitude to all of them for their kind co-operation. Thanks are also due to Thiruvalargal B. Natarajan, K. B. Patwardhan and W. D. Gopalakrishnan, who have participated in the discussion on 'Clay' and made contributions.

The Task Force benefited immensely by the services of Dr. S. Saravanan, the Secretary. As a scholar and specialist in geology he made important contributions at the discussion meetings and as Secretary he was of great help in co-ordinating the ideas and thinking of the Members on the various topics and in preparing the final report.

I wish to remain at your service and will be happy to provide any further information that you may need.

With kind regards.

Yours sincerely,

D. BRIGHT SINGH.

Encloser : One Report.

To

Dr. Kalaignar M. KARUNANIDHI,
Chairman,
State Planning Commission,
Fort St. George, Madras-9.

Copy to :

Thiru S. MADHAVAN,
Hon'ble Minister for Industries,
Fort St. George, Madras-9.

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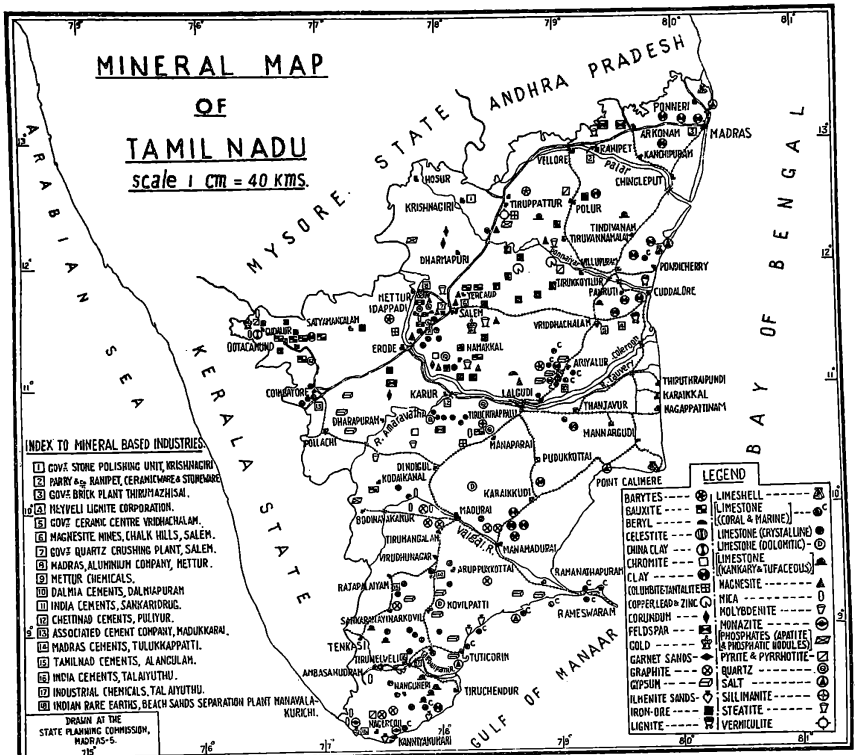
MINERAL MAP
OF
TAMIL NADU
scale 1 cm = 40 kms.
ARABIAN SEA
KERALA STATE
MYSORE STATE
ANDHRA PRADESH
BAY OF BENGAL
GULF OF MANAAR
PONNERI
MADRAS
ARKONAM
KANCHIPURAM
RANIPET
VELLORE
Palar
CHINGLEPUT
HOSUR
KRISHNAGIRI
TIRUPPATTUR
POLUR
TINDIVANAM
TIRUVANNAMALAI
DHARMAPURI
VILLUPURAM
PONDICHERRY
TIRUKKOYILUR
PANRUTI
CUDDALORE
METTUR DAM
IDAPPADI
SALEM
VRIDHACHALAM
SATYAMANGALAM
GOBICHETTIPALAYAM
OOTACAMOND
ERODE
MANJAKKAL
ARIYALUR
Coleroon
K. Kaveri
THIRUTHRAIPUNDI
KARAIKKAL
NAGAPPATTINAM
COIMBATORE
KARUR
LALGUDI
THANJAVUR
DHARAPURAM
R. Amaravathi
TIRUCHIRAPPALLI
MANNARGUDI
POLLACHI
MANAPPARAI
PUDUKKOTTAI
DINDIGUL
KODAIKANAL
KARAIKKUDI
POINT CALIMERE
MADURAI
BODINAYAKANUR
VAIGAI R.
TIRUMANGALAM
MANAMADURAI
VIRUDHUNAGAR
RAMANATHAPURAM
ARUPPUKKOTTAI
RAJAPALAYAM
KOVILPATTI
RAMESWARAM
SANKARAPAYMARKOVIL
TENKASI
TUTICORIN
TIRUNELVELI
AMBASAMUDRAM
NANGUNERI
TIRUCHENDUR
NAGERCOIL
KANNIYAKUMARI
KURICHI.
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1 GOVT. STONE POLISHING UNIT, KRISHNAGIRI
2 PARRY & Co. RANIPET, CERAMICWARE & STONEWARE
3 GOVT. BRICK PLANT THIRUMAZHISAI.
4 NEYVELI LIGNITE CORPORATION.
5 GOVT. CERAMIC CENTRE VRIDHACHALAM.
6 MAGNESITE MINES, CHALK HILLS, SALEM.
7 GOVT. QUARTZ CRUSHING PLANT, SALEM.
8 MADRAS ALUMINIUM COMPANY, METTUR.
9 METTUR CHEMICALS.
10 DALMIA CEMENTS, DALMIAPURAM
11 INDIA CEMENTS, SANKARIDRUG.
12 CHETTINAD CEMENTS, PULIYUR.
13 ASSOCIATED CEMENT COMPANY, MADUKKARAI.
14 MADRAS CEMENTS, TULUKKAPPATTI.
15 TAMILNAD CEMENTS, ALANGULAM.
16 INDIA CEMENTS, TALAIYUTHU.
17 INDUSTRIAL CHEMICALS, TALAIYUTHU.
18 INDIAN RARE EARTHS, BEACH SANDS SEPARATION PLANT MANAVALA-KURICHI.
LEGEND
BARYTES
BAUXITE
BERYL
CELESTITE
CHINA CLAY
CHROMITE
CLAY
COLUMBITE-TANTALITE
COPPER, LEAD & ZINC
CORUNDUM
FELDSPAR
GOLD
GARNET SANDS
GRAPHITE
GIPSUM
ILMENITE SANDS
IRON-ORE
LIGNITE
LIMESHELL
LIMESTONE (CORAL & MARINE)
LIMESTONE (CRYSTALLINE)
LIMESTONE (DOLOMITIC)
LIMESTONE (KANKARY & TUFACEOUS)
MAGNESITE
MICA
MOLYBDENITE
MONAZITE
PHOSPHATES (APATITE & PHOSPHATIC NODULES)
PYRITE & PYRRHOTITE
QUARTZ
SALT
SILLIMANITE
STEATITE
VERMICULITE
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CHAPTER I.

PLANNING IN THE MINERAL SECTOR.

1.1 *Introduction :*

The mineral resources of the earth have contributed largely to the growth of modern civilisation. There has always been a close correlation between mineral exploitation and industrialisation of a country. Mineral resources form the basis of industrial power. The level of development of the mineral resources, achieved through proper planning, determines to a large extent the level of industrialisation existing or that can be achieved during a period of time. The mineral policy which forms an important part of the national economic policy reflects the attitude of the Government towards the development of its mineral resources.

1.2 *Mineral Policy and State's responsibility* :

The mineral policy of the Government of India is enunciated in the Industrial policy resolution of 1956. Under this resolution minerals have been classified into three categories.

The first category includes mining and processing of coal and lignite, mineral oils, iron ore, manganese ore, chrome ore, gypsum, sulphur, gold and diamonds, copper, lead, zinc, tin, molybdenum and woolfrom and atomic minerals.

The second category includes all minerals other than minor minerals and the third all the minor minerals.

The future exploitation and development of minerals, mentioned in the first category will be exclusive responsibility of the State, according to the policy. Minerals of second category will be progressively State-mined and only the State will generally take the initiative. The minerals in the third category have been left for exploitation and development by the private sector.

Hence, it is clear that the responsibility of the State is more in undertaking an organised development programme for the proper utilisation of the mineral wealth. It is for this reason the State of Tamil Nadu embarks on a long term perspective planning for the Mineral Development.

1.3 *Geological Formations of Tamil Nadu and their Mineral Potentialities :*

Southern India, of which Tamil Nadu, is a part, has been a stable land for hundreds of millions of years and is composed of the oldest rocks of the world, called Archaean rocks. These Archaean system of rocks are repositories of the most of the mineral wealth in Tamil Nadu. The mineral deposits occurring in these rocks include iron ores, magnesite, corundum, mica, chromite, barytes, beryl, limestone, copper and pyrites and were formed either along with the rocks in which they occur or later by the action of aqueous solutions derived from the younger invading rocks.

The Gondwana formations which dates back to 250 million years is the store house for the coal which accounts for the 60 per cent of the total national revenue in the Mineral Sector. Unfortunately the Gondwana formation in Tamil Nadu is quite limited in extent and even in that no coal reserves have been struck so far. In Kattavalkam, near Kancheepuram only a thin seam of carbonaceous shale was discovered in such formations. However, the clay and silt deposits are restricted to these Gondwana formations in Tamil Nadu and are the main source of supply of raw materials for ceramic industries.

The Cretaceous formations of Tamil Nadu dating back to 80 million years occur in the region between Pondicherry and Ariyalur in the Tiruchirappalli district. It was in the Cretaceous period the sea transgressed about 60 miles into the interior. The so-called "bad lands" that stretch along the village Uttatur, Karai, and Kalpadi in the Lalgudi and Perambalur taluks of the Tiruchirappalli district represents the remnants of the old sea beds. The mineral salts present in the sea water at that time have been deposited in these bad lands as gypsum, celestite, barytes, phosphatic nodules, limestone, chalk, etc. These are now made use of in several industries.

The Eocene formation in Tamil Nadu exists in the region between the Cauvery and Vellar rivers and it is in this formation that search for oil has been undertaken.

The sea transgression occurring during Cretaceous period, gradually receded eastwards during Eocene and early Tertiary Period (Miocene period), leaving perhaps patches of water in shallow depressions as lagoons or as back waters in the Cuddalore-Thanjavur belt as well as in Pudukottai and Ramanathapuram areas. The streams from the hinterland of Salem, South Arcot, Tiruchirappalli areas, brought down and deposited into these back waters, plenty of water, sand, clay and forest vegetation, that are subsequently converted into sandstone, clay and lignite owing to the high pressure and temperature during their deep burial into the earth's crust. It is this lignite that we are now mining at Neyveli. The clay has now been found useful for ceramic industries.

While all these geological events were taking place in the present State of Tamil Nadu, weathering agents such as solar heat, rain and other atmospheric agencies by their action disintegrated the hard rocks of earlier periods. The materials derived through such disintegration was transported to the sea through rivers. As a result of this disintegration process the felspar of granites and pegmatites in several places, notably in South Arcot, Tirunelveli and Nilgiris, have been converted into China clay. Thus these weathering agencies have converted the chanockites of huge massifs like Shevroys, Palnis, Nilgiris, Kodaikanals along their peaks into Bauxite, a rich source of aluminium in Tamil Nadu. The disintegrated sands of southern hills have accumulated as beach sands, consisting of garnet, monazite, rutile, zircon, etc. In other regions, the alluvial soil of recent times, is being deposited by the rivers.

EXPLOITATION OF MINERALS IN THE STATE 1970 (IN METRIC TONS)

SL.No	DISTRICT	BAUXITE	CHINACLAY (CRUDE)	CHINACLAY (PROCESSED)	FELDSPAR	FIRE CLAY	GYPSUM	LIMESHELL	LIMESTONE	MAGNESITE	QUARTZ	VERMICULITE	LIGNITE
1	CHINGLEPUT							791					
2	COIMBATORE						66,669		591825				
3	DHARMAPURI								490				
4	KANYAKUMARI												
5	MADRAS												
6	MADURAI								284,602				
7	NILGIRIS	22,800											
8	NORTHARCOT										309		
9	RAMANATHAPURAM						4.156		397,075				
10	SALEM	62,000							646,606	346761			
11	SOUTHARCOT		5,904	3547		25,146							3544599
12	THANJAVUR												
13	TIRUCHIRAPPALLI				7.611		16,328		739849				
14	TIRUNELVELI						8,118		103,2906				
TOTAL		84,800	5,904	3,547	7,611	25,146	95,271	791	3693353	346761	309	——	3544599

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CHAPTER II.

MINERAL EXPLORATION—THE RECORD SO FAR.

2.1 *Introduction :*

In Tamil Nadu, with increasing industrialisation and expanding horizon of mineral trade, mineral exploration has received an impetus and important sectors of the mineral economy have registered steady progress. As far as the mineral production is concerned, Tamil Nadu is emerging as an important State despite its deficiency in key minerals.

The value of mineral production in Tamil Nadu is tabulated along with the value of mineral production in the different States in the Indian Union during 1961—1970 in the Table No. I.

TABLE I.

Serial number and States.	1961.	1962.	1963.	1964.	1965.
(1)	(2)	(3)	(4)	(5)	(6)
			(VALUE IN LAKH OF RUPEES.)		
1 Andhra Pradesh	892·16	1,048·13	1,169·19	1,232·81	1,480·95
2 Assam	509·78	760·38	945·40	1,254·12	1,583·75
3 Bihar	6,558·99	7,569·73	8,561·31	8,470·99	9,482·66
4 Delhi	15·73	19·63	19·84	33·36	24·93
5 Gujarat	301·06	443·39	762·95	833·04	1,288·81
6 Haryana	29·40	33·81	32·49	37·40	44·25
7 Himachal Pradesh	12·15	13·59	10·07	15·82	13·31
8 Jammu and Kashmir	14·28	9·34	13·05	11·33	7·43
9 Kerala ..	152·02	156·35	86·17	85·98	89·81
10 Madhya Pradesh ...	2,021·08	2,282·87	2,790·57	2,893·68	3,611·06
11 Maharashtra	477·46	482·28	482·49	576·22	724·71
12 Mysore	863·70	949·32	811·77	880·16	799·96
13 Orissa	1,041·37	1,190·20	1,263·71	1,197·87	1,396·87
14 Punjab	0·25	0·64	0·55	0·57	4·46
15 Rajasthan ...	609·07	604·88	709·91	849·61	976·82
16 Tamil Nadu	317·18	395·67	540·58	704·19	868·17
17 Uttar Pradesh	287·84	721·23	996·82	1,061·39	1,118·27
18 West Bengal	3,618·04	4,043·48	4,532·84	4,586·78	5,000·55
Total ..	17,721·56	20,814·92	23,729·71	24,725·32	28,436·77

TABLE I—*cont.*

Serial number and States.	1966.	1967.	1968.	1969.	1970.
(1)—*cont.*	(7)	(8)	(9)	(10)	(11)
			(VALUE IN LAKH OF RUPEES.)		
1 Andhra Pradesh ..	1,516·73	1,671·43	1,773·31	1,074·29	1,690·11
2 Assam	2,236·06	3,007·45	3,060·69	3,355·00	1,310·87
3 Bihar	10,003·01	10,480·14	12,564·21	13,509·60	13,037·49
4 Delhi	25·60	18·32	18·06	2·33	2·79
5 Gujarat	2,001·05	3,234·67	3,430·87	4,065·54	1,456·63
Haryana	54·50	55·90	75·16	44·62	44·05
Himachal Pradesh	18·37	15·71	18·10	8·43	8·71
8 Jammu and Kashmir	10·99	10·09	18·49	9·75	12·63
9 Kerala	106·50	156·93	147·45	55·53	10·33
10 Madhya Pradesh ...	4,030·07	4,884·98	5,466·56	5,768·55	6,148·04
11 Maharashtra ...	728·10	821·19	920·41	823·81	885·86
12 Mysore ...	899·84	952·22	1,237·60	989·10	1,044·61
13 Orissa ...	1,487·30	1,576·66	1,911·09	2,051·23	2,044·41
14 Punjab	11·91	9·12	9·96	0·11	0·09
15 Rajasthan ..	1,009·39	1,053·27	1,085·55	521·03	548·66
16 Tamil Nadu	978·32	1,233·18	1,282·19	1,220·04	1,124·53
17 Uttar Pradesh	976·14	1,334·76	1,072·09	64·91	83·75
18 West Bengal	2,276·29	5,950·67	6,837·98	7,220·50	6,766·06
Total	31,971·16	36,466·69	40,939·37	41,364·46	36,511·85

2.2. *Position prior to* 1957 :

Prior to the year 1957, mineral production in the State was quite unimpressive. In 1957 mineral production contributed an insignificant amount of 0.1 per cent to the net output of the State. The value of minerals produced in the State formed 1·8 per cent of the value of India's mineral production and gave Re. 0.09 worth of mineral output per capita as compared with Rs. 2.82 in India.

The deficiency of minerals in the State was even more striking during this period in the case of metallic ores and industrial fuels. The bulk of mineral production consisted of 50 per cent salt, 20 per cent of limestone, 11 per cent of magnesite, 9 per cent of ilmenite and 6 per cent of gypsum. The lack of production of any metallic ore and industrial fuel had been a serious set back to the industrial development of the State. For this reason,

mining as a source of employment was relatively unimportant in the State. Employment in 1957 in all mining operations including extraction of common salt from sea was 49,000 or about 5 per cent of the working force in non-agricultural occupations.

In order to carry out more detailed geological mapping and prospecting of areas which are mineral bearing, the State Government started the Geology Branch of Industries Department in 1957. The unit consisting of a retired Superintending Geologist from the Geological Survey of India and two Assistant Geologists were asked to carry out prospecting and detailed surveys of minerals. The needs for expanding the Geology Branch was soon felt and the Government spared no effort to expand the unit, by appointing another geologist from the Geological Survey of India. The Geology Branch, during 1964, had on its staff 16 Officers and 12 Technical Assistants besides a sufficiently large number of chemists. The Chemical and Analytical Laboratory attached to the Industries Department had undertaken the work of analysing, every year, hundreds of samples of minerals, rocks, ores and water collected by the geologists from different parts of the State. Efforts were taken to secure enough drills for purposes of drilling up to 2,000 feet in hard rock formations and also for the construction of tube wells wherever the ground water conditions appeared favourable.

2·3· *Explorative activities of GSI, AEC and ONGC* :

It is gratifying to note that the three organisations, viz., Geological Survey of India, Oil and Natural Gas Commission and Atomic Energy Commission contributed their maximum for the exploration activities in the Mineral sector in Tamil Nadu, concurrently.

2·4· *Activities during Second Plan Period* :

During the period from 1957 to 1961, the major items of geological work carried out included (i) detailed propsecting work on the bauxite deposits of Shevroy hills, Salem district, (ii) prospecting work on the bauxite deposits near Elada, Kotagiri, Boradai, and Dodhabetta in Nilgiris district, (iii) investigations of ground water resources in the Avadi-Villivakkam area near Madras. Apart from these, mineral surveys for pyrite in North Arcot district, Gypsum (Tiruchirappalli district) and Graphite (Tirunelveli district were carried out in detail. Because of these activities, the share of Tamil Nadu in the All-India Mineral Production in terms of value had risen to 1·7 per cent.

2·5· *Activities during Third Plan Period* :

The details of geological work carried out during the Third Plan Period (1961–1965) are summarised below. An outlay of Rs. 30·31 lakhs was envisaged in the plan period.

2·5·1· (i) Detailed investigation of the iron ores of Kanjamalai and Godumalai near Salem was carried out in connection with the setting up of a steel plant utilising the iron ores of Kanjamalai and the lignite from Neyveli. The investigation included large

scale mapping and systematic sampling. Further work was taken up in connection with the project by the geological personnel of the Neyveli-Salem Steel Project set up by the Government of Tamil Nadu. This included sampling, drilling, experimental mining, audit work and the preparation of all geological data on the iron ores of Kanjamalai. Further the limestone deposits in the Salem district were examined in detail to assess their suitability as flux in the iron and steel industry.

2·5·2· (ii) Another major achievement was the detailed examination of the limestone deposits in the Ramanathapuram, Madurai and Tiruchirappalli districts in connection wit the utilisation of the deposits for setting up cement plants. As a result of these surveys, the total limestone reserves suitable for cement manufacture had been estimated at about 200 million tons. This resulted in the setting up of three cement plants—two in the private sector and one in public sector.

2·5·3· (iii) Detailed prospecting of various promising deposits of bauxite was undertaken. This resulted in the discovery of Bauxite with reserves of 7·5 million tonnes and led to the setting up of Aluminium Plant at Mettur by Tiruvalargal MALCO with a capacity of 10,000 tonnes of aluminium ingots per annum. This is now being expanded to produce 20,000 tonnes of aluminium ingots per annum.

2·5·4· (iv) Discovery of Gypsum deposits having reserves of 2 million tonnes suitable for meeting the additional requirements of the cement plants in the State.

2·5·5· (v) Graphite deposits with reserves of about 2·7 lakhs tonnes suitable for the manufacture of crucibles were discovered.

2·5·6· (vi) Massive Sillimanite and Sillimanite—bearing gneiss with reserves of about 4,000 tonnes was found and is now being successfully exploited by a private firm.

2·5·7· (vii) The refractory clay occurrences in South Arcot district were examined in detail for exploitation and use in the Government Ceramic Unit at Vridhachalam. The total reserves have been estimated at well over 6 million tonnes.

2·5·8· (viii) Quartz and Feldspar deposits having a reserve of about half a million tonnes to be used in the manufacture of ceramic-wares were located.

2·5·9· (ix) Mineral Surveys were carried out for magnesite, baryte, steatite, corundum.

2·5·10. (x) Investigation for Vermiculite occurring near Tirupattur in North Arcot district proved to be promising. 35 trial pits were opened of which 25 showed the presence of Vermiculite to a depth ranging from 2 to 4 meters. Good quality vermiculite with an expansion ratio of 1 : 15 occurs up to 17 per cent of the total rock matters. It is estimated that 1·93 lakhs tonnes of vermiculite is likely to be available.

Table II illustrates how far the targets set in the Third Plan Period were achieved.

TABLE II.

Value in Rs. '000.
Quantity in tonnes.

Serial number and mineral.	1960 (*Actual*).		1961 (*Actual.*)		1965–66 (*Estimated*).		1965–66 (*Actuals*).	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity. (Metric tonnes).*	*Value.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1 Apatite	149	4	..	..		..		..
2 Asbestos	..	..	30	3	..	1,000	..	900
3 Bauxite ..	789	16	553	11	50,000		68,416	
4 China-Clay	203	..	301	2	..			
5 Corundum	30	9	28	8			..	..
6 Feldspar	100	1	896	5			4,617	26
7 Fireclay	15,839	32	16,565	30	..	..	19,496	107
8 Gypsum	82,247	920	74,676	828	100,000	11,00	117,167	1,758
9 Ilmenite	9,150	486	4,055	216	..	..	26,854	464
10 Lignite	..	..	2,263	49	5,500,000	7,15,002	289,107	46,194
11 Limestone	1,620,949	5,538	1,867,664	6,530	2,395,000	80,832	586,672	14,436
12 Magnesite	151,886	2,404	203,446	3,193	330,000	49,50	235,325	4,421
13 Mica (Crude)	114	130	114	119			25	26
14 Quartz	207	1	287	1	..	..		..
15 Salt	768,158	10,536	730,100	11,607	1,000,000	1,50,00		..
16 Iron ..		..		..				..
17 Minor Minerals		3,157		3,473	..	..		..
18 Others ..				..	3,857	50,00		18,243

The upward trend in the value of mineral production in Tamil Nadu continued in the Third Plan Period.

The total value of mineral production in the State reached the all time high of Rs. 106·8 million in 1965 as against Rs. 79·9 million in 1964, showing a significant increase of about 34 per cent. The increase in value was mainly due to the phenomenal increase in the output of lignite. The rise in the output of limestone was also a contributory factor towards the increase in the total value of mineral production in the State. As a result, the share of Tamil Nadu in the All-India mineral production which stood at 1·7 per cent in terms of value shot up to 3·1 per cent, and the State reached a position of 8th rank among the States in the value of mineral production. Lignite, limestone, salt, magnesite, gypsum, bauxite, Ilmenite are the chief contributors. Compared to 1960 the output of minerals rose in terms of quantity by nearly 40 points (Table IV).

The trend in the value of mineral production in Tamil Nadu during 1956—1965 is presented in Table III. The value is inclusive of the value of the output of "Minor Minerals."

TABLE III.

Year.	*Value* (*Rs.* 1,000).	
1956	13,665	
1957	15,940	
1958	16,679	
1959	16,564	
1960	23,414	(R)
1961	43,328	(R)
1962	52,596	(R)
1963	70,113	(R)
1964	79,868	(R)
1965	106,799	

R=Revised.

Table IV shows the Index Number of mineral production in Tamil Nadu during 1960 to 1965 (Base 1960=100).

TABLE IV.

Year.	Base 1960=100. *Index.*
1960	100
1961	103·6
1962	110·0
1963	119·5
1964	133·4
1965	139·6

2·6 *Activities during the Fourth Plan Period.*

The Fourth Plan Programme is based on the groundwork prepared during the previous plan periods. During the three annual plan periods, 1967, 1968 and 1969, several systematic mineral surveys were undertaken in hitherto unsurveyed areas especially in the hill tracts of Tirunelveli, Madurai and Coimbatore districts. In the beginning of the Fourth Plan period, detailed investigations, including drilling of the earlier reported occurrences of minerals like limestone, graphite, clays and iron ores were taken up with a view to test the quality and assess the quantity of the reserves. This has resulted in proving about 30 million tonnes of limestone in parts of Sattur and Srivilliputhur taluks of Ramanathapuram district and culminated in the establishment of the Tamil Nadu Cements--a state owned undertaking. Likewise, the high grade limestone (crystalline and sedimentary types) occurring in parts of Salem and Tiruchirappalli districts were reassessed and the areas were recommended for reservation for the proposed Salem Steel Project. A sizeable deposit of massive sillimanite and cordierite sillimanite gneiss was located in Kulithalai taluk of Tiruchirappalli district and is now being exploited by Thiruvalargal Southern Mines and Metals. About 17,000 tonnes of graphite similar to those around Sivaganga of Ramanathapuram district were proved near Thirumangalam in Madurai district. Investigations were carried out on the earlier reported occurrences of graphite near Kuruvikulam in Sankarankoil taluk of Tirunelveli district and also on the occurrences near Kallupatti in Usilampatti taluk of Madurai district. During the period under review, a sizeable deposit of dolomite near Kadalai in Kovilpatti taluk of Tirunelveli district with a reserve of about two million tonnes was located and the same has been reserved for use in the Steel Plant. In 1970, Tamil Nadu ranked seventh in the value of mineral production among the States in the Indian Union. The trend in the quantity and value of different minerals in the State during 1961 to 1970 is brought out in Table V.

2·7 *Commissioning of U.N.D.P.*

A very important event in the geological activities of the State is the commissioning of Tamil Nadu Mineral Development Project in April 1968 under the auspices of United Nations Development Project. According to this programme the experts from United Nations undertook a sophisticated mineral survey including air-borne geophysical survey on select areas in the State and also in the hilly terrains where the usual field investigation poses a problem. Under the terms and conditions, the State Government had contributed a sum of Rs. 34·62 lakhs for a period of three years from 1968—1971 while the United Nations Development Programme contributed a sum of Rs. 78·79 lakhs making a composite scheme for Rs. 105·09 lakhs. An area of about 17,000 sq. kilometres in parts of North Arcot, South Arcot and Dharmapuri and Salem districts was taken up for extensive and intensive mineral exploration by United Nations Development Programmes. As a result of the survey and ground follow-up work, a huge reserve of iron ores in Kavuthimalai Reserve Forest in Thiruvannamalai, North Arcot District was located. As a preliminary finding the experts have estimated the reserves of iron ores to be of the order 140 million tonnes with an iron content varying between 40 and 44 per cent. Detailed prospecting is being continued and the State Government have now requested the United Nations Development Projects to take up a special feasibility study with a view to set up a concentration plant based on the available ore reserves.

TABLE No. V.

(Quantity in Metric Tonnes)
(Value in lakhs of Rupees)
(Calendar Year)

Serial number and mineral.	1961		1962		1963		1964		1965		1966	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1 Asbestos ..	30	0·03	..	..	..	..	..	..	..	..	..	..
2 Bauxite	553	0·11	341	0·04	6,790	0·65	35,867	4·88	68,416	9·00	59,606	7·82
3 China Clay (Non-Saleable Crude).	390	..	2,729		6,168	..	5,062	..	2,459	..	768	..
4 China Clay (Saleable).	301	0·02	365	0·03	3,968	0·27	5,634	0·48	4,356	0·34	4,276	0·26
5 China Clay (Processed).	..		1,376	1·76	3,424	4·38	3,066	3·92	1,500	1·92	10	0·01
6 Corundum ..	28	0·08	19	0·06	..	..	..	..	..	..	..	..
7 Feldspar ..	1,516	0·09	4,790	0·21	4,755	0·23	6,837	0·37	4,617	0·26	4,787	0·22
8 Fire Clay ..	17,150	0·33	17,684	0·38	21,486	0·77	17,317	0·85	19,496	1·07	22,691	1·07
9 Gypsum ..	74,676	8·28	83,926	10·11	102,857	12·68	119,826	17·44	1,17,167	17·58	1,27,131	20·29
10 Ilmenite	4,056	2·15	..		..	..	7,584	1·31	26,854	4·64	23,901	4·50
11 Iron Ore ..	..	..	..	..	..	..	1,219	0·12	420	0·06	..	..
12 Lignite	2,263	0·49	1,74,805	37·24	987,174	2,14·91	1,567,454	3,85·28	2,280,107	461·94	2,561,006	562·40
13 Limestone ..	1,867,664	67·80	2,038,217	77·28	2,080,372	81·92	2,399,501	1,08·53	2,586,672	144·36	2,701,092	175·29
14 Magnesite ..	2,03,446	31·93	2,06,601	33·58	228,923	38·71	201,789	38·09	2,35,325	44·21	2,28,691	39·30
15 Mica (Crude) ..	114	1·19	29	0·25	9	0·12	58	0·12	25	0·25	38	0·38
16 Quartz and Silica.	1,141	0·05	2,650	0·13	3,768	0·10	1,739	0·08	2,063	0·10	1,428	0·06
17 Salt (Rock) ..	..	..	..			..	..	..	..	..	..	..
18 Garnet (Abrasive).	..	..	..	..		..	..	..	..	..	30	0·02
19 Rutile	..	..	..	..		..	..	..	..	..	493	4·85
20 Others	..	204·63	..	234·60		185·75	..	142·72	..	182·43	..	161·85
Total (in Tamil Nadu).	..	317·18	..	395·67	..	540·58	..	704·19	..	868·17	..	978·32
Percentage to Total Production in India.	..	1·7	..	1·9	..	2·3	..	2·8	..	3·1	..	3·1

(Quantity in Metric Tonnes)
(Value in lakhs of Rupees)
(Calendar Year)

Serial number and minerals.	1967		1968		1969		1970		Estimated. Mineral Production 1970–71.		Actual Production. In 1970–71.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity (Tonnes).	Value (Rs. '000).	Quantity (Tonnes).	Value (Rs. in lakhs.)
	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1 Asbestos	..	..	..	..	..	..	..	..	..	..	..	..
* 2 Bauxite	47,876	6·22	77,942	10·28	64,843	10·15	84,783	14·38	1,50,000	3,000	84,783	14·38
3 China Clay (Non-Saleable Crude).	0,385	..	6,199	..	13,568	..	4,408	..	12,000	9,370 **	4,408	..
4 China Clay (Saleable).	7,469	0·41	4,776	0·34	1,150	0·06	736	0·03			736	0·03
5 China Clay (Processed)	1,840	2·35	2,653	3·39	3,714	4·76	3,074	4·03			3,074	4·03
6 Corundum ..	..	..	..	..	..	..	..	..	..	..	..	..
7 Feldspar ..	5,556	0·29	5,026	0·25	0,047	0·29	7,308	0·42	..	..	7,308	0·42
8 Fire Clay ..	24,115	1·15	19,848	1·18	20,524	0·08	24,223	1·07	..	..	24,223	1·07
9 Gypsum	1,01,711	18·79	1,29,551	23·95	1,14,820	22·16	84,180	15·51	..	..	84,180	15·51
10 Ilmenite	31,096	10·30	45,351	14·76	34,504	11·20	1,015*	1·61*	..	..	1,015*	1·61*
11 Iron Ore ..	..	..	..	..	..	..	..	..	1,250,000	25,000	..	..
12 Lignite	29,27,350	763·52	41,21,147	784·25	41,87,030	860·57	3,544,599	728·41	12,000,000	1,56,000	3,544,599	728·41
13 Limestone ..	1,35,380	225·08	31,35,553	227·70	32,23,742	234·61	3,714,932	276·27	4,875,000	17,063	3,714,932	276·27
14 Magnesite ..	2,40,995	45·21	2,47,543	50·39	2,86,243	60·49	3,42,459	81·00	4,80,000	7,200	3,41,443	81·70
15 Mica (Crude) ..	26	0·26	64	0·63	63	0·72	89	1·09	..	..	89	1·09
16 Quartz and Silica.	7,305	0·45	638	0·02	1,138	0·07	309	0·01	15,000	**	309	0·01
17 Salt (Rock) ..	..	..	..	..	..	..	..	..	1,471,000	22,065	..	..
18 Garnet (Abrasive).	307	0·17	737	0·41	150	0·08	N.A.	N.A.	..	..	N.A.	N.A.
19 Rutile	1,244	12·25	1,248	12·29	1,395	13·73	N.A.	N.A.	..	..	N.A.	N.A.
20 Others	..	145·83	..	153·35	..	40·18	N.A.	N.A.	..	..	N.A.	N.A.
Total (in Tamil Nadu), Rs.		12,33·18		12,82·19	..	12,20·04	..	1,124·53	..	2,39,698	..	1,124·53
Percentage to total Production in India.	..	3·4		3·1		3·0		3·1	..	..	..	..

N.A.—Not available.

*Sillimanite.

** Includes the value of quartz also.

Another important discovery is the location of Radio-active and rare mineral deposits of pyrocchlore containing uranium, niobium and tantalum elements in Sevathur area, Tirupathur Taluk that has led the way for further intensive exploration for these rare minerals by the Atomic Energy Commission. The United Nations Development Programme also aided in proving the exact reserves of Vermiculite deposits associated in the rare minerals group of rocks (Carbonatite) and estimated those to be of the order of 3·5 lakh tonnes. As beneficiaries, the project received from the United Nations Development Programme costly equipments such as Atomic Absorption Spectrophotometer, Induced polarisation for geophysical survey, Electro Magnetic equipments, Gamma Ray Spectrometer and Ore Dressing Equipment, which resulted in the establishment of more modern geo-chemical and ore dressing laboratories. The United Nations Development Programmes also provided training of counterpart personnel in modern and sophisticated surveys in photo-geology, geophysics, geochemistry and field geology as well as training of a few officers overseas in the above sophisticated fields of geological exploration.

2.8 *II phase of U.N.D.P.*

As the Project area during the I phase was restricted to a few northern districts in Tamil Nadu, the hitherto neglected hilly tracts in Salem, Coimbatore and Madurai Districts are proposed to be taken up for survey under a Second Phase for which assistance is being sought from the United Nations Development Programmes. The general objective of the II phase of the project is to conduct an intensive exploration survey for new mineral deposits over an additional area of 13,000 sq. kms. and to complete development and economic evaluation of deposits in the present project area. The II phase will produce initially needed basic technical data on the area studied, and provide useful assistance to the surveying of other natural resources for development activities. A detailed investigation to find out the possibilities of further occurrences of phosphates (apatite), rare earths, iron ores, base metals, chromite, etc., is envisaged. Sophisticated surveys such as photo-geological interpretation of structures, geophysical and geochemical reconnaissances are proposed to be conducted in the second phase. The proposals are under the consideration of the U.N. and the project is expected to be completed by the end of Fourth Plan period.

CHAPTER III.

CRITICAL REVIEW OF THE FOURTH PLAN PROJECTS AND THE NEED FOR PERSPECTIVE PLANNING.

3.1 *NCAER Suggestions.*

Soon after the completion of the Third Plan Period, the National Council of Applied Economic Research prepared a Mineral Development Programme for the quinquennial period covering 1966–71. The following explorative schemes were suggested :—

3.1.1. Investigation of mineral resources of Kalrayan, Pachamalai and Kollimalai Hills, Salem.

3.1.2. Detailed investigation of all iron ores in Salem, Trichy, South and North Arcot Districts.

3.1.3. Investigation of Gold occurrences in Nilgiris, Coimbatore and Salem Districts.

3.1.4. Ground Water Investigation.

3.1.5. Search for Bauxite, Mica, graphite, etc., in Palni.

It was considered desirable to include the following on a priority basis :

3.1.6. Exploration for coal in Ramanathapuram.

3.1.7. Search for further Bauxite deposits.

3.1.8. Search for further flux grade limestone.

3.1.9. Exploration for Base Metals.

3.1.10. Investigation of the feasibility of producing basic refractory bricks from dunite and low grade chrome ore at the Central Glass and Ceramic Research Institute and the National Metallurgical Laboratory and Service Tests in the Steel Plants.

A total outlay of Rs. 65 lakhs, inclusive of Rs. 15 lakhs for coal was suggested for this quinquennial period.

Up to the period ending 1971, items 1 and 2 have partially been finished ; item 5 was almost completed, Groundwater exploration has since been transferred to the Directorate of Ground Water, no work has been done by the Geology Branch.

Similarly exploration for coal in Ramanathapuram, beneficiation test on Bauxite, magnesite and Ilmenite, and the feasibility study for producing Basic Refractory Bricks as outlined above are still pending, perhaps, for want of facilities.

Some of the programmes suggested by the NCAER could not be carried out as these programmes lost their priority to the more attractive programmes evolved through the excellent work of U.N.D.P. teams. When in the last three years of the original Fourth Plan annual plans were formulated, a fresh programme was drawn up involving a total outlay of Rs. 103·88 lakhs.

All these schemes are likely to be continued into the Fifth Plan period as there is no likelihood of their completion before the end of the Fourth Plan.

The review of the various plan period programmes reveals that the failure to reach the targetted figures in respect of limestone, bauxite and magnesite, is mainly due to the lack of a pragmatic approach to mineral exploitation, a systematic and scientific programme of mineral survey and mining. On the Survey side, the department should have a target fixed for every year and cover systematically the formations. The observations should be recorded and maintained permanently. The mode of systematic survey conducted by the UNDP team stands in contrast with the conventional mode of surveying adopted by the department. On the mining side, the mine owners adopt a crude and orthodox method of mining as these companies are highly profit oriented. They do not bother at all about the waste arising from simple hand mining, cobbing and sorting. Such wastage due to bad methods of mining is quite common in almost all the magnesite mines of Salem district. The magnesite of Salem is of the world's best quality and the State accounts for 98 per cent of the All-India magnesite production. In these mines, only a fourth of the minned magnesite is recovered as suitable for refractories and the rest is chipped off as impure. Often lean blocks are left off as uneconomical to work out. It is for this reason that out of the total occurrence of 80 million tons only 44 million tons are considered useful for refractories. The same thing could be said of several minerals in the State. Presently the various raw materials for cement factories, talc industries, refractory industries are all being supplied by private contractors. Being interested in immediate and maximum benefit, these private people resort to bad methods of mining which impair the progress of the mining industry in the State. Widespread illicit exploitation of several minerals in the State is another hazard that contributes to the deterioration of the mining industry.

3·2. *Need for perspective planning.*

Under these circumstances, it is essential to formulate an organised development programmes comprising a systematic plan of Mineral Survey and a scientific method of exploration and conservation, besides a scheme to set up an efficient machinery for Mineral Administration. The Policy of conservation should be given equal importance with that of exploration, for, minerals, unlike produce of the soil, are but "one crop" materials; they are vanishing assets, most of which once removed are largely gone for ever. Therefore their reserves and distribution command interest. Hence the scientific exploration and conservation of minerals should be the key note of the mineral policy in any perspective plan for the economic development of the State.

A well-knit, integrated and scientific perspective plan for the mineral sector can, therefore, be evolved by undertaking :

3·2·1· Systematic Programme of Mineral Survey.

3·2·2. Scientific method of Exploitation with due attention to conservation.

3·2·3. An efficient administrative machiney for minerals.

An efficient administrative machinery for minerals is the essential pre-requisite to achieve the systematic exploration and scientific exploitation of the mineral wealth of the State. Hence, as first step it is suggested that the Geology Branch attached to the

Department of Industries and Commerce is thoroughly strengthened and streamlined. This should be done step by step according to a time schedule along the following lines :—

Step 1.—Strengthening the existing Geology Branch by Streamlining its activities. This should be achieved before the end of the IV Plan Period (1974).

Step 2.—The Geology Branch is to be upgraded to the level of a *Directorate*. This is to be done during the first two years of V Plan period. The following wings of the Directorate may concurrently be formed :—

(*a*) Explorative (Survey) Wing.

(*b*) Exploitation (Mining) Wing.

(*c*) Pilot Test (Feasibility Studies) Wing.

(*d*) Research and Development Wing.

(*e*) Marketing Wing.

Step 3.—In the beginning of the VI Plan period a *State owned Mineral Development Corporation* is to be set up. The corporation will bring into its fold the various wings, barring Explorative Wing, which will be retained with the Directorate itself.

Before we go into the details of this set-up and the various functions attached to the different wings of the Directorate and Corporation, it is quite imperative to analyse *Minaralwise the potentials for further development in the perspective plan period.* These analysis will aid us in identifying the deposits for which developmental programmes could be chalked out. When these developmental programmes culminate into a scheme or a project, the details will have to be worked out and the scheme or project to be fitted into any of the suggested wings.

In the following pages, the potentials for further development are discussed mineralwise.

CHAPTER IV.

PROPOSALS FOR FURTHER DEVELOPMENT.

4·1. *Apatite and Rock Phosphate* :

4·1·1. *General.*—Natural phosphates comprising apatite, phosphate rock, etc., constitute the principal raw material for the production of commercial phosphatic fertilizers. There is bound to be rapidly growing demand for phosphatic fertilisers in view of the ambitious agricultural development programmes of the country. India continued to be in short supply of apatite and rock phosphate during 1971–72 and her requirements of these minerals were almost entirely met by imports from the Middle Eastern Countries. It is for this reason, that indigenous resources are to be developed and utilised to the maximum possible extent.

4·1·2. *Occurrences.*—Occurrences of apatite rock of commercial importance in India as at present known are confined to Singhbhum district, Bihar and Vishakapatnam district, Andhra Pradesh, Ajmer and Durgapur districts of Rajasthan and Tiruchirappalli, Dharmapuri and North Arcot districts of Tmail Nadu. The potentialities of the deposits in Himachal Pradesh and Pondicherry are being assessed.

The All-India production and consumption of apatite and rock phosphate are given in the Tables VI and VII respectively.

TABLE VI.

State.	1965.		1966.	
	Quantity (Tonnes).	*Value Rs.* ('000).	*Quantity (Tonnes).*	*Value (Rs.* '000).
(1)	(2)	(3)	(4)	(5)
Andhra Pradesh	972	77	2,953	192
Bihar	6,104	227	13,322	473 (R)
	7,076	304	16,275	665 (R)

(R) Revised on the basis of the final value intimated subsequently by the IISCO.

TABLE VII.

Industry.	*Consumption (Tonnes).*	
	1965.	1966.
(1)	(2)	(3)
Fertilizer	454,404 (28)	510,682 (29)
Iron and Steel	*9,294 (1)	*8,966 (1)
Chemical	1,930 (1)	35 (1)
Total of the above	465,628	519,683

* Relates to apatite consumption.

The shortage in production is becoming more acute in recent years.

Tamil Nadu being one of the few states endowed with apatite and rock phosphate resources, a development programme becomes essential.

In Tamil Nadu phosphatic nodules occur in the Tiruchirappalli district in cretaceous rocks. The belt extends for a distance of over 16 kms. running from south near Neikulam to the north near Sirukanbur and is 1·6 kms. wide. The concentration of phosphatic nodule is variable and the best deposits are located around Nambakurichi. Divergent estimations were given by geologists on the total reserves of these deposits. This varies from one million to two million tonnes. Samples of the material analyse 24 to 27 per cent P_2O_5. About 100 to 150 tonnes of phosphate nodules were produced annually from this area before the year, 1960. Tamil Nadu stopped up producing apatite since 1960 (Table VIII).

Apatite-bearing rocks are found near Hogenakal in Dharmapuri district. The apatite is found as small disseminated crystals and the host rocks are found as patches having widths between 1·5 metres to 60 metres and lengths of 15 kms. discontinuously. Apatite forms 10 per cent of the host rock. Samples of apatite of this locality analyse 37 to 39 per cent P_2O_5.

Apatite crystals with 33 to 38 per cent of P_2O_5 occur as float and in diopside gneisses around Kothagudi in Periyakulam. Owing to the limited extent of the deposit, it is not fit for commercial exploitation.

In the North Arcot district, apatite occurs as disseminations and streaks associated with phlogaphite in carbonatites at Sevathur. The total reserves of apatite have been estimated to be 190,000 tonnes with P_2O_5 content of 27·48 per cent. Apatite in this belt occurs in carbonatite-alkali syenite suite of rocks intimately associated with phlogaphite and radio-active minerals.

4·1·3 *Recommendations* :

The following recommendations are made in respect of apatite and rock phosphate :—

(1) The controversial estimation of the resources of rock phosphate in Tiruchirappalli demands a realistic estimation of the reserves of this material. Hence it is suggested that an intensive survey aided by a number of deep trenches and pits should be taken up in the places of its occurrence.

(2) It is suggested that a proper large scale method of mining the Gypsum on modern lines may be evolved first so that the associated phosphatic nodule may also be recovered at a reasonable cost.

(3) It is generally agreed that in view of the growing demand for phosphatic fertilisers in connection with the agricultural programmes of the country, it is absolutely necessary that the indigenous resources of apatite and rock phosphate are developed to the maximum possible extent.

(4) Action to be taken to assess the exact size of reserves of apatite crystals in carbonatite-syenite complex of Sevathur, Thirupathur, North Arcot district.

(5) In the process of the extraction of Uranium from pyrochlore by the Atomic Energy Commission, a planned method of exploitation of the associated apatite should be evolved.

(6) The RRL, Hyderabad and the NML carried out pilot plant benefication studies on low grade mixed apatite samples from Bihar. The results indicated that the low grade apatite sample can be upgraded to produce the desired apatite concentrate suitable for the manufacture of fertilisers. Since a suitable method of benefication is available, the estimation of the reserves of low grade deposits can also be made and a benefication test on these low grade ores may be carried out, if suitable reserves are proved.

(7) The use of nitric acid instead of hydrochloric acid or sulphuric acid for decomposing rock phosphate resulting in the production of two valuable concentrated inorganic chemical fertilisers, viz., mono-ammonium phosphate and ammonium nitrate in solution, which can directly be utilised as fertiliser, appears to be attractive and can be suggested to the fertilisers manufacturing concerns. This procedure can be employed successfully even for utilising rock phosphate containing large amounts of calcium carbonate, the reason being that the entire calcium carbonate will be converted into calcium nitrate and finally valuable precipitated calcium carbonate and ammonium nitrate are obtained. Hitherto the benefication of phosphatic nodules of Tiruchirappalli posed a problem owing to its contamination with carbonate matter. The above procedure eliminates this difficulty.

The trend in the production of apatite in Tamil Nadu is given in the following table :—

TABLE VIII.

	Metric Tons.		Thousand Rupees.	
	Total.		*Tamil Nadu.*	
Year.	*Quantity.*	*Value.*	*Quantity.*	*Value.*
(1)	(2)	(3)	(4)	(5)
1960	14,921	486	149	4
1961	20,140	593		
1962	29,018	858		
1963	13,127	406		
1964	4,049	143		
1965	7,076	304		
1966	16,275	665		
1967	11,717	620		
1968	6,695	542		
1969	9,316	760	..	
1970	15,997	982		
1971	11,307	742		
1972 January	598	36		

4·2 *Barytes* :

4·2·1 *General.*—Barytes, the sulphate of barium is also known as heavy spar and in Tamil it is called "கனலக்கல்". The value of barytes as an economic mineral is based on its important properties such as inertness, stability and weight. The powdered mineral as such without further processing is made use of as drilling mud in oil well drilling. Barytes is consumed largely by chemical and paint industries also.

4·2·2 *Occurrences.*—In Tamil Nadu, Barytes occurs in Tiruchirappalli, Coimbatore and North Arcot districts.

A small deposit with a total yield of about 200 tonnes occurs south-east of Karai, a village in Perambalur taluk in the Cretaceous rock of the area.

About 35,000 tonnes of barytes analysing $BaSO_4$ 83 per cent and 94 per cent occur in the hillocks known as Kurichikaradu in Bhavani taluk. It occurs as distinct veins and runs for 400 metres, the individual veins ranging in width between 6 and 30 metres (20 and 100 feet). Barytes occurs as distinct idiomorphic crystals with quartz as the main impurity.

Barytes mixed with quartz occurs over a wide area between Alangayam and Andiyappanur in Tirupathur taluk. The quartz barytes occur in sheet-like masses between the country rocks on the hills. Actually barytes occurs as disseminated crystals half to one inch in size in a quartz matrix. Seldom the barytes crystals measure to 5 inches long. These deposits are found in the hills of (i) Narasingapuram Reserved Forest area, (ii) Kallarapatti Reserved Forest Area and (iii) Andiyappanur area. A recent investigation by the Geology Branch based on the report by Sir Thomas Hollod (1920) revealed that the reserves of this are in the order of 5 million tonnes. Though the reserve seems to be large, the intimate admixture of baryte with quartz, which prevents the benefication process difficult, scales down considerably the actual exploitable reserve of this deposit.

4·2·3 *Programme of work in the future.*—In view of the good quality and extensive deposit in Cuddapah district of Andhra Pradesh, the comparatively poor deposits in the Tamil Nadu State have little commercial importance at present. Nevertheless, in view of the strategic importance of the mineral, the following developmental programmes are to be undertaken.

(1) As only a preliminary prospecting by trenching and pitting has been made so far, and a rough estimate of the reserve calculated, a detailed drilling programmes should be undertaken. The United Nations Development Project team may be requested to recommend a suitable method of Geophysical Survey for this mineral.

(2) Barytes is invariably the gangue associated with lead mineralisation. Hence, it is a pre-requisite that before detailed investigation for sulphide bodies are carried out, a comprehensive geophysical survey should be undertaken to demarcate or decipher the concealed bodies in the mineralised zone (i.e. lead).

(3) The benefication possibility tests can be done—not immediately—but after the establishment of the Mineral Testing Laboratory. Before that, I.B.M. may be contacted as benefication tests on certain barytes have been carried out by them.

4.3. *Bauxite.*

4.3.1. *General.*—Bauxite, besides being used for the extraction of alluminium metal, is also utilised for the manufacture of chemicals; abrasives and activated bauxite. Sulphate of alumina, alums, potash alums, and sodium aluminate are the chief chemical products manufactured from bauxite. In recent years, the exploration of Bauxite has assumed greater importance with the expansion of the aluminium manufacturing industry in response to the increased requirements of aluminium for primary and conventional uses and to carry out the substitution programmes in the case of other non-ferrous metals, mainly copper. The trend of production of Bauxite, both in India and in the State, during the years 1960–71 is shown in Table IX.

TABLE IX.

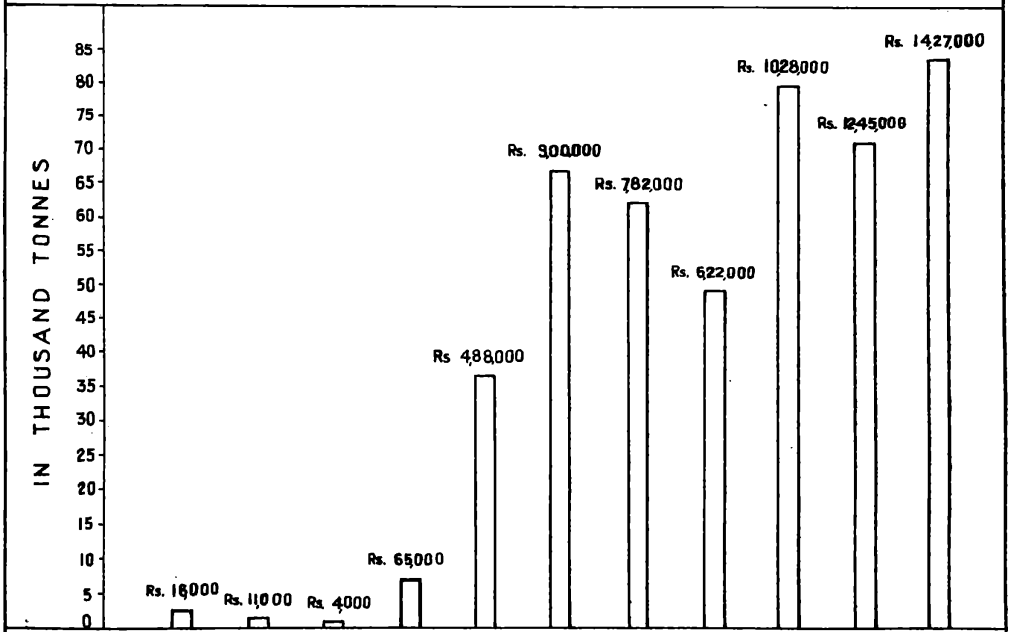
Year.	Metric Tons.		Thousand Rupees.	
	Total.		*Tamil Nadu.*	
	Quantity.	*Value.*	*Quantity.*	*Value.*
(1)	(2)	(3)	(4)	(5)
1960	387,380	4,089	789	16
1961	475,905	4,683	553	11
1962	586,781	6,082	341	4
1963	566,693	5,806	6,790	65
1964	593,482	6,255	35,867	438
1965	706,649	7,435	68,416	900
1966	749,948	8,124	59,606	782
1967	804,093	9,189	47,876	622
1968	961,020	10,072	77,942	1,028
1969	1,084,899	13,862	72,183	1,245
1970	1,369,522	17,463	84,800	1,427
1971 ..	1,491,160	18,141	73,558	1,282
1972 January	159,236	2,007	7,127	138

4.3.2. *Occurrences.*—In Tamil Nadu, Bauxite occurs in Salem, Nilgiris and Madurai districts.

In Salem district, Bauxite occurs in six peaks in the Shevaroy hills about 8 kms. from Yercaud which is 23 kms. from Salem Town. The bauxite is found as cappings on the peaks of Sholakkadu I, Sholakkadu II, Shevaroy Hills No: IV, V and VI. The bauxite cappings are of uneven thickness being thickest at the pleateu area. The ore is earthy, soft, porous, and pale yellow to brick red in colour and is mainly made up of gibbsite. The Al_2O_3 content averages 45 per cent and the total reserves in Shevaroy region is estimated at 5·3 million tonnes.

In the Nilgiris district, seven deposits are located in the Kotagiri Area besides a few deposits in the areas between Kotagiri and Ootacamund and around Ootacamund. Of the 7 deposits of Kotagiri area, two occur very near Kotagiri and the other five near Elada. The deposits of the former group are located on Taylor's Hill near Kerkombai village.

PRODUCTION OF BAUXITE DURING 1960-70 IN TAMIL NADU



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and around Elada. The reserves of Kotagiri area are estimated at 400,000 tonnes with varying Al_2O_3 content of 30 to 45 per cent. In the Elada area 5 deposits of the bauxite are found of which three are located near Avarahalla. The total reserves have been estimated to be 500,000 tonnes of 35 to 50 per cent Al_2O_3 content. The other two deposits are found on two hillocks near Battakobai with an estimated reserve of 380,000 tonnes of 36 to 41 per cent of Al_2O_3 content.

In the area between Kotagiri and Ootacamund near Yedapalli, Rangaswamibetta and Boradai, important deposits of bauxite are found. The Yedapalli deposit has a reserve of about 30,000 tonnes with an Al_2O_3 content of 48 per cent while the deposit near Rangaswamibetta and Boradai are expected to contain 150,000 tonnes of bauxite with Al_2O_3 content varying from 38 to 41 per cent.

The third major occurrence of bauxite in Nilgiris district is around Ootacamund in three localities. Totally they may yield about 4·5 lakh tonnes with the Al_2O_3 content varying between 38 to 41 per cent.

Thus the probable reserves of all the occurrences of bauxite in Nilgiris district would be nearly 3·4 million tonnes of which about one million tonnes contains less than 40 per cent alumina.

In Madurai district, bauxite of fairly good quality occurs about 28 kms. south-west of Kodaikanal. The total reserves have been estimated at 2·23 million tonnes of which one million tonnes can be expected to contain 45 to 55 per cent of alumina.

Besides this, the Geological Survey of India had recenty located 19 occurrences of bauxite in the Kollimalai hills and have estimated the total reserves to be around 2·59 million tonnes analysing 35 to 50 per cent alumina.

Thus Tamil Nadu has roughly 13·5 millions tonnes of bauxite not to speak of very low grade ores obtained during mining in Shevaroy and Palani Hills as detailed below in Table X.

TABLE X.

Region.	*Total.*	*Medium grade 45 to 50 per cent.*	*Low grade 35 to 45 per cent.*
(1)	(2)	(3)	(4)
		(IN MILLION TONNES.)	
1 Shevaroys (Salem)	5·30	4·0	1·30
2 Kotagiri-Ootacamund (Nilgiris)	2·40	2·4	1·00
3 Kodaikanal (Madurai)	2·23	1·0	1·23
4 Kollimalai (Salem)	2·59	1·0	1·59
	13·52	8·40	5·12

The figures given above are likely to be enhanced several times when the detailed pitting programme to estimate thickness of the deposits in the entire region and their quality and depth gets completed.

If grading is done according to the specification of bauxite laid down for the aluminium industry, the metallurgical grade bauxite reserves of Tamil Nadu should be considered as meagre. There is no export of bauxite from Tamil Nadu as the entire quantity produced is consumed by the Madras Aluminium Company, and Thiruvalargal Shevaroys Private Limited. Since the bauxite of Shevaroys hills is not of requisite grade bauxite is procured form Saurashtra for blending and upgrading the ore. About 75,000 tonnes of bauxite is consumed annually by the Madras Aluminium Company for the production of 10,000 tonnes of aluminium metal. The requirement of bauxite in Tamil Nadu can be estimated to be around 1,50,000 tonnes from 1972. The available reserves of bauxite in Tamil Nadu are just enough to meet the needs of the only existing aluminium plant.

4.3.3. *Recommendations.*—India's reserves of high grade bauxite are estimated at 62 million tonnes [1]. The NCAER has estimated that by 1981 aluminium production in India would have to be of the order of 1·2 million tonnes [2]. At this level of production, the present known reserves of high grade bauxite would last only for about 12 years. Eventhough there are not likely to be shortages in the immediate future, the same cannot be said of the long period. The requirements of aluminium are rapidly growing in our economy not only because of its increased utilisation in various industries but also because of its use as good substitute for other non-ferrous metals like copper and zinc in which India is highly deficient. In these circumstances, attention will have to be paid to augmenting the reserves position . Tamil Nadu, being one of the important States endowed with bauxite deposits, it has to bear the responsibility of proper exploitation and planned utilisation of this product. The reserve position of bauxite may be augmented by the following methods :—

(1) Benefication of low grade bauxites—such an attempt has already been made by the Directorate of Mines, Orissa.

(2) Further discoveries of bauxite—by suitable survey methods. Bauxite can be looked for in the plains also.

(3) Attention may also be paid to fix up alternate sources for alumina as is being done in some foreign countries.

Aluminous clays, nepheline syenite and coal ash are the chief products substituted successfully for bauxite in aluminium production. It is reported that alumina was produced from coal ash during the war and that the process is now again attracting commercial attention [3]. Nepheline syenite is currently being used in the U.S.S.R. is given below [4]. Nepheline syenite from Kola Peninsula is used and analysed 30 per cent alumina

[1] Indian Mineral Year Book, 1960, page 78.

[2] NCAER, Looking ahead.

[3] Mineral facts and problems, 1960, U.S. Bureau of Mines. Bulk No. 585. Pages 20 and 125.

[4] Engineering and Mining Journal, Vol. 161, No. 6, June 1960, page 238.

20 per cent soda and potash, 43 per cent silica and others 7 per cent. A slurry is made with limestone and the same calcined in a kiln with fine coal at 650° to 1000° C; here limestone decomposes and the lime reacts with nepheline at 1300° C to form a clinker composed of dicalcium silicates and water soluble aluminates of sodium and potassium silicates go for cement production. The alumina bearing solution is autoclaved in CO_2 atmosphere, producing alumina as the hydroxide. A major reason for the economy of the process is said to be the production of valuable by-products soda ash, potash and cement. Similar procedures can be followed for extracting alumina from highly siliceous clay low in iron or from felspar or from anorthosites.

In Tamil Nadu, nepheline syenite is found in the neighbourhood of Sivamalai in Coimbatore district while in Sittampundi (Thiruchengodu taluk) of Salem district big bodies of anorthosites* occur as hillocks and this has inexhaustive material that could substitute bauxite. Hence, some pilot testing, possibly during the end of Fourth Plan Period (1972–74) or in the beginning of the Fifth Plan Period, could be initiated for utilising these alternate sources and as well as for working out the economic process.

4.4. *Chromite* :

4.4.1. *General.*—Chromite is the chief ore of Chromium metal. The following are the principal use of chromite in industries :—

(*a*) for manufacture of chromium metal.

(*b*) for the manufacture of refractories.

(*c*) for the preparation of chromium compounds.

Chromium should have atleast 48 per cent of Cr_2O_3 for metallurgical purposes with Cr_2O_3 : FeO ratio 2·5 : 1 or 3 : 1. The percentage of sulphur and phosphorus should not exceed 0·5 per cent.

Chromite is converted into ferro-chrome and then used in the manufacture of various types of chromium steels which are indispensable in modern metallurgical industry. Chromium replaces largely Nickel in electro-plating the parts of various machineries, for the former is cheaper.

4.4.2. *Occurrences.*—In Tamil Nadu, important deposits of chromite occur near Sittampundi area in Namakkal taluk of Salem district where the mineral is found to occur in somewhat parallel ore bands in a calc-silicate belt passing through Erayamangalam—Molasi, Chettiapalayam, Panadapalayam, Vadivelanpalayam, terminating near Illupulli. In this region, chromite occurs as layered sheets, lenses, granular aggregate and disseminated ore bodies. The average Cr_2O_3 content of 22 samples or crude ore analysed is, however, reported to be 26·6 per cent. Less important deposits occur near the Dunite pocket in Kanjamalai.

In the Chalk hill, at the foot hills of Shevroys, chromite occurs as veins and also as nodules and angular blocks in the magnesites of the area. The veins range in thickness from 4 to 6 feet. This deposit was worked during the last century. The ore found in this region is reported to have as sayed between 49 to 50 per cent Cr_2O_3. The old mine is worth further investigation.

* The nomenclature of this rock type is in dispute. However, the high aluminous nature of this rock qualifies it as a right substitute for bauxite.

The specifications of different grades of chromite are compared with the analysis of Sittampundi ore below :—

	Cr_2O_3	Al_2O_3	Fe_2O_3	MgO.
Metallurgical grade	48 (minimum).			
Refractory grade	38—48	12—24	14—24	14—18
Chemical grade ..	48—50			
Sittampundi Chromite ..	21—28	24—41		.32—2·36
Chalk Hills	49—50			

	SiO_2	S	O	Cr : Fe
Metallurgical grade	..	0·5	0·2	2·8 : 1
Refractory grade	10			
Chemical grade ..	6			1·6 : 1
Sittampundi Chromite ..	0·14			1·1 : 1
Chalk Hills				

The comparison of Tamil Nadu chromite ore with the specifications laid down for the various grades reveal that the Tamil Nadu ore is falling short of the specifications. While earlier specification for various basic refractory raw materials were very stringent, recent researches show that low grade material equivalent to the Sittampundi ore can be used with great advantage. Significant advances have been made in this respect by the Tata Iron and Steel Co. which have opened up possibilities of using (i) a hybrid chrome ore, (ii) a hydrous magnesium silicate rock. With these low grade materials, they have developed bricks superior to those made from conventional raw materials. Actually " Tatas " are now taking such a low grade ore that assays 19·04 per cent of Cr_2O_3 23·6 of SiO_2, 24·52 of MgO, 10·04 of Al_2O_3. Such a lowering would permit the entire chromite bearing rock (Chromitite) of Sittampundi and other area to be used and the reserves would be improved to 750,000 tonnes to one million tonnes of usable ore. In view of the fact that large reserves of dunite are likely to be available in the same area, where the chromite ore occurs, it is ideal to think of an establishment of a chrome-magnesia forsterite brick factory.

4.4.3. *Recommendations.*—The following programme is put up for the development of chromite deposits :—

(1) In the light of 'Tatas' research on feasibility of using low grade chrome ores, the ores of Tamil Nadu gains importance and in view of the large reserves of dunite and magnesite available, a pilot testing can be undertaken for the manufacture of chrome-magnesia—forsterite bricks on the lines of " Tatas ".

(2) A thorough and careful survey of the ultra basic formations of Tamil Nadu is to be undertaken to locate the new deposits of chromite.

(3) A pilot study for the extraction of sodium dichromate and a valuable bi-product aluminium from the low grade chromite ore is to be undertaken, if more deposits are located. This may be taken up either at the end of the Fifth Plan or at the beginning of the Sixth Plan.

(4) The presence of platinum on the chromite bearing rocks of Sittampundi Complex should be examined.

4.5. *Clay* :

Clay is a general term used for fine grained, soft, earthy material, the cheif property of which is plasticity. The physical properties of clay to be studied are :

(*a*) Plasticity ;
(*b*) Tensile strength ;
(*c*) Air and fire shrinkage ;
(*d*) Fusibility ;
(*e*) Colour ;
(*f*) Porosity and
(*g*) Size of grains.

In fact the commercial utility of clay deposits depends on the physical properties enumerated above and to some extent chemical composition. Clays are generally products of disintegration of rocks and minerals ; the clays that are formed by weathering of the felspars in rocks of the earth are known as residual clays.

If the disintegrated products are taken away by flowing streams, and rivers and subsequently deposit them in the lakes, seas and river mouths, they constitute what is called " Transported Clays ".

Occurrences of clays are found in the districts of Chingleput, North Arcot, South Arcot, Tiruchirappalli, Thanjavur, Ramanathapuram and the Nilgiris.

Chingleput district.

		Reserves (IN TONNES).
Soft shales	Gunduperambudur ..	2,000,000
	Mattur ..	1,400,000
	Other areas	41,000
Clays	Vaiyapur	181,500
	Ariyathur	553,400
	Kilacheri and Mappedu ..	3,000,000
	Attirambakkam—Oddapai ..	4,500,000

The clays of the non-refractory type are suitable for stoneware and sanitaryware. The Ariyalur and Kilacheri deposits are being worked by Parry & Co. and the Tiruvellore Stoneware Co.

North Arcot District.

White clay	Karigiri	N.A.
Do.	Pappantangal	Do.
Do.	Pallur	Do.
Buff coloured	Renganpatti	Do.

South Arcot District.

Panruti ..	2,000,000
Gadilam	
Karaikkal	
Melnippu	
Kilnippu	
Melmambattur	
Thiruvedi	
Palaiyam ..	
Vandrayamkuppam	
Vilangalpatti ..	
Suriampatti	
Vanadevi ..	
Mavedipalayam	
Thiruvendrapuram	
Panikuppam	

The above are in the main white to pale yellowish in colour and analyse :

	Per cent.
Al_2O_3	30–33
Fe_2O_3	2·5—4·0
SiO_2	50–53

The less contaminated types are suitable for refractories and the rest for stoneware.

Tiruvakkarai ..	4,000,000 tonnes.
Kumalampatti	

The clays in Tindivanam taluk contain free quartz and show remarkable improvement in refractoriness on washing. Unwashed clays appear to be suitable for semi-silica refractory bricks and when washed are suitable for 35—40 per cent alumina bricks and whiteware. .. .. ..

White clays of Kaolinitic composition occur around Tisaiyanvilai of Tirunelveli district and surrounding areas due to the alteration of granite gneiss. The occurrences have been investigated by the State Geology Branch in detail. Tests were carried out to determine the industrial utilisation.

Neyveli.

Three types of clays are found overlying the lignite-fireclay, white clay and ball clays. The white or china clays occur at a depth of about 49 m. and is 4·5 to 8 m. thick with a plastic clay underneath.

The fireclays in the form they are available, are suitable for manufacture of refractories from moderate heat and with calcined bauxite are suitable for high heat duty firebricks. The white clays are suitable for ivory white earthware, high and low tension electrical porcelain, high quality stoneware and vitrified whitewares when blended with white burning clay.

Salt glazed wares, high and low tension insulators, high grade stoneware and vitrified ceramic ware where, efired colour is not of importance can be made out of the ball clay.

The Neyveli Lignite Corporation has installed a clay washing plant capable of producing 20 tonnes of washed clay in two 8 hour shifts per day. Analysis of the washed clay is as follows :—

	Per cent.
SiO_2	46—48
Al_2O_3	38—39
Fe_2O_3	0·4—0·6
TiO_2	0·6—0·8
CaO+MgO	Traces
Loss on ignition	12·0—14·0

Since the clay horizon is extensive, the washing capacity can easily be expanded many times more. The clay washing plant yields sand tailings of the following composition ;—

	Per cent.
SiO_2	98·58
Fe_2O_3	0·06
TiO_2	0·10
Al_2O_3	0·64
CaO	0·12
MgO	0·31

The clay is suitable for sanitary and stoneware.

Ramanathapuram District.

Sivagangai .. 1,300,000 tonnes.

Washing does not improve these clays appreciably. The material is stated to be suitable for high heat duty refractories.

Tiruchirappalli District.

Yellow to light grey plastic clays are seen near Karai, Terani and Uttatur. They do not fuse at 1,300°C and exhibit 38 per cent shrinkage on firing and analyse :—

SiO_2	49·82	Al_2O_3	32·67
Fe_2O_3	1·98	MnO	Nil.
CO	0·13	MgO	0·09
K_2O	0·62	Na_2O	0·49 and H^2O 14·18

Reserves are estimated at 600,000 tonnes.

Nilgiris District.

Very good China clays are known to occur in Gudalur taluk of this district. They need to be investigated in detail.

There is an urgent need to undertake a thorough scientific survey of various clay deposits of Tamilnadu. The quality of the clay deposits of every locality should be fixed up by subjecting these samples to various physical, chemical and special tests including X-ray and differential Thermal analyses tests. From the quality thus fixed up, it is easy to sort out the clays according to the specifications required by different consumers. Correct estimation of the reserves is presently lacking. Thus the quantity and quality of evey deposit should be precisely fixed up.

The production of non-saleable, saleable crude clays, the processed China clay and the fire clay in this State is tabulated below along with the corresponding All-India figures in Tables XI, XII, XIII and XIV.

TABLE XI.

(Non-saleable crude.)

Year.	METRIC TONS.		THOUSAND RUPEES.	
	Total		*Tamil Nadu*	
	Quantity.	*Value.*	*Quantity.*	*Value.*
1960	317,929			
1961	323,155		390	
1962 ..	318,215		2,729	
1963	302,525		6,168	
1964 ..	308,224		5,062	
1965	307,341		2,459	
1966	348,554	--	768	
1967	335,465	--	6,385	
1968 .. --	357,454		6,199	
1969	375,329	--	13,568	
1970	342,537		4,939	
1971	380,103		7,720	
1972 January	37,811			

TABLE XII.

(Saleable Crude.)

Year.	METRIC TONS. Total Quantity.	Total Value.	THOUSAND RUPEES. Tamil Nadu Quantity.	Tamil Nadu Value.
1960 ..	71,129	320	203	
1961 ..	62,409	356	301	2
1962 ..	95,828	563	365	3
1963 ..	141,474	1,010	3,968	27
1964 ..	140,015	1,048	5,634	48
1965 ..	187,753	1,661	4,356	34
1966 ..	200,829	1,621	4,276	26
1967 ..	189,696	1,732	7,469	41
1968 ..	166,141	1,794	4,776	34
1969 ..	185,428	1,752	2,487	14
1970 ..	204,117	1,667	965	7
1971	217,803	1,993		
1972 January	19,694	207		

TABLE XIII.

(China Clay—Processed.)

Year.	METRIC TONS. Total Quantity.	Total Value.	THOUSAND RUPEES. Tamil Nadu Quantity.	Tamil Nadu Value.
1960 ..	82,916	5,243		
1961	79,175	5,956	..	..
1962	81,640	6,064	1,376	176
1963	83,447	6,029	3,424	438
1964	87,641	6,609	3,066	392
1965	93,115	7,032	1,590	192
1966	96,088	8,272	10	1
1967	97,331	8,350	1,840	235
1968	97,029	8,017	2,653	339
1969	97,793	8,725	3,603	461
1970	99,296	8,409	3,547	468
1971	105,428	10,193	1,898	313
1972 January	9,744	862	228	40

TABLE XIV.

(Fire Clay.)

Year.	METRIC TONS.		THOUSAND RUPEES.	
	Total		*Tamil Nadu*	
	Quantity.	*Value.*	*Quantity.*	*Value.*
1960	274,678	2,287	15,839	32
1961	301,531	2,503	17,150	33
1962	400,890	3,362	17,684	38
1963	461,753	3,514	21,486	77
1964 ..	443,747	3,560	17,317	85
1965 ..	475,909	3,957	19,496	107
1966 ..	483,574	4,003	22,691	107
1967	445,545	3,582	24,115	115
1968	473,569	3,887	19,848	118
1969	512,885	4,150	20,770	100
1970	550,606	4,591	25,116	147
1971	583,862	4,305	24,196	117
1972 January	60,856	496	2,357	10

4.5.3. *Recommendations.*

The following developmental programmes are recommended to be undertaken regarding Clay :—

(1) The quality and quantity of individual deposit to be fixed on the lines suggested above.

(2) The possibility of increasing the production of fire bricks from 10,000 tonnes per annum at present to the projected requirement of 30,000 tonnes per annum is to be explored.

(3) Neyveli Lignite Corporation should be prevailed upon to give importance to the mining of white clay to support the suggested ceremic units.

(4) A vitreous glazed Mosaic Tiles Industry is to be established. The additional requirements for white and sanitaryware may be obtained by setting up additional washing capacity to the extent of another 20 tonnes a day. This would require an investment of Rs. 15 lakhs (NCAER).

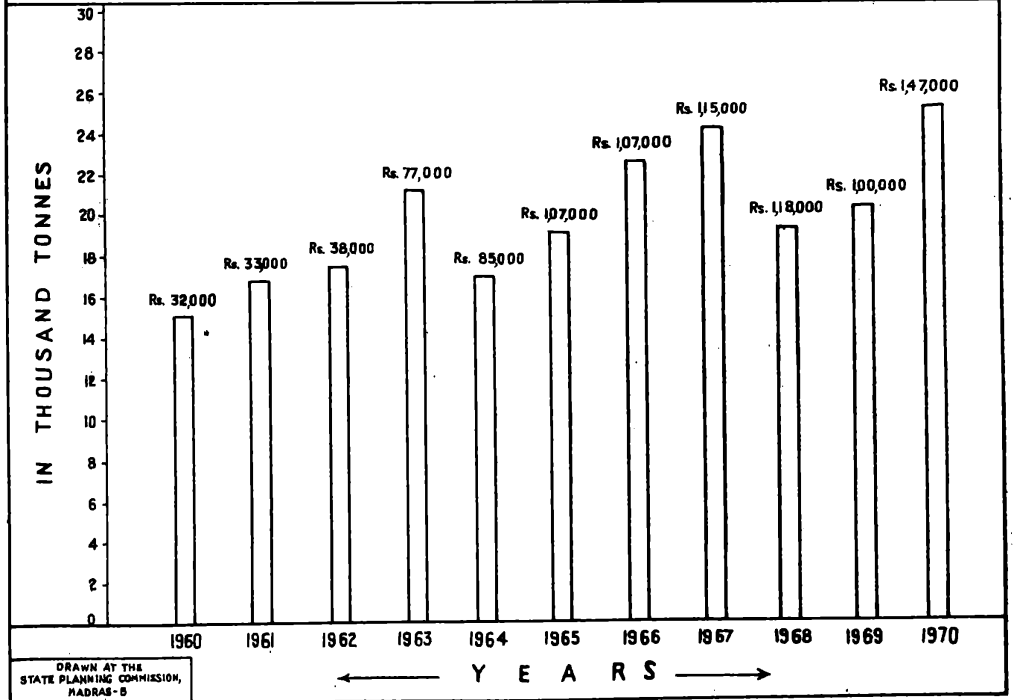
(5) Two Crockery Units to be established.

(6) A high-tension, low-tension insulator unit to be put up.

(7) A market research organisation for ceramics and final products is to be established.

The programmes 4, 5, 6 and 7 though fall within the scope of the industrial sector, industries of this type can be put up under the Market Wing of the Directorate or the Corporation, just as the Department of Industries maintain certain production and sales

PRODUCTION OF FIRECLAY DURING 1960-'70 IN TAMIL NADU



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wings. In fact some Japanese concerns are willing to colloborate on these ventures. The profit that are earned through these ventures can be spent towards the maintenance cost of the Corporation. The stages by which these are to be established are discussed at the end of the report. The demand for white sanitary and stoneware in the State will be very much higher during the Fifth and Sixth Plan periods as per the estimates made by the NCAER[1]. The same holds good for construction bricks. So the production should be increased in accordance with this demand for which there is an abundant scope.

4.6. *Copper, Lead and Zinc.*

4.6.1. *Occurrences.*—Following three occurrences of the base metals are known in the State :

(i) Mamandur in South Arcot district.

(ii) Twelve kilometres south of Tirunelveli on the road to Nanguneri in Tirunelveli district.

(iii) In Velimalai reserve forest, 18 kilometres north of Nagercoil in Kanyakumari district.

4.6.2. *Zone of Mineralisation.*—

A mineralised shear zone with chalopyrite, malachite, azurite, galena and sphalarite has been discovered near Mamandur, in Kallakurichi taluk, South Arcot. Six drill holes were put down by the Geological Survey of India, to depths between 100 to 130 metres Reserves are estimated at 0·9 million tonnes of ore assaying 0·63 per cent copper, 2·0 percent lead and 2·73 per cent zinc. Surface indication point to one or two more shear zones in the vicinity. Though the Mamandur deposits appeared to be very promising owing to its multifarious metal values, further exploration proved the deposits to be trivial. But a through search all along the shear zones of South Arcot whose trend coincides with that of eastern ghat orogeny, viz., north east-south west should be searched intensively for sulphide mineralisation.

Debris dug out from a well 12 km. south of Tirunelveli was found to contain up to 1·5 per cent copper. Surface indications in Kanyakumari district show pyrrhotite with 0·63 to 1·79 per cent copper, 0·47 to 0·79 per cent nickel and traces of molybdenum.

4.6.3. *Recommendations.*—

The presence of several shear zones in the Mamandur area indicates scientifically the possibility of occurrences of sulphide minerals. Hence the following programme is to be undertaken :—

(1) All the zones of shear trending north east-south west should be carefully mapped.

(2) By proper geophysical method the zone of sulphide mineralisation should be explored by deep drilling operations.

Both these could be undertaken in the Fourth Plan itself (1972—74). The assistance of United Nation Development Projects experts may be sought for these works.

[1] Industrial programmes for the Fourth Plan period, Madras State, 1965.

4.7. *Graphite.*

4.7.1. *General.*—Graphite is a crystalline form of carbon generally found in igneous and metamorhpic rocks. The mineral occurs in granites, pegmatites gneisses and limestones as veins or pockets. It also occurs in schists. Graphite may be found as flakes, lumps or as disseminations. It soils the finger when scratched.

The mineral graphite it usually dark grey or black in colour. Graphite flakes are generally flexible but inelastic. The mineral is infusible and it is a fairly good conductor of electricity. It closely resembles molybdenite in colour, appearance and feel. But graphite has a lower specific gravity (2·2) when compared with that of molybdenite (4·7) and gives a jet black streak on a porcelain plate in contrast to the distinctly greenish tinge of molybdenite.

Chemically, graphite is made up of only pure carbon just like charcoal or diamond. In fact, it is only a crystalline modification of carbon. The purity of graphite varies in nature from 30 to 98 per cent. The best graphite contains about 98 per cent of carbon. The second and third grades may have 75 to 90 and 50 to 75 per cent respectively.

Generally the ore, after recovery from the mine is crushed and the impurities are separated and the mineral is concentrated. Subsequently, it is ground into fine powder in ball mills.

4.7.2. *Uses.*—Due to the high melting point of the mineral, graphite(3000°C.) and its insolubility in acids, it is used in many industries. Flaky graphite mixed with fire clay is made into crucibles which are extensively used for smelting noble metals. In electrical industry, it finds various uses. It is used in the manufacture of brushes for dynamos and other electric machineries; as electrodes in electric arc furnaces; in dry batteries and also for foundry facings. Graphite forms an excellent lubricant when mixed with oil or grease and is therefore extensively used in heavy machineries. Graphite with low percentage of carbon, i.e., 30 to 35 per cent , is used for paints.

The well known use of graphite is in making lead pencils for writing. For this purpose, soft, amorphus graphite is mixed with black clay and antimony sulphide and kneaded. It is passed through a mesh and comes out in the shape of a wire. This is cut into proper length and finally baked at a temperature ranging from 1039°C to 1850°C. The hardness of lead in any pencil is dependent on the amount of clay mixed and also on the degree of baking. There are also other uses of graphite such as for making glazing powder, pipe cement, etc.

Artificial graphite can be made by heating petroleum or anthracite coke with quartz and saw dust at 4000°C. This gives flaky graphitic carbon which may be used for making polishes, dry batteries and also in the manufacture of lead pencils.

4.7.3. *Occurrences.*—In Tamil Nadu, Graphite occurs in Tiruchirappalli, Coimbatore, Madurai, Tirunelveli and Ramanathapuram districts. But the deposits in Tirumangalam in Madurai District and Sivagangai in Ramanathapuram are the only two workable deposits of Tamil Nadu.

Detailed investigation for graphite in Komalipatti and Sendudayanathapuram villages in Sivagangai area has been carried out. For this purpose 16 angular bore holes were completed aggregating to a total depth of 455 metres. Graphite bearing zones have been met with in these bore-holes at several horizons between 3 and 32 metres. Besides drilling 14 linear trenches were opened in the soil covered areas to prove the continuity of the graphite bearing rocks and samples were collected from the newly opened trenches. Some 41 samples were beneficiated in the field laboratory to determine the percentage of graphite in the rock which was found to vary between 18 and 23. The graphite bearing zone has been proved along the strike direction for a distance of nearly 2,000 metres. Preliminary estimates of reserves is of the order of 180,000 tonnes of graphite bearing rock. Representative bulk samples collected from trenches in the area were sent to the ore dressing laboratory of the Tamil Nadu Mineral Development Project for conducting beneficiation tests and also to the Government Crucible Factory, Rajahmundry, Andhra Pradesh and to the Southern Graphite Crucible Factory, Salem for determining their suitability for crucible manufacture.

The Sivagangai graphite are found to be useful for the manufacture of crucibles, Electric arc carbons and for refractories.

Further prospecting by trenching and drilling in this area is in progress.

A reconnaissance study of the graphite occurrence around Kalluthu of Usilampatti taluk of Madurai district was carried out in collaboration with the Geophysical party of the Geological Survey of India. The self potential values obtained during the initial traverses seem to be encouraging and further work is under progress. Detailed mapping of the area is also being carried out to delineate the graphite bearing quartz veins.

Graphite being a prescribed substance under the Atomic Energy Act, 1962, the data on its production is kept confidential.

4.7.4. *Recommendations* : (1) A graphite Crucible plant may be established in Sivagangai.

(2) Possibility of exploiting Thirumangalam deposit may be examined.

4.8. *Gypsum.*

4.8.1. *General.*—Gypsum, a hydrated sulphate of calcium ($CaSO_4$, $2H_2O$) is a widely distributed non-metallic mineral. Deposits of gypsum are worked mainly in Tamil Nadu, Rajasthan, Gujarat, Uttar Pradesh, Jammu and Kashmir and Maharashtra.

4.8.2. *Occurrences.*—Among all the States in South India, Tamil Nadu is the only area with sizeable reserves of gypsum, mainly in Tiruchirappalli district (15·3 million tonnes). Some small deposits occur in Ramanathapuram district where the reserves are estimated at only a few thousand tonnes. Occurrences in Coimbatore and Tirunelveli districts are more substantial. Gypsum occurs in the State in two forms; one is of marine origin and the other is the alluvial form of gypsum. In Tiruchirappalli district, in the Perambalur and Lalgudi taluks, gypsum occurs in the "bad lands".

The mineral occurs in clay beds from Chittali in the north to Tappay in the South. The mineral occurs mainly in Odiyam, Maravathur, west of Sirukambur and in the area enclosed by Karai, Terani, Uttatur, Nambakurichi, Peruvalapatti in the west and Sirukalapur, Garudamangalam Anaipadi, Kulukalnatham in the east. In addition to this the mineral occurs around Tappay near Palambadi. Gypsum occurs in an area of about 22 sq. miles. There are four varieties of gypsum in this area, (1) Selenite or Transparent crystals, (2) Fibrous variety, (3) Platy variety, (4) fine dissemination type. Fibrous and selenite varieties are common. Gypsum of alluvial character occurs in the black soils especially near the coastal areas of Mudukalathur taluk of Ramanathapuram at the Avanthandai, Kokkadi, Panbasi, Tanurai, Kilakai and Alarakaraivadi. Out of the above, the first two localities appear to be of some economic importance. Each acre is estimated to yield over 300 tonnes, for a depth of 12 feet. The total quantity of gypsum expected out of the Avanthandai Kokkadi area is about 20,000 tonnes. Some of the gypsum has already been mined in these areas for supply to Messrs. India Cements, Ltd.

Small quantities of Gypsum occur at Kandasamipuram, Jagavirapuram, Kuthumani, Suppalapuram and Ramanuthu in Tirunelveli district and around the villages Gomayalapuram, Periyapudur, Palladam and Ariyur in Coimbatore district.

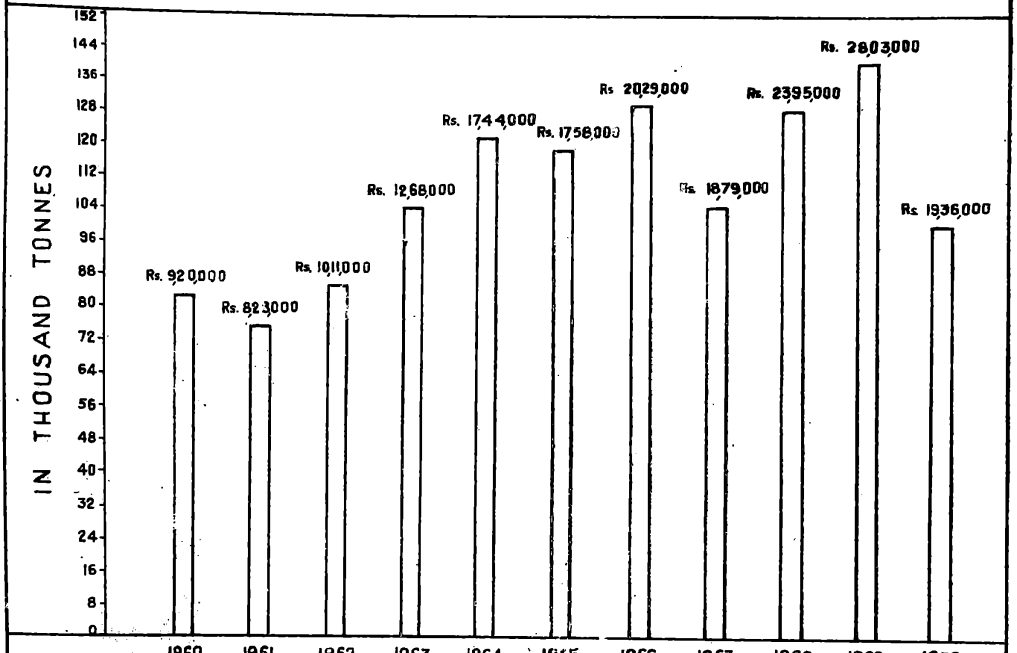
Besides this, about 50,000 tonnes per annum of Gypsum is produced in the salt panes during the solar evoporation of sea water for producing common salt.

Fertilisers and Cement are the two important industries in which gypsum finds use. High purity gypsum is utilised in large quantities in the manufacture of ammonium sulphate fertiliser ; gypsum of lesser purity in crushed form is utilised in the manufacture of Portland cements where it acts as a retartor, controlling the setting time of cement. Gypsum finds use in agriculture as a surface plaster for conserving moisture in soil and for aiding nitrogen absorption. Calcined gypsum finds use in plasters and manufacture of plaster of Paris. There are other uses for gypsum in paper, paint, rubber and textiles industries. Alabaster, a massive variety of gypsum is employed for artistic, stationery and ornamental purposes. Selenite, a crystalline vareity is used to a limited extent for the making of Gypsum Plate in microscopes. The various uses of Gypsum makes it an important raw material and its development should be programmed in a proper manner. The industry-wise despatches of Gypsum during 1965 and 1966 are shown below :—

TABLE XV.

Name of the Industry.	1965 (*Tonnes*).	1966 (*Tonnes*).
Fertiliser	640,865	694,245
Cement	453,946	506,442
Agriculture	3,673	4,165
Plaster of Paris	2,579	1,957
Others (unspecified)	33,575	40,292

PRODUCTION OF GYPSUM DURING 1960-'70 IN TAMIL NADU



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Production of Gypsum in the last one decade in the State is given in Table XVI.

TABLE XVI.

Metric tons. *Thousand Rupees.*

Year.	Total.		Tamil Nadu.	
	Quantity.	*Value.*	*Quantity.*	*Value.*
1960	997,443	6,240	82,247	920
1961	865,582	5,363	74,676	828
1962	1,122,110	6,806	83,925	1,011
1963	1,190,912	7,304	102,857	1,268
1964	882,493	6,867	119,826	1,744
1965 ..	1,160,366	8,577	117,167	1,758
1966 ..	1,298,042	10,196	127,131	2,029
1967	1,039,030	8,433	101,711	1,879
1968	1,337,529	12,097	129,551	2,395
1969	1,390,680	13,688	133,167	2,803
1970	920,536	8,829	93,120	1,936
1971 ..	1,703,482	11,308	104,318	2,144
1972 Jan. ..	105,794	1,055	4,790	104

In addition to consumption in the cement factories in Tamil Nadu, Gypsum is also sent to the neighbouring states.

4.8.3. *Recommendations.*

The following proposals are suggested with regard to gypsum deposits of the State :

(1) It should be confessed that no systematic evaluation of potential reserves has been made till date ; this needs to be done as the first step towards the exploitation of this mineral.

(2) The production of gypsum in 1971 is 104,318 Metric Tonnes or roughly 9·6 per cent of the All-India production. There are excellent prospects for the development of cement and fertiliser industries which consume gypsum in large quantities. However the present supply of gypsum is unsatisfactory on account of the primitive methods of mining and beneficiation employed which restrict production and give a low recovery rate as well as a relatively higher cost of production. It is recommended that a pilot project should be undertaken for testing improved methods of mining and recovery, provided investigations establish the occurrence of sufficiently workable reserves. The recovery rate can be easily stepped up by 50 per cent and the cost substantially reduced by introducing elementary mechanisation.

4.9. *Ilmenite and Rutile.*

4.9.1. *General.*—Ilmenite is an ore of Titanium metal which has now assumed strategic importance. It is a dark mineral resembling magnetite in appearance and occurs either as massive lumps or as loose sands. It is often associated with iron ore. Ilmenite occurs as placer deposits at the mouth of rivers or the beach and is very often mixed with other minerals like magnetite, rutile, monazite and zircon.

Though Titanium, because of its certain special properties, is finding new uses, the mineral ilmenite is at present mainly used for making quality white paints known as "Titanium White". Among its chemical uses titanium chloride is useful to remove the colours from clothes and titanium tetrachloride is made use of as smoke screen and also for sky writing. Another important use of Ilmenite is in the production of titanium metal and ferro-titanium. Titanium combines the properties of strength with lightness and hence is used in special structural materials for the air-craft and other aviation industry. In advanced countries, the second largest consumption of titanium next to pigment manufacture is in the metallurgical industry. India is developing her own air-craft industry for which requirements of titanium alloys are expected to be appreciable before long.

Rutile (Pure form of TiO2) occurs with Ilmenite in the beach sands of Kanyakumari district to the extent of 3 to 4 per cent. Rutile is mainly utilised in the manufacture of arc-welding electrode in order to give smoothness.

4.9.2. *Occurrences.* Tamil Nadu the deposits are essentially 'placers' in character and occur in patches as small as 60 metres by 15 metres and as extensive as 15 km. by 100 metres. The placers are the result of seasonal but endless process of natural replenishment caused by continuous tidal wave action. In the coastal tract of Kanyakumari, there are three regions in which we get the concentrated patches of ilmenite in large amounts of beach sands consisting of 55 per cent of Ilmenite, 7 per cent of garnet, 5 per cent of monozite, 3 per cent of zircon and some quartz.

The Kadiapatnam-Manavalakurichi stretch of beach deposit has an estimated reserve of 180,000 tonnes with a daily replenishment rate of about 15 cm. The garnet content is very high, and, in the early stages, the high Cr_2O_3 contents in Ilmenite was found deleterious.

The second region is situated near Midalam, 14 km. north west of Colachel on the Arabian coast. The occurrence is between Midalam and Kurumani towards south. The length of the beach is about 1·5 kilometres. The width of the beach is about 50 metres, with an elevated straw-line approximately 5 metres from the water-line. The deposit is roughly estimated to be about 100,000 tonnes with endless replenishment potential. Also, the Geology department has just completed extensive investigations and the results are awaited. It is understood that Indian Rare Earths at Manavalakurichi carry out seasonal mining of this area and remove about 50,000 tonnes of beach sand a year from points of highest concentration. They have now applied for mining lease for about 76 acres of coastal strip in this area.

The third one is the Leepuram-Vattakottai region. Leepuram lies 2 miles north of Kanyakumari on the east coast and strandles the deposit commencing right from Cape Camorin and up to the border of Tirunelveli district. The occurrence is in patches for about 3 kms. and more intense for about 2 km. upto the point where the coast is cut by the fort. But during April to September, the occurrence is uniform and the entire coast of about 5 km. is an unending sight of blackish sand. The deposit is active placers in type and is highly concentrated. Test pits of 2 metres depth in a strip of over 500 metres, south of the Fort revealed uniform deposition of Ilmenite rich black sand with no intruding striation of sand. It is possible the deposits would go considerably deeper. The ilmenite content here is estimated to be about 85—92 per cent Monozite 3–7 per cent with traces of zircon, sillimanite, and garnet of heavy mineral fraction.

A cursory estimate of the resources place the available quantity between 100,000 and 150,000 tonnes with infinite replacement potential. Recent studies conducted by the Geology Department show a deposition rate of 12 to 50 cm. per day. An area of 46 acres (approx) had been released to Indian Rare Earths, who have opted for selected patches of the beach. It is understood that mining has not commenced because of the objections by holders of patta lands bordering the beach. In the same region, near Thattaruppallam, the geology department had done extensive investigations of this deposit. This occurence is located about 1.8 km. north-east of Vattakottai Fort and extends for a length of 600 metres, with widths varying between 10 metres and 70 metres. The heavy minerals found are mainly, ilmenite, magnetite with small percentages of garnet and rutile.

Important deposits are known to occur at the mouths of Vaipar and Kallar river in Tirunelveli district, Avudaipalayam, Idindakarai, Taruvaikkulam, mouth of Nambiar. Mouth of Tambaraparani, Vijiyapatti and Kuttankulli are the other places in the district where fairly good deposits of Ilmenite occur. The reserves are not correctly known.

There are some small, patches of ilmenite in the Ramanathapuram coast also, among which the more important are in Kilakarai, Periyapattanam, Ariyavam the mouth of Virusuli and Pambar.

Garnet and Ilmenite sands occur between Pamban and Ariyankadu villages over a distances of 4 miles. About 1,200 tonnes of garnet and 400 tonnes of ilmenite are estimated to occur.

There are several occurences along Thanjavur coast but they are all small and minor patches except the one found near Tranquebar. Some rocks occur near Tiruvalaivasal mouth of Coleroon, between Mimisal and Adirampatnam. Reserve figures are not estimated for these deposits.

4.9.3. *Quality.* The chemical analysis of the Manavalakurichi Ilmenite is given along with that from Chavara in Kerala State for purposes of comparison in the Table XVII

TABLE XVII.

	Manavalakurichi.		*Chavara.*	
	I	II	I	II
TiO_2	54·0	54·19	10·03	60·71
Fe_2O_3	17·0	14·52	24·77	25·57
FeO	23·0	25·30	9·67	8·04
Al_2O_3	..	1·92	..	1·69
MnO	0·40	0·50	0·47	0·39
CaO	..	..	..	..
MgO	..	0·81	..	0·84
Cr_2O_3 ..	0·05	0·09	0·08	0·13
V_2O_5	0·18	0·02	0·20	0·03
P_2O_5 ..	0·22	0·04	0·19	Tr.
SiO_2	1·18	0·87	0·71	0·67
ZrO	..	1·45	..	0·80
Rare earth ..	..	0·02	..	Tr.

Specifications for Titania Pigment manufacture lay down that chorimium oxide should not exceed 0·2 per cent and Vanadium pentoxide 0·5 per cent in the ilmenite. While the analyses above are already within these limits, a sample recently analysed at the National Metallurgical Laboratory gave 0·28 per cent chromium oxide and 0·25 per cent Vanadium pentoxide. The bulk of Ilmenite produced is exported, the entire production is contributed by the Kerala and Tamil Nadu States. Of late, India which used to be the major exporter of Ilmenite in the world has lost her position as can be seen below from export figures.

TABLE XVIII.

Year.	*Tonnes.*
1957	352,767
1958	288,216
1959	281,057
1960	278,916
1961	125,213
1962	101,248
1963	80,150

This affected the production to a great extent. In Tamil Nadu Production of Ilmenite which stood at 4,056 tonnes in 1961 recorded considerable increase to 24 thousand tonnes in 1966 and 35 thousand tonnes in 1969. The output of Ilmenite came down to 14 thousand tonnes in 1970 which is a decline of 60 per cent compared with 1969.

4.9.4. *Production.* Table XIX below gives details relating to volume and the value of Ilmenite Produced in Tamil Nadu.

TABLE XIX.

Year.	*Tonnes.* (METRIC TONNES)	*Value.* (LAKHS)
1961	4,056	2·15
1962		
1963		
1964	7,584	1·31
1965	26,854	4·64
1966	23,901	4·50
1967	31,696	10·30
1968	45,351	14·76
1969	35,504	11·20
1970	1,015*	1·60

* Sillimanite.

While difficulties appear to have arisen on account of the impurities in recent years the major reasons for the fall in shipments are :

(i) high prices of Ilmenite India, F.O.B. Koilthotam—Rs. 73·16 as against Australia, F.O.B.—Rs. 42·65.

(ii) Irregular shipments, and slow shipments.

Also, new sources have been developed with consequent increased competition.

In an attempt to reduce the impurities, tests have been conducted at the National Mettallurgical Laboratory by smelting Ilmenite and recovering iron in electric furnaces after the procedure adopted in Canada.

In so far as some of the world's major producers of titanium pigment have used Indian Ilmenite and without any difficulty produced top grade pigment till recently, one may well look at the benification plants for the causes for the deterioration of the concentrates. It is well known that these plants are outmoded and are operated inefficiently. Immediate steps are to be taken for a thorough overhauling of the plant at Manavalakurichi.

There is vertical and horizontal integration between the producers of Titanium minerals and the producers of titanium pigments and metal. This is equally true of India as of the developed countries. It is imperative to plan the exploitation of the resources primarily with reference to our national programmes and priorities. To achieve optimum results, the development of mineral resources should be industry-based.

4.9.5. *Industries Processing Titanium Minerals :*

Indian Rare Earths and F.X.P. Minerals are the only two producers in the country. The former have plants at Chavara and Manavalakurichi and latter at Koilthottam (Chavara). The current production and plans are as follows :—

(1) F.X.P. MINERALS.	*Tonnes per year (approximate).*
Ilmenite	30,000
Rutile	600

(2) INDIAN RARE EARTHS.

	Current production. (IN TONNES PER YEAR APPROXIMATE.)	*Planned production* (1972). (IN TONNES PER YEAR APPROXIMATE.)
Ilmenite	130,000	180,000
Rutile	6,000	8,000
Monazite ..	3,000	4,000

The Rutile proportion varies considerably and the above are the targetted production figures. Considerable tonnages of Ilmenite and Rutile are committed to Ishihara Sangyo of Japan for long time deliveries.

Industries using Titanium Minerals.

(1) Travancore Titanium Products	50,000 tonnes per year of Ilmenite by 1972.
(2) Dharanghadhara Chemicals (Sahupuram for beneficiation) ..	40,000 tonnes per year of Ilmenite.
(3) Welding Electrode Industries	Over 5,000 tonnes per year of Rutile with an expected annual growth rate of 10 per cent.

Chlorinators (India) Ltd., Calcutta, have plans with an expected yearly off-take of about 10,000 tonnes of Ilmenite.

Ballarpur Paper and Straw Mills Ltd., have announced plans of a ' Titanium Complex ' near Alwaye for the production of 25,000 tonnes per year of Pigment (Requiring 50,000 tonnes per year of Ilmenite), 3,000 tonnes per year of Sponge (needing 10—12,000 tonnes per year of Ilmenite) and 80,000 tonnes per year of Titanium Tetrachloride (requiring about 140,000 tonnes per yer of Ilmenite). They plan to upgrade or beneficiate Ilmenite using the ' BENILITE ' process as the starting feed material for the above complex. They are to be assisted by Benilite Corporation of America under colloboration.

The projected demand is estimated at about 300,000 tonnes of Ilmenite and 10—12,000 tonnes of Rutile annually. The current productions and announced expansion programmes will yield 250,000 tonnes of Ilmenite and 9,000 tonnes of Rutile per year, granting that productions matching rated capacities are achieved. The shortfall can be met only by extension of operations. It is understood that plans to work the Ratnagiri and Orissa reserves are actively being pursued and Indian Rare Earths may feature in these operations.

The pattern of our economy and rate of industrial growth place great emphasis on Titanium—based industries. The present national demand for Titanium pigments is supplemented by imports. Travancore Titanium products is the only producer of pigments, who are expanding their capacity to 240,000 tonnes per year. Their production is confined to anatase grade only. But the demand is expected to outstrip by far the local production by 1975–78.

Steel industry activity determines welding rod consumption, steel activity is expanding and so will requirements of welding electrodes, and consequently natural rutile. Wherever natural rutile sand is in short supply, the upgraded Ilmenite (usually called synthetic Rutile) is the only other alternative.

Consumption of Titanium metal is at present confined mostly to aeronautics and space. India is in the foetal stage and the years to come can be expected to demand sufficient tonnages of this metal.

The available resources in the State are workable. An industry for processing the beach sand and separation of Ilmenite and other heavy minerals will be commercially viable. The existing national and international conditions seem most favourable.

4.9.6. *Recommendations :*

Bearing all these points in mind, the following proposals are worthwhile considering :

(1) Tamil Nadu Government should accord top priority to the commercial exploitation of the Ilmenite resources in the State and set in motion a crash programme for setting up a full scale plant for the production of Ilmenite, Rutile, etc., from the Beach sands. The possibility of manufacturing of Titanium metal may be explored.

(2) The Geology department may be entrusted with the task of investigating the occurence and rate of replenishment in the Vaipar—Kallar Delta.

(3) Vaipar—Kallar Delta may be considered for locating a separation plant. The advantages are close proximity to a major port, viz., Tuticorin, availability of extensive Government waste lands and the ready availability of high voltage electricity. The resources in this area are estimated to support independantly a separation plant for processing of Ilmenite and other heavy minerals with a rated capacity of 50,000 to 70,000 tonnes.

(4) To arrange for feasibility and project studies.

(5) A technical committee to visit the units working in India for study of produotion methods and cost involvements.

(6) The committee should visit Ceylon, whose plant is considered to be most modern and best suited for working the resources in India.

CHAPTER V.

PROPOSALS FOR FURTHER DEVELOPMENT—*cont.*

5·1. *Iron ores.* There has always been a close correlation between economic development and steel output. The widespread beneficial effect of steel development could be gauged from the *fact that every job in the Steel Industry creates 8 to 10 new jobs in other industries which use steel as raw material.* Besides these factory jobs, additional employment is generated in various other fields such as mining, transport and construction. Thus steel production has been considered the barometer of economic activity. In our country however, concerted effort to raise the iron ore production has been made only after the attainment of independence.

The degree of industrialisation of a country, in fact, is judged by per capita consumption of steel. The per capita consumption of crude steel in India was about 16 Kg. during 1965 against 656, 540 and 294 for the U.S.A., West Germany and Japan. Even with the increasing industrialisation of the country with the help of 3 steel plants in public sector the per capita production of steel is still insignificant when compared to Japan, West Germany and the U.S.A., India's share in the world output of steel was just 1.1 per cent in 1970. The leading producers of the world are the U.S.A. having 120 million tonnes per annum, the U.S.S.R. 115 million tonnes per annum and Japan with 95 million tonnes anually.

The increasing trend in the output of iron ore in the last few years may be observed from the following Tables XX and XXI.

TABLE XX.

State-wise Railments of Iron Ore, 1965 and 1966 (Excluding Goa).

States.	1965			1966		
	Railments for internal consumption.	*Railments for exports.*	*Total Railments.*	*Railments for internal consumption.*	*Railments for exports.*	*Total. Railments.*
			(IN TONNES.)			
Andhra Pradesh	1,637	150,491	152,128	849	150,579	151,428
Bihar ..	3,449,691	758,604	4,208,295	3,267,319	1,921,642	5,188,961
Madhya Pradesh	2,506,402	26,144	2,592,516	3,567,548	41,851	3,609,399
Tamil Nadu ..	419	..	419			
Maharashtra ..		338,585	338,585		237,375	237,375
Mysore ..	161,017	2,388,652	2,550,560	198,576	2,784,176	2,982,752
Orissa ..	5,545,581	699,551	6,245,132	4,951,892	889,886	5,841,778
Rajasthan		10,825	10,825			
All-India Total	11,725,647	4,372,822	16,098,460	11,986,184	6,025,509	18,011,693

TABLE XXI.

OUTPUT OF IRON ORES IN VARIOUS STATES IN INDIA AND IN INDIA.

(Quantity : In metric tons ; value : Thousand Rupees.)

Year.	Andhra Pradesh.		Bihar.		Goa.		Haryana.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1967	155,463	985	5,381,682	77,706	6,750,511	66,493	..	
1968	185,876	1,199	5,731,208	80,563	6,856,480	69,593	20	
1969	114,508	826	5,352,600	82,108	7,057,105	83,845		
1970	111,069	728	5,135,240	82,434	9,138,280	107,192		
1971	107,868	648	4,818,990	77,229	10,552,191	117,604		
	674,784	4,386	26,419,720	406,040	40,954,567	444,727	20	

Year.	Madhya Pradesh.		Maharashtra.	
	Quantity.	Value.	Quantity.	Value.
1967	4,558,374	35,102	190,018	3,108
1968	5,403,463	49,325	212,430	3,373
1969	6,339,560	70,559	267,712	3,003
1970	7,168,050	90,437	445,856	5,010
1971	7,644,008	96,193	610,107	6,932
Total ..	31,173,455	341,616	1,726,123	21,331

Year.	Mysore.		Orissa.	
	Quantity.	Value.	Quantity.	Value.
1967	3,118,831	16,798	5,699,282	53,785
1968	3,428,289	19,493	6,142,635	56,305
1969	2,981,912	17,083	6,790,676	66,864
1970	2,996,417	18,009	6,368,645	64,177
1971	3,569,098	21,706	6,416,850	71,441
Total	16,094,547	93,089	31,418,088	312,572

TABLE XXI—*cont.*

(Quantity : metric tons ; value : Thousand Rupees.)

Year.	Rajasthan.		All-India Total.	
	Quantity.	Value.	Quantity.	Value.
1967			25,855,161	253,977
1968	189	1	27,960,500	285,752
1969	2,699	27	29,566,772	324,320
1970	2,753	18	31,366,315	368,005
1971	115	1	33,719,227	301,754
Total	5,761	47	148,468,065	1,623,808

5.1.2. *Production of iron ore*:

This tempo of exploration and exploitation of iron ore deposits has rapidly been enhanced only since the Second Plan Period owing to the commissioning of three public sector steel plants and the expansion of Tata Iron Steel Company. The Year 1966 recorded a significant progress in the iron ore mining industry in India. The output of 17.2 million tonnes recorded a sharp rise of 17 per cent in the next year 1966, when the total output figure exceeded 20 million tonnes. The production is in accordance with the envisaged targets of the III and IV Plan periods.

Iron ore deposits are located in every State in the country. The richer deposits are, however, confined to Bihar, Orissa, Madhya Pradesh, Maharashtra and Mysore though Andhra Pradesh and Rajasthan also contribute to the iron ore production in the country. Tamil Nadu's contribution to the iron ore production is almost nil, despite the vast resources of iron ore in the Salem (Kanjamalai), Trichirappalli and North Arcot regions. This is mainly due to fact that presently commercial exploitation is confined to the rich haematite ores of Bihar, Bengal, Orissa, Andhra Pradesh, Madhya Prdesh and Mysore. The ores of Tamil Nadu are of the magnetite type, amenable for benefication and suitable for the manufacture of high grade special alloy steel. A slight complication in the technology of extraction of metal from these ores precluded the possibility of utilising them. With a slight modification in the technology, these ores could have easily been used for the manufacture of special steel alloys the production of which would have accelerated the industrialisation of the country.

Another main reason for not utilising the magnetite ore of Tamil Nadu is the non-availability of proper fuel to convert the ore into metal and metal into steel.

5.1.3. *Need for Long Term Planning* :

Planning for steel should be well ahead of panning for the rest of the sectors for the following reasons :—

1. Iron and steel has pervasive uses in the production of several commodities and is a basic commodity.

2. To assemble the various raw materials in bulk needed for steel production involves transport problem.

3. The process of converting iron ore to metal and metal into steel involves numerous stages.

4. The problem of transport comes up again in distributing the finished products to the various consumer centres.

5. The gestation period, i.e., the period between the decision to set up a steel plant and the time when the unit actually goes into production and the finished product is ready for despatch to consumers and or stockists, is appreciably long.

All these make it essential for the developing countries first to project their future demand for steel on a long-term basis and then think of the production facilities. Such long term projections for basic-commodities like steel take into account the possible changes in the structure of economy of the country. Also it helps to make the planning of steel production a continual process, which is essential owing to the long time interval involved. Further, a knowledge of the magnitude of steel demand over some years can help decisions on the planning of indigenous fabrication of metallurgical equipment and the complementary facilities for intermediate products like heavy castings and forgings; all these industries are capital intensive and therefore call for advance planning.

5.1.4. *Demand for steel in India* :

The demand for steel in 1981 has been projected by National Council of Applied Economic Research* as 32 million tonnes of finished steel and 43 millions of ingot steel.

In addition to the 32 million tonnes of steel mentioned above for domestic consumptions it is also visualised that there could be exports of finished steel to the tune of five million tonnes in 1981 and which would fetch about Rs. 400 crores of foreign exchange. Thus in all, about 37 million tonnes of finished steel would have to be produced in 1981. The net value of this production in 1981, would be very nearly Rs. 1,500 crores, thereby, the steel industries itself would be directly contributing nearly 10 per cent to the total industrial income.

The place of steel in 1981 both in the industrial pattern and the country's economy is very vital.

To achieve this target of 37 million tonnes of steel in 1981, the iron ore production capacity has to be increased to 75 million tonnes, i.e., the present production should be trebled.

This can be achieved only by keeping pace with technological advancement achieved in the foreign countries. The following steps should be taken immediately:—

(1) Acquire the technological know-how of iron and steel making, utilising concentrated ores (from low grade ores occurring in Tamil Nadu) instead of looking for natural rich ores.

(2) Proper mechanisation of Iron ore mines.

* National Council of Applied Economic Research Long Term Planning for Iron and Steel, 1965.

5.1.5. *Tamil Nadu's unique position in Iron Ore Production* :

Iron Ore mined in India is of haematite type and is mostly of high grade (containing 60 per cent of Fe). As such concentration of the ore to improve them is generally not necessary before marketing. As has been pointed out already, the entire reserves of 800 million tonnes (Table XXII) of iron ore of Tamil Nadu are of the magnetite type. The metal (Fe) content ranges from 30–45 per cent.

TABLE XXII.

TOTAL RESERVES OF IRON ORES IN TAMIL NADU.

(Magnetite Type).

Salem-Tiruchirappalli Region :	
1. Kanjamalai Region	240 million tonnes.
2. Godumalai Region	70 million tonnes.
3. Tirthamalai Region	60 million tonnes.
4. Kollimalai Region ..	68 million tonnes.
5. Rasipuram-Namakkal Region	34 million tonnes.
6. Chitteri-Tainandamalai Region	56 million tonnes.
7. Pachchamali Region	11 million tonnes.
8. Attur-Sigiliam Kombai	12 million tonnes.
	551 million tonnes.
Tiruvannamalai Region :	
9. Kavuthimalai Region	56·0 million tonnes.
10. Vediappanmalai Region	60·0 million tonnes.
11. Uchchimalai West Region	20·0 million tonnes.
12. Uchimalai East Region	4·0 million tonnes.
13. Pinjur Reserve Forest ..	4·0 million tonnes.
14. Radhapuram Resrve Forest	4.5 million tonnes.
15. Kutalavadi Reserve Forest ..	2·4 million tonnes.
16. Sanandal	1·4 million tonnes.
17. Vayvidantangal	0·5 million tonnes.
18. Machengam	24·0 million tonnes.
19. Polur (Kattipundi)	36·0 million tonnes.
20. Kambugudi and Vasantapuram	35·0 million tonnes.
	247·8 million tonnes.
Salem-Tiruchirappalli Region	551·0 million tonnes.
Tiruvannamalai Region	247·8 million tonnes.
Total	798·8 million tonnes.

5.1.6. *Quality of the ore* :

The Kanjamalai ores, the raw material for the proposed plant at Salem are easily amenable to magnetic concentration to be utilised for the production of special alloy steel. This is possible bacause the iron oxide portion in the rock is highly magnetic. The injurious elements like phosphorous and sulphur are present only in negligible quantities making the concentrates specially suited for production of special alloy steel (Refer the various analysis given in Tables XXIII, XXIV, XXV, XXVI).

TABLE XXIII.

CHEMICAL ANALYSIS OF ADIT GROOVE SAMPLES

(Kanjamalai.)

Serial number.	*Sample number.*	*Interval in Metres.*	*Total Fe per cent.*	*Silica (SiO_2 per cent).*	*Phosphorous*	*Sulphur.*
1	AG 1	0 to 5	35·72	42·02	0·03619	0·005
2	AG 2	5 to 10	36·95	43·49	0·0312	0·0019
3	AG 3	10 to 15	34·81	41·98	0·0179	0·0014
4	AG 4	15 to 20	34·15	44·64	0·0307	0·0047
5	AG 5	20 to 25	29·32	47·04	0·0303	0·0041
6	AG 6	25 to 30	33·78	42·11	0·0476	0·0025
7	AG 7	30 to 35	30·36	48·50	0·0228	0·0014
8	AG 8	35 to 40	29·87	47·45	0·0463	0·0013
9	AG 9	40 to 45	33·37	44·42	0·0631	0·0238
10	AG 10	45 to 50	31·34	45·98	0·0333	0·0016
11	AG 11	50 to 55	33·61	43·93	0·0334	traces.
12	AG 12	55 to 60	32·58	42·39	0·0307	0·0036
13	AG 13	60 to 65	30·28	48·71	0·0438	0·0041
14	AG 14	65 to 70	29·34	37·84	0·0149	0·0166
15	AG 15	70 to 75	31·74	33·96	0·0579	0·0320
16	AG 16	75 to 80	33·45	42·81	0·1127	0·1127
17	AG 17	80 to 85	37·46	38·89	0·0939	0·0193
18	AG 18	85 to 90	35·91	35·61	0·1198	0·0082
19	AG 19	90 to 95	40·24	31·12	0·1139	0·0165
20	AG 20	95 to 100	23·47	41·39	0·0359	0·0055
21	AG 21	100 to 105	9·65	31·12	0·0169	0·0047
22	AG 22	105 to 110	18·31	32·58	0·0176	0·0049

TABLE XXIV.

ANALYSIS OF KANJAMALAI IRON ORES.

Serial number and Source.	*Fe.*	SiO_2	Al_2O_3	*CaO*	*MgO*	*P*	*S*	TiO_2	*MnO*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 Royal Institute of Science, Sweeden.	36·3	44·2	1·92	1·80	0·90	0·09			
2 Institute of Mineral Dressing. Froiberg, East Germany.	37·4	41·5	0·24	0·55	0·94	0·004	0·10		
3 National Metallurgical Laboratory, Jamshedpur.	36·5	44·2	1·92	1·80	0·90	0·09			
4 Published Literature of the Geological Survey of India.	36·86	44·44	..	..	..	0·136	0·002		
	36·42	44·60	1·17	1·32	1·64	0·386			
	31·60	50·34	1·28	1·22	1·59	0·118			
	35·08	46·55	0·43	1·05	1·86	0·100	..		
	34·70	49·07	..	..		0·086	0·006		
5 R. N. Corporation, New York.	35·5	45·1	0·12	0·10	0·70	0·01	0·02		
6 Sala Maskin fabrics AB Sala, Sweeden.	35·7								
7 National Metallurgical Laboratory, Jamshedpur.	37·0	47·0	0·8	0·20	1·00	0·007			
8 National Metallurgical Laboratory, Jamshedpur.	36·51	44·88	1·35	1·17	1·77	0·10	n.d.	n.d.	n.d.
9 Adit Sample (average).	35·48	42·77				0·051	0·012		
10 Float ore (average).	39·02	42·11	0·67	0·45	Traces.	0·03	0·001	Traces.	
11 "Iron Ores of Kanjamalai" unpublished thesis of Thiru S. Saravanan (1959)	56·50	22·01	3·91	1·53	2·81	0·24*	0·02	2·85	
	44·96	29·68	2·95	2·33	1·52	1·52*	Tr.	2·50	..
	38·10	36·20	2·85	2·84	0·85	0·16*	0·05	2·39	..
	37·05	40·91	2·20	1·03	0·73	0·11*	Tr.	2·36	..
	34·47	44·59	2·27	1·11	0·91	0·13*	0·03	2·36	..
	28·37	50·23	2·51	0·95	1·73	0·18*	Nil	2·65	..
	25·68	55·33	2·70	0·83	1·52	0·15	0·05	2·21	..
	25·91	55·98	2·43	0·91	1·01	0·13*	0·04	2·55	..

* P_2O_5

TABLE XXV.

CHEMICAL ANALYSES OF CONCENTRATES OBTAINED FROM KANJAMALAI IRON ORES.

Serial number and Source.	*Fe* (PER CENT.)	*Si* O_2 (PER CENT.)	*Al* $_2O_3$ (PER CENT.)	*Ca*0 (PER CENT.)	*Mg*0 (PER CENT.)	*P* (PER CENT.)	*Remarks.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
National Metallurgical Laboratory, Jamshedpur.	65·62	7·74	1·01	0·29	0·90	0·027	Wet Magnetic process.
Kerala Maskin Fabrics, Sweeden.	69·30	2·30	0·11	0·16	0·14	0·025	Sala process L.O.I. 0·40 per cent Mn. Traces S. 0·1 per cent TiO_2 0·008 per cent.
Madras Government	65·18	13·01	0·88	n.d.	n.d.	0·073	Dry Magnetic Laboratory Scale primary coarse crushing.
Madras Government ..	62·47	10·26	0·70	n.d.	n.d.	0·056	Do.
Royal Institute of Science, Sweeden.	62·10	13·30	1·12	1·00	0·70	0·081	Wet process primary.
Do.	68·80	n.d.	n.d.	n.d.	n.d.	0·022	Dry Process.
Electro Kemisk, Norway.	71·00	n.d.	n.d.	n.d.	n.d.	n.d.	Thune Separator and shaking table.
Dr. S. Saravanan	76·58		—	—			

TABLE XXVI.

RESULTS OF ORE-DRESSING TESTS IN THE KANJAMALAI IRON ORE.

1ST BAND.

(C.T.A.L. MADRAS.)

Sample number.	*Analysis of feed.*		*Analysis of concentrate.*			
	Fe.	*Acid insolubles.*	*Fe.* (—50+100)	*Acid insolubles.* (—50+100)	*Fe.* (—50+fines).	*Acid insolubles.* (—50+fines).
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 ..	39·43	42·86	65·4	7·5	61·5	11·8
2 ..	38·59	46·26	60·0	15·3	53·4	26·5
3 ..	38·9	45·5	62·7	12·2	60·7	14·9
4 ..	15·87	49·04	59·01	11·6	56·8	19·2
5 ..	36·5	46·82	61·9	12·2	59·8	14·8
6 ..	36·43	49·93	65·0	8·8	62·2	13·1
7 ..	36·47	47·54	67·4	5·7	54·6	22·5
8 ..	34·14	51·37	65·2	7·8	54·1	22·7
9 ..	33·72	51·22	64·4	8·3	59·6	15·2
10	31·37	54·71	59·0	16·2	55·4	23·5

TABLE XXVI—*contd.*

RESULTS OF ORE-DRESSING TESTS IN THE KANJAMALAI IRON ORE 1ST BAND

(C.T.A.L. MADRAS)—*contd.*

Sample number.	Analysis of feed.		Analysis of concentrate.			
			(—50 +100)		(—50 + fines).	
	Fe.	Acid insolubles.	Fe.	Acid insolubles.	Fe.	Acid insolubles.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
11 ..	33·15	51·33	60·9	12·0	58·75	14·6
12 ..	33·78	51·14	60·3	14·9	57·8	19·7
13 ..	35·84	52·13	66·3	5·9	60·3	13·4
14 ..	33·8	56·44	62·6	13·9	51·4	27·9
15 ..	34·84	53·43	61·4	14·9	60·5	16·7
16 ..	33·22	51·94	60·1	14·5	56·8	20·7
17 ..	32·13	54·17	59·3	17·5	60·7	14·7
18 ..	34·71	51·94	64·8	98·8	61·4	14·0
19 ..	34·84	52·31	61·4	12·5	54·0	23·4
20 ..	34·26	51·62	67·8	5·7	63·0	9·5
21 ..	35·67	49·14	66·5	8·1	60·8	11·4
22 ..	35·3	49·83	64·0	9·2	59·7	15·9
23 ..	32·56	54·49	65·5	8·9	63·8	10·3
24 ..	31·74	34·20	58·6	15·6	60·7	14·7
25 ..	34·57	50·81	60·0	44·0	58·9	17·2
26 ..	33·55	51·94	61·3	13·7	60·8	13·1
27 ..	36·29	46·97	60·5	14·1	52·4	26·3
28 ..	32·22	54·24	54·6	21·7	53·0	23·7
29 ..	36·84	47·03	61·8	13·8	52·2	24·7
30 ..	34·81	50·67	51·8	16·7	55·8	20·8
31 ..	33·88	50·07	51·5	25·7	52·9	24·2
32 ..	36·57	48·32	64·0	10·3	59·8	15·8
33 ..	35·46	69·68	64·7	6·7	58·6	15·4
34 ..	31·84	53·67	66·0	6·4	56·8	23·2
35 ..	35·60	49·48	62·3	12·4	60·6	15·0
36 ..	30·9	54·2	57·6	18·1	56·1	19·0
37 ..	30·36	57·98	47·8	32·5	47·6	32·7
38 ..	32·09	53·8	57·0	17·2	60·7	15·2
39 ..	35·05	49·5	60·4	13·8	60·2	14·2
40 ..	36·24	48·08	61·5	12·3	59·7	14·9
50 ..	35·01	47·75	66·1	4·01	60·0	10·0
60 ..	36·66	45·06	54·1	22·3	55·3	21·0
70 ..	37·91	41·55	61·1	13·8	61·1	14·7

TABLE XXVI—*cont.*

RESULTS OF ORE-DRESSING TESTS IN THE KANJAMALAI IRON ORE 1ST BAND

(C.T.A.I., MADRAS)—(*contd.*).

Sample number.	*Analysis of feed.*		*Analysis of concentrate.*			
			(− 50 + 100)		(− 50 + fines).	
	Fe.	*Acid insolubles.*	*Fe.*	*Acid insolubles.*	*Fe.*	*Acid insolubles.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
80 ..	35·49	48·53	59·8	12·3	61·1	9·8
90 ..	39·62	42·23	65·7	7·9	65·3	8·9
100 ..	34·73	45·14	57·4	17·0	55·1	23·8
110 ..	34·02	54·04	54·9	24·0	60·6	19·3
120 ..	38·4	45·8	60·4	15·8	63·6	9·7
130 ..	37·31	44·16	60·7	15·8	62·5	8·3

5.1.7 *Other Major Occurrences :*

Besides the Kanjamalai ores, there are good deposits of iron ore situated in Kavuthimalai and Vediappanmalai near Thiruvannamalai, North Arcot district.

The preliminary investigations proved that the iron ores of Kavuthimalai, Vediappanmalai, and other reported occurrences in and around Thiruvannamalai are almost in all respects similar to Kanjamalai deposits.

The chemical analyses of grab samples of Kavuthimalai, Vediappanmalai, Uchchimalai are given in the Table XXVII.

TABLE XXVII.

Sample number.	*Silica as SiO_2.*	*Total iron as Fe_2O_3.*	*Iron as Fe.*	*Iron as FeO.*	*Titanium as TiO_2.*	*Phosphorus as P.*	*Sulphur as S.*
	(PER CENT.)	(PER CENT.)	(PER CENT.)	(PER CENT.)	(PER CENT.)	(PER CENT.)	(PER CENT.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Kavuthimalai.—							
K 1	..	50·88	42·7	..	n.d.	0·10	0·03
K 10	44·01	55·88	39·08	11·08	n.d.	0·08	0·09
K 20	43·01	55·89	39·08	..	n.d.	0·10	0·05
K 30	46·10	53·60	37·41	8·30	n.d.	0·10	0·02
K 40	42·85	55·08	38·40	4·59	n.d.	0·09	0·07
K 50	42·63	56·69	39·65	5·53	n.d.	0·10	0·06
K 60	42·01	56·69	39·65	14·31	n.d.	0·10	0·08
K 70	40·84	57·48	40·20	7·21	n.d.	0·5	0·05
K 80 ..	40·03	58·96	35·91	8·63	n.d.	0·5	0·07

TABLE XXVII—*cont.*

Sample number.	Silica as SiO_2. (PER CENT.)	Total iron as Fe_2O_3. (PER CENT.)	Iron as Fe. (PER CENT.)	Iron as FeO. (PER CENT.)	Titanium as TiO_2. (PER CENT.)	Phosphorus as P. (PER CENT.)	Sulphur as S. (PER CENT.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Kavuthimalai—cont.							
K 90	35·30	62·27	43·55	8·76	n.d.	0·07	0·07
K 100	55·15	55·08	38·52	10·36	n.d.	12·0	50·09
K 110	47·20	51·30	35·89	7·80	n.d.	0·05	0·08
K 120	42·20	56·58	38·57	8·02	n.d.	0·05	0·07
K 130	39·26	60·16	42·07	10·75	n.d.	0·08	0·05
K 140	40·08	56·80	39·72	7·86	n.d.	0·06	0·04
K 150	42·68	56·58	39·57	7·20	n.d.	0·08	0·04
K 160	45·05	53·98	37·75	15·67	n.d.	0·08	0·10
K 170	44·14	55·08	38·40	8·48	n.d.	0·06	0·03
K 180	37·40	62·27	43·55	12·85	n.d.	0·08	0·07
K 190	36·00	63·87	44·67	4·25	n.d.	0·05	0·12
Vediappanmalai.—							
V 1		59·88	41·89		n.d.	0·01	0·002
V 10		48·79	33·52		n.d.	0·02	0·003
V 20		57·27	40·05		n.d.	0·02	0·02
V 30		52·69	36·85		n.d.	0·04	0·05
V 40		53·65	37·51		n.d.	0·02	0·04
V 50		57·48	40·21		n.d.	0·05	0·04
V 60		53·48	38·20		n.d.	0·01	0·02
V 70		50·30	38·90		n.d.	0·04	0·03
V 80		57·84	41·30		n.d.	0·15	0·01
V 90		59·89	42·80		n.d.	0·14	0·04
V 100		53·50	38·20		n.d.	0·07	0·02
V 105	46·68	48·06	34·30	6·09	n.d.	0·10	0·02
V 110		63·08	45·0	9·03	n.d.	0·10	0·04
V 120	..	48·79	34·8		n.d.	0·16	0·09
V 130	34·90	73·86	52·7	8·12	n.d.	0·08	0·25
V 140		57·20	40·8		n.d.	0·06	0·10
V 150		45·21	31·62		n.d.	0·09	0·10
V 160		63·87	44·68		n.d.	0·05	0·10
V 170		47·82	33·45		n.d.	0·06	0·01
V 180		52·57	36·81		n.d.	0·06	0·01
V 190		59·07	41·32		n.d.	0·06	0·01

TABLE XXVII—*cont.*

Serial number.	Silica as $Si O_2$.	Total iron as Fe_2O_3.	Iron as Fe.	Iron as FeO.	Titanium as $Ti O_2$.	Phosphorus as P.	Sulphur as S.
	(PER CENT).	(PER CENT).	(PER CENT).	(PER CENT).	(PER CENT).	(PER CENT).	(PER CENT).
(1)	(2)	(3)	(4)	(5)		(6)	(7)
Uchchimalai—							
UM 1	45·19	52·93	37·06	3·46	n.d.	0·10	0·07
UM 10	38·48	56·43	40·87	7·47	n.d.	0·10	0·14
UM 20	37·65	59·34	41·51	9·80	n.d.	0·05	0·10
UM 30	41·64	56·67	39·63	5·28	n.d.	0·07	0·03
UM 40	41·30	57·82	40·43	9·95	n.d.	0·07	0·10

The economic aspects of these deposits are indicated below :

1. Kavuthimalai and Vediyappanmalai are situated about 250 rail kilometres away from Madras harbour and about 155 rail kilometres from Cuddalore.

2. 100 million tonnes of reserve potential has been established, which could represent some 25 million tonnes of concentrate.

3. Economic mining could be carried out, with an annual concentrate target of 800,000 to one million tonnes per year. This would last for atleast 25 years.

4. Open cut mechanical Mining can be carried out satisfactorily as the magnetite quartzites occur as residual hills.

5. Benefication of the Kavuthimalai material indicates that from the coarse and medium grained ore satisfactory recovery of material upgraded to 68 per cent 'Fe' could be effected by an initial grinding to less than 0·1 mm.

6. There are adequate power supply in Tamil Nadu. There is a power station at Neyveli some 100 kilometres south-east of Thiruvannamalai.

7. The lignite mine at Neyveli could probably supply fuel for pelletisation.

5.1.8 *Ready rich ore versus concentrated ore :*

The non-availability of coking coal and the low content of iron in the ores were hitherto considered as the formidable difficulties in the establishment of modern iron and steel works in Tamil Nadu utilising the magnetite ores of Kanjamalai. The recent technological innovations in steel making have now provided ways and means of utilising the unconventional raw materials like lignite instead of coking coal, magnetite ore (Concentrate) instead of ready haematite ore with rich composition. Especially in the past one decade there has practically been a revolution in the Iron-making technology. In fact, in recent years there has been an increasing preference for the use of concentrated ores in the form

of sinters, pellets or other form of beneficiated agglomerates in iron and steel making. The main reasons for this trend, particularly in several industrially advanced countries such as the U.S.A., Japan, West Germany, etc., are as follows :—

1. Even the huge deposits of conventional lump ores of haematite are fast getting depleted.

2. The presence of too much fines and 'blue dust' makes it costly to produces iron of quality and there is much wastage of ore and transport losses as fines.

3. The pellets and agglomerates of concentrated ore are always of uniform composition while in the case of conventional ores, there may be variations of chemical composition of the feed into blast furnace from one charge to another. Moreover there is more control of impurities in agglomerated ore.

4. New technological advances such as direct reduction methods and the L.D. Process (in place of bessemer converters) of steel making have made it economical to use concentrated feed for iron and steel making. It is possible for steel makers to produce tailor made metal to required specifications since the concentrates are uniform.

5. In the case of transported or shipped ore, the concentrates are preferred since more "Fe" (iron) is carried per ton of ore, thus cutting the cost of freight.

An idea of the trend towards beneficiated ore may be obtained from the fact that in 1945 only 22 per cent of the 87 million tons of iron ore used in steel factories in the U.S.A., was of the beneficiated type, while by 1964 it rose to 77 per cent of the ore used in that country. The same trend is observed in many other advanced countries of the world. Low grade ores, especially of magnetite type are being crushed, ground, beneficiated and agglomerated for use in the iron and steel industry. Large deposits are being opened up in U.S.A., Canada, South America, Western Australia and East Africa to meet the growing demands for concentrates. Some of these ores are as poor as 15 to 18 per cent in their "Fe" (iron) content but after beneficiation, the magnetic concentrates grade 62 to 68 per cent in "Fe" content. However, one of the main pre-requisites for the use of such ore is that the ultimate cost of production of the concentrates or agglomerates must be low. Iron is still the cheapest and most widely used metal in the world and the margin of profit in iron ore trade is necessarily low. Therefore advantageous location, sizeable ore reserves and suitable physical and chemical properties are necessary if such low grade ores are to be profitably utilised after concentration.

5.1.9 *Salem Plant and Kanjamalai Ore* :

Because of these, the importance of Magnetite Ores of Tamil Nadu has gone up. Nevertheless there has been an undue delay in the establishment of steel industry in Salem. This delay continued even after the technical feasibility and economic viability of project was conclusively proved. After this inordinate delay, on the insistance of the Tamil Nadu Government, the permission for the plant was accorded. The construction of work of the Salem Steel Plant was inaugurated by the Prime Minister of India Thirumathi Indra Gandhi on Wednesday, the 16th September 1970, and "the dream of Tamil Nadu for many years" had come true. In the words of Dr. M. N. Dastur "The decision to establish

the Salem Steel Plant is not a mere matter of prestige or political expediency, but is based on sound techno economic considerations in the broader national interests". The need for disposal of steel industry in accordance with the principles of planned regional development has been recognised for long and it is in furtherance of this national objective that this and other two steel plants have been proposed to be set up in the south during the next few years. The Salem Steel Plant along with the other proposed two is bound to play a prominent role in shaping the industrial and economical development of Southern India in general and Tamil Nadu in particular. With the production of 0·25 million tonnes of special alloy steel at Salem utilising the iron ores of Kanjamalai, Tamil Nadu's first contribution to the All-India production of iron and steel will start. The state-wise analysis of the estimated demand for rolled mild steel in 1965–66 reveals that the demand in the southern States of Madras, Mysore, Andhra Pradesh and Kerala taken toge her is likely to be of the order of 1.17 million tonnes or 17 per cent of the All-India total for that year. It is also predicted that the impact of the considerable demand for steel from the three heavy industries in the public sector, in the south, namely, the High Pressure Boiler Plant at Tiruchirappalli, Heavy Electrical Plant in Hyderabad and Marine Engine Diesel Project in Madras will be felt more in the Fifth Plan period. The domestic demand for the southern region is placed at 2·4 million tonnes in the year 1970–71 nearly 20 per cent of the total domestic demand of India.

In pursuance of the decision of the Union Government to set up an Iron and Steel Industry in Salem, a new company "Salem Steels Limited" was incorporated in Madras on 25th October 1972 under the Indian Companies Act for the implementation of the Salem Special Steels Project. During the inauguration of the company the Union Minister of Steels remarked "Salem was different from the other steel plants in the country in that here we have the construction began from the rear. The cold rolling complex is to be put up first, which would use imported metal, until the other facilities were ready. They would simultaneously be moving towards the hot metal facility and the production of electrical steel. In the meantime, adequate expertise in this highly sophisticated field would be acquired. There would be the coke oven, blast furnace, steel melting shop, etc. working up an integrated special and alloy steel plant "KANJAMALAI ORE WOULD BE USED IN THE LATER STAGES".

The starting of "Salem Steels Limited" is happy news. However, it is disappointing to note that after a prolonged delay the authorities have not chosen a technology suitable for the utilisation of Kanjamalai ore for which Tamil Nadu has been pressing for long. The real criterion is that of efficiency which requires the correct choice of technology related to the local raw materials and the scale of production and the adoption of a pattern of growth which would enable the plant to continue to be viable and to expand economically in step with demand.

For optimum utilisation of the iron resources of Tamil Nadu, the following recommendations are made :

(1) To insist on the Government of India the need to utilise fully the local raw materials for the proposed Steel Plant at Salem.

(2) In view of the large anticipated demand for special steel alloy, there is ample justification for setting Salem Steel Plant at a much larger scale than envisaged at present

3. To errect immediately a concentration plant with plans to develop the same as pelletisation plant later at Thiruvannamalai utilising the Kavuthimalai and Vediappanmalai deposits. The export possibility of these ores may be examined, in case the possibility of establishing major or mini-steel plants are remote.

4. To study in detail the scope for establishing sponge iron plants on a regional basis to feed the continuous steel casting plants in the State. This could relieve the active threat of Iron Supply position in this part of the country not to talk of the stress and strain of our railways.

5.2. *Limestones.*

5.2.1 *General.*—Limestone is a carbonate of Calcium; pure limestone contains 56 per cent of CaO and 44 per cent of CO_2. However limestones are seldom 100 per cent pure. They carry varying amounts of silica, alumina, magnesia, iron oxides and other impurities.

Limestone is one of the most widely used industrial minerals being next only to coal and petroleum in the quantity used. It has several uses in various types of industries. Over 4 million tons are mined every year in Tamil Nadu. The important uses particularly with reference to Tamil Nadu are in the following industries :—

1. Cement manufacture.
2. Chemical industries such as calcium carbide, bleaching powder, etc.
3. For manufacture of lime for industrial, pharmaceutical and constructional uses.
4. In metallurgy as a flux.
5. Industrial uses such as production of carbon-dioxide gas, in glass manufacture, in paper manufacture, as filler in rubber industry, in leather tanning, in ceramics, paints, water purification and manufacture of glass wool.
6. Other uses such as road metal, concrete aggregate soil conditioner, etc.

The present pattern of consumption of limestone is presented in Table XXVIII which gives an indication of the relative importance of the various consuming industries.

TABLE XXVIII.

Consumption of limestone in different industries (as percentage).

	PERCENTAGE.
Cement	72·11
Iron and Steel	21·64
Paper	1·96
Chemical (Calcium carbide, Caustic Soda Bleaching powder).	2·64
Sugar	1·20
Glass	0·45
	100·00

5.2·2· *Occurrences.* There are large reserves of limestone in Tamil Nadu, particularly in the districts of Tirunelveli, Ramanathapuram, Tiruchirappalli and Salem. The total reserves of lime-stone in the State may be about 300 million tonnes of which about 75 per cent would be in the abovementioned districts. During recent years extensive work has been carried out on various deposits to determine the quality of the reserves and suitability for various industries.

The different types of limestone occurring in the major deposits in the State are as follows :—

1. Crystalline variety consisting of coarse grained calcite occurring as long narrow bands amidst the Precambrian gneisses found chiefly in Tirunelveli, Ramanathapuram, Tiruchirappalli (western taluks), Salem, Coimbatore and Madurai districts.

2. Massive sedimentary variety belonging to Cretaceous age which occur as irregular bedded deposits associated with sandstones and clays around Ariyalur in Tiruchirappalli district. The Pondicherry and South Arcot occurrences also are similar but less pure. The one found near Tisayanvillai in Nanguneri taluk, Tirunelveli district is a new find and belongs to the sedimentary type.

3. Coral material found along the coastal areas in Tirunelveli and Ramanathapuram districts and lime shells found in South Arcot and Chingleput districts. These represent organisms of sub-recent and recent times which have been growing in the shallow lagoonal areas and have accumulated at the sea bed. They are high purity calcium carbonate material, particularly the coral masses which occur along the coast and around numerous islands in the Gulf of Mannar between Rameswaram and Tuticorin.

The various deposits range widely in composition but the bulk of them may be termed to be of cement grade and this explains the growth of the cement industry on a large scale in this State (Table XXIX). Chemical industries based on limestone have also developed to some extent. They manufacture calcium carbide, bleaching powder, P.V.C., caustic soda, etc.

TABLE XXIX.

Name of the factory.	*Annual production in* 1971 (in tonnes).	*Installed capacity in tonnes* (Annual).
(1)	(2)	(3)
(1) Messrs. India Cements, Tirunelveli district	825,741	864,000
(2) Madras Cements, Ramanathapuram district	171,700	190,000
(3) Tamil Nadu Cements, Ramanathapuram district.	275,072	400,000
(4) Dalmia Coments, Tiruchirappalli district ..	512,085	525,000

TABLE XXIX—*cont.*

Name of the Factory	*Annual production in* 1971 (in tonnes).	*Installed capacity in tonnes* (Annual).
(1)	(2)	(3)
(5) Chettinad Cements, Tiruchirappalli district	241,296	400,000
(6) India Cements, Salem district	451,018	450,000*
(7) A. C. C. Cements	320,970	384,000
Total ..	2,797,882	3,213,000

(Total cement produced in India in 1971 was 14,904,231 tonnes.)

* Recently increased to 700,000 tonnes (1972).

5.2.3 *Production*—

The trend and value of limestone production in the country as well as in the State is tabulated in the following Table XXX:—

TABLE XXX.

QUANTITY IN METRIC TONS.
VALUE IN THOUSAND RUPEES.

Year.	*Total for the Country,*		*Tamil Nadu.*	
	Quantity.	*Value.*	*Quantity.*	*Value.*
(1)	(2)	(3)	(4)	(5)
1960	12,935,399	61,169	1,620,949	5,717
1961	14,754,597	74,589	1,867,664	6,780
1962	16,938,874	93,501	2,038,217	7,728
1963	17,346,674	98,068	2,080,372	8,192
1964	17,016,621	100,331	2,399,501	10,853
1965	19,957,057	128,359	2,586,672	14,436
1966	19,830,704	142,364	2,701,092	17,529
1967	19,586,269	152,524	3,135,380	22,598
1968	21,030,461	184,350	3,135,553	22,770
1969	22,516,976	211,930	3,233,714	28,851
1970	23,800,730	230,231	3,693,353	34,227
1971	24,952,840	213,256	4,084,171	30,541
1972 January	2,203,235	18,650	375,498	2,724

PRODUCTION OF LIMESTONE DURING 1960-70 IN TAMIL NADU

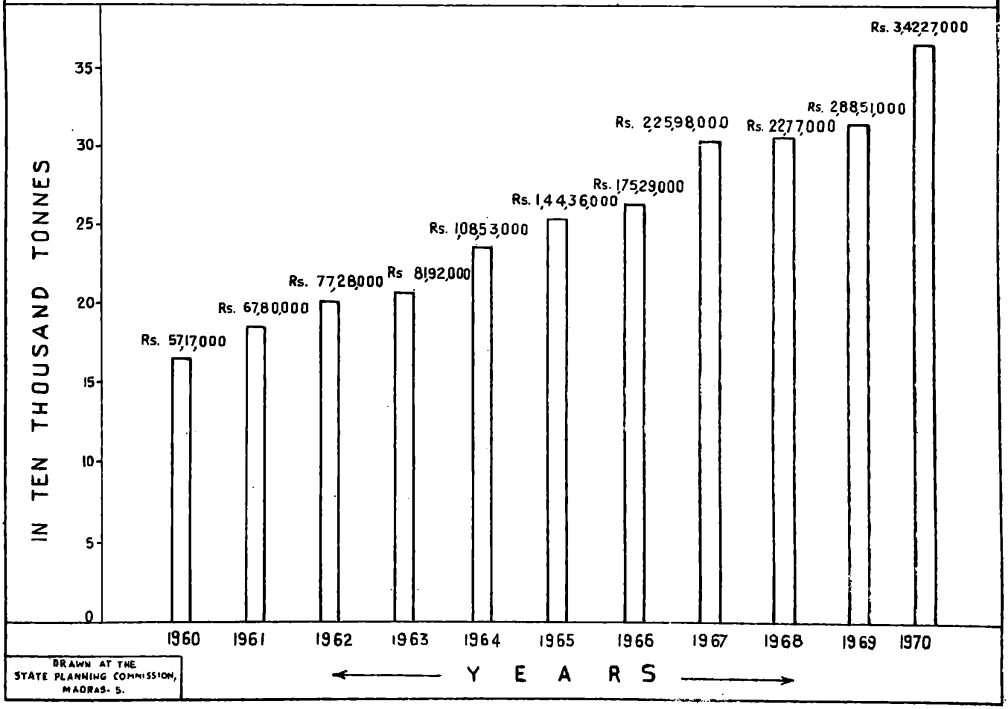

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Table XXXI gives the corresponding figures relating to Limeshell :—

TABLE XXXI.

QUANTITY IN METRIC TONS.

VALUE IN THOUSAND RUPEES.

Year.	Total for the country.		Tamil Nadu.	
	Quantity.	Value.	Quantity.	Value.
(1)	(2)	(3)	(4)	(5)
1960				--
1961			--	--
1962			--	--
1963			--	--
1964	72,594	875	--	--
1965	56,655	836	--	--
1966	49,499	907	--	
1967	74,953	1,059	...	
1968	70,886	1,255	144	4
1969	90,137	1,484	279	8
1970	80,598	1,497	791	24
1971	95,069	1,742	1,739	52
1972 January ...	5,874	104	40	1

5.2.4 *Limestone in Cement Industry.*

A glance at table XXX gives an idea of the increasing trend in the limestone production. This is mainly due to the expansion in cement production in the State. There are seven major cement factories in the State with a total capacity of 3·412 million tonnes. The production capacity of our State accounts for about 47 per cent of the capacity in the South Zone and for more than 17 per cent of the total production capacity in the country. During the year 1970, the production of cement in Tamil Nadu was 23·88 lakh tonnes contributing to about 45 per cent of the production in the southern region and about 17 per cent of the total production in the country. Against this, the total consumption of cement in the State during 1970 amounted to only 12·15 lakh tonnes, the net per capita consumption being 30·71 kilogrammes as against a per capita consumption of 48·03 kilograms in Gujarat, 43·88 kilogrammes in Punjab and 42·28 kilogrammes in Haryana and an All India average of 24·61. Thus, it would seen that there is a lot

of scope for improvement in the per capita consumption of cement in a developed state like Tamil Nadu. A large proportion of the cement produced in the State is at present being utilised to meet the demand in other States.

It has been estimated that the demand for cement may be expected to increase annually by about 12·5 per cent. The expansion schemes of the existing cement industries should be cautiously worked out after ascertaining the availability of cement grade limestones. Though the reserves of limestone are generally sufficient to carry on for the next 20 to 30 years at the present rate of production, compared to some of the neighbouring States, Tamil Nadu is not richly endowed with limestone reserves. The total deposits in the State amount barely to about 300 million tonnes as against more than 1,250 million tonnes in Mysore and about 12,800 million tonnes in Andhra Pradesh.

5·2·5· *Limestone and Chemical Industries.*

The main chemical industries in the State involving the use of limestone are manufacture of Calcium carbide, caustic soda, bleaching powder, etc. Calcium carbide is used for two major products : (1) manufacture of cynamide and (2) generation of acetylene.

There is at present one unit manufacturing Calcium carbide at Talayuthu (Industrial Chemical, Limited), with a capacity of 10,000 tonnes per annum. This unit has been utilising coral masses occurring along the islands between Tuticorin and Rameswaram. However, these corals which form reefs in the Gulf of Manaar have an important role in preventing erosion of the coast and of the numerous islands in the neighbourhood. Since the reefs act as a barrier against the waves of the sea especially during storms, they also prevents the silting of the Kilakarai channel. Therefore severe restrictions have been placed upon the removal of these living coral masses and only very little quantity say about 8,000 to 10,000 tons per annum, is available from this source.

In view of the large demand for calcium carbide in the country, there is scope for the establishment of another plant in the State with a capacity of 10,0000 tons per annum. The Tamil Nadu Industrial Development Corporation have obtained a letter for this purpose and are now considering various petitions for setting up of the factory. Perhaps using a rotary kiln and with a suitable blend of high grade crystalline and sedimentary limestones and coral materials, it would be possible to obtain good quality calcium carbide. It would also be worthwhile to plan for a future expansion in its capacity since the demand for calcium carbide is bound to increase in the country, especially for defence purposes.

Mettur Chemicals Limited, produce caustic soda, bleaching powder and stable bleaching powder in addition to several other chemicals. They draw the limestone requirements from the high grade crystalline limestones in the Salem district. However, the high grade pockets in the limestones suitable for chemical industries are few and occur as isolated lenses, within the limestone band. Therefore the cost of mining is high and the purer stones would have to be sorted out manually. In view of the highly crystalline nature of the limestones, the Mettur Chemicals have a special type of kiln known as Fluidized-bed kiln near Sankaridurg which produces lime in the form of fine powder with highly reactive properties. However the cost of production is high and the industry is finding it difficult to obtain high grade lime at an economic price.

5·2·6· *Demand for Quick Lime.*

Lime or quick lime (CaO) finds use in a very large number of chemical industries, in house construction, in leather tanning, pharmaceutical industry, in pesticides, as a soil conditioner, for softening of water and for sanitary purposes. As a basic and important industrial raw material there is very great demand for lime in Tamil Nadu and it is estimated that in Madras City alone there is an unfulfilled demand of about 200 tons per day. While there are not any high grade limestones near Madras there are a number of limestone deposits in Tiruchirappalli Ramanathapuram and Tirunelveli districts which could be considered for lime manufacture. The coral masses in the Gulf of Mannar and lime shells found in lagoons such as the Pulicat and Markanam lakes also provide a good source for high purity lime. Thus there is wide scope for manufacture of lime in the State. The type of kilns to be used has to be chosen with reference to the burning characteristics of the limestone.

5·2·7· *Limestone as Flux.*

Limestone is the most essential flux material in the iron and steel industry and is used to remove the silica and other impurities from the ore during smelting operations and to maintain slag density.

There are several deposits of crystalline limestone which are chemically of flux grade composition. However many of them do not have the required physical strength due to the tendency to break along the cleavages. Another disadvantage of the coarsely crystalline calcitic limestone is that during calcination for manufacture of lime the crystals have a tendency to disintegrate to powder (decrepitation) and choke the vertical limekiln, resulting in improper calcination. By using rotary or fluidized-bed type of kilns it is possible to get properly calcined lime from crystalline calcitic limestone but the lime is in the form of powdery form, not well suited for the converters in the steel industry.

Moreover in the case of some of the medium and fine grained crystalline limestones it has been possible to get well calcined lime without decrepitation or choking of the vertical kiln.

Some of the high grade limestones occurring near Tiruchengodu have been reserved for the Salem Steel Plant but due to their coarse crystalline nature their suitability is now questioned. However since the process of iron making outlined by the consultants envisages use of basic pellets of magnetite concentrate mixed with finely powdered limestone as the feed for iron making, the crystalline limestones can still find use. The total requirements of Salem Steel Plant is less than 5 million tons of which one half is of steel making grade (L 2·5 per cent SiO_2) and the rest of iron making grade (L 7 per cent SiO_2).

In the Ariyalur taluk of Tiruchirappalli district there are patches in the cretaceous limestones which are chemically and physically well suited as flux material. Since the requirement of flux grade limestone for the Salem district will have to be given top priority, it is recommended that these limestone deposits are immediately reserved for the Salem Steel Plant.

5·2·8· *Recommendations.*

1. A detailed assessment of the quality and the size of reserves of all the limestones. large and small in the state will have to be taken up.

2. All cement plants in the State should be required to carry out detailed prospecting of the limestone reserves (such a survey should be insisted upon before any scheme for expansion is sanctioned).

3. In view of the importance of limestones as an industrial mineral suitable measures should be taken to prevent illegal mining or wastage of limestones by improper use.

4. Possibility of setting up additional plants for calcium carbide can be explored.

5. In view of the large demand for industrial lime it is recommended that a number of modern mechanised lime kilns be set up, wherever suitable deposits are available, to produce high grade industrial lime.

6. All the high grade limestones in cretaceous formations around Ariyalur in Tiruchirappalli district should be reserved for Salem Steel Plant.

7. Two or three small units producing precipitated calcium carbonate can be set up in the State to meet the existing demand.

5·3· *Dolomite,*

5·3·1· *General.*—Dolomite is a carbonate of calcium and magnesium which in the theoritically pure varieties would be represented 30·4 per cent CaO, 21·7 per cent MgO and the rest as CO_2.

The dolomite occurrence in Tamil Nadu, so far known, is too small to be of economic significance. The occurrence of dolomite near Kovilpatti in Tirunelveli district in Tamil Nadu has already been reserved for use in the Salem Steel Project. This appears to be the best possible use for this deposit in view of the scarcity of the mineral in the State. These deposits occurred in Kadalai and Vallinayakapuram about 9 kilometres east of Kovilpatti in Tirunelveli district. The total reserves of pure dolomite available have been estimated at two million tonnes. Another minor occurrence north of Lingapatti village in the same area is estimated to contain 15,000 tonnes of dolomite. Small occurrences of dolomitic limestone occur at Tettampatti hamlet near Nattam in Melur taluk, Madurai district.

5·4· *Lignite.*

5·4·1· *General.*—Tamil Nadu is the chief producer of lignite in the country. Practically the entire production of lignite in India has been reported from Tamil Nadu State excepting a small quantity of 7,000 tonnes produced in Rajasthan. Lignite accounted for about 64.7 per cent of total value of mineral production in the State. The trend in the production of lignite during the years 1960-71 is given in Table XXXII.

TABLE XXXII.

Quantity in Metric tons. Value in Thousand Rupees.

Year.	Total for the country.		Tamil Nadu.	
	Quantity.	Value.	Quantity.	Value.
1960	46,945	1,389		
1961	63,765	1,822	2,263	49
1962	210,748	4,738	174,805	3,724
1963	999,230	21,683	987,174	21,491
1964	1,569,175	38,578	1,567,454	38,528
1965	2,300,292	46,561	2,289,107	46,194
1966	2,568,184	56,475	2,561,006	56,240
1967	2,929,407	76,420	2,927,350	76,352
1968	4,126,203	78,573	4,121,147	78,426
1969	4,187,691	86,058	4,187,630	86,056
1970	3,544,599	89,856	3,544,599	89,856
1971	3,660,200	92,769	3,660,200	92,769
1972 Jan.	292,306	7,410	292,306	7,410

5·4·2· *Modern Industrial Complex.*—Lignite, as mentioned earlier, was formed during the Tertiary Period and is mined in Neyveli in South Arcot district. The quality of lignite is as follows :—

Moisture—10·12 per cent ; Ash—5·6 per cent ; Volatiles—44·48 per cent.
Fixed carbon—35·40 per cent ; Phosphorus—Negligible.
Sulphur—below 1 per cent ; Thermal value—4,568—5,850 B.T. U/lb.

The Neyveli Tertiary formations has enormous resources of lignite and has been estimated at over 2,000 million tonnes in an area of 259 sq. kilometres. This lignite is the chief raw material for the Neyveli complex consisting of the thermal plant, fertiliser, carbonisation and briquetting plant.

The expansion of the lignite mining scheme was taken up in response to the growing demand for lignite from power generation schemes, fertiliser and B and C (Briquetting and Carbonisation Units) units. The reserves of lignite available in the area acquired by the Neyveli Lignite Corporation are 200 million tonnes over an area 14·24 square kilometres. The depth at which lignite seam occurs is from 5 to 30 m. below the mean sea level with an average lignite thickness of 15 m. in the form of bedded deposits. Clay occurs in pockets and patches only in an erratic form and is kept aside while stripping over burden by the excavators.

Two bucket wheel excavators with a capacity of 350 litres each were in operation for mining lignite with a view to ensure a steady supply of lignite to industrial unit according to demand. The conveyors have been laid for transporting lignite straight from mines to industrial units. One more wheel excavator of 700 litres capacity was commissioned in July 1966 to give relief to other machines for major overhaul and repairs.

The fertiliser unit which is designed to produce 152,000 tonnes of Urea annually built under West German and Italian technical collaboration is the only fertiliser factory in India which uses lignite as raw material. Urea prills were produced in March 1966 and these contain 46 per cent nitrogen and represent the most concentrated solid nitrogenous fertiliser which is non-corrosive and odourless. The rated maximum capacity of the plant for the Urea prills is 500 tonnes per day.

The capacity of the thermal power station is being further increased to 600 MW by the addition of two more units of 100 MW capacity each. The expansion is being financed under an agreement made between the Government of India and the U.S.S.R. during the year. The production of power is very much lower than envisaged as there is not much progress in the exploitation of lignite. It is said that the lignite mined now is of inferior quality compared with the earlier ores. Due to deterioration in the quality of lignite with a calorific value of 2,450 k.cal/kg., (4,410 B.T.U/lb) only, the consumption of lignite in the various facilities of the integrated project are now expected to be more. The original proposal of opening a second mine cut to raise the production to seven million tonnes was shelved as the cost of mining would go up very much owing to the unfavourable thickness ratio of overburden to lignite and also due to the general deterioration in the quality of lignite mined. However this again be examined in the light of recent technological innovation in the mining methods. This becomes essential because of Neyveli lignite is the solitary source of supply of fuel in South India.

5·4·3· *Recommendation—*

In the circumstances, the following proposals may be considered :—

1. In advanced countries, underground gasification of lignite is generally favoured where other methods of extraction are uneconomic. Attempts to gasify coal " in situ " have been made in various countries, particularly, in the U.S.S.R. and U.K. Trials in this line have had greater success in the former country. There, oxygen gasification of coal and lignite is practised for seams up to 10 meters thick. At one time Messrs. Humphery and Glasgeow were entrusted with the preparation of a project report for underground gasification of the Palana Lignite in Rajasthan. According to an excerpt from a report by the Director, Central Fuel Research Institute, Dhanbad[1] this firm concluded that power generation costs would be of the order of 2·6 paise per KWH for Palana lignite. The feasibility of such a method in Tamil Nadu needs to be investigated.

2. Intensive search in and around the coal horizon in Ramanathapuram district where coal was struck during 1965.

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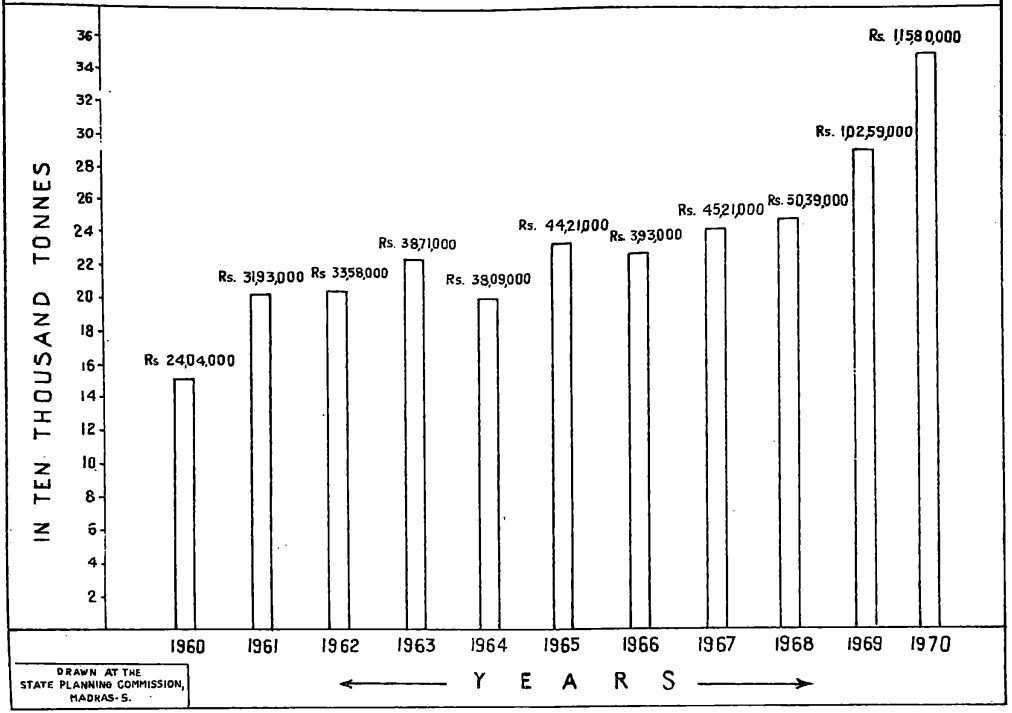
[1] Journal of Mines, Metals and Fuels, May 1961, p. 15. A note on the underground gasification of coal in India.

PRODUCTION OF MAGNESITE DURING 1960-'70 IN TAMIL NADU



DRAWN AT THE STATE PLANNING COMMISSION, MADRAS-5.

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5.5. Magnesite

5.5.1. *General.*—Magnesite, a carbonate of magnesium is extensively used as a refractory. The mineral is white in colour and the impurities are commonly silica, iron and lime. Magnesite occurs in nature usually as a secondary deposit and is formed due to alteration of ultrabasic rocks mostly dunite and peridotite, and also as (1) replacement deposits in carbonate rocks, (2) bedded deposits and (3) as vein deposits. Magnesite formed from the alteration of ultrabasic rocks is of amorphous nature, and that from dolomite and replacement deposits is crystalline. Tamil Nadu ore is of the former type. The main magnesite producing countries in the world are Austria, U.S.A., Yugoslavia, India, U.S.S.R., Greece and Bulgaria.

Tamil Nadu has the unique distinction of being the most important source of magnesite in the country. The production of magnesite at 203 thousand tonnes in 1961 recorded a rise to 229 thousand tonnes in 1966 and to 286 thousand tonnes in 1969. It touched a new peak of 342 thousand tonnes in 1970 registering a rise of 19·6 per cent over the preceding year. The trend in the production is shown in Table XXXIII.

TABLE XXXIII.

	METRIC TONS.		(THOUSAND RUPEES.)	
	Total for the country		*Tamil Nadu*	
Year.	*Quantity.*	*Value.*	*Quantity.*	*Value.*
(1)	(2)	(3)	(4)	(5)
1960	156,331	2,683	151,886	2,404
1961	209,744	3,477	203,446	3,193
1962	212,888	3,637	206,601	3,358
1963	235,066	4,153	228,923	3,871
1964	207,936	4,096	201,789	3,809
1965	238,905	4,572	235,335	4,421
1966	232,053	4,056	228,691	3,930
1967	246,448	4,728	240,995	4,521
1968	253,073	5,248	247,543	5,039
1969	297,893	10,558	290,213	10,259
1970 ..	354,291	11,870	2,346,761	11,580
1971	296,573	8,375	9,286,213,	7,752
1972 January	28,697	815	27,760	745

Thus Tamil Nadu maintained its supremacy as the leading producer of magnesite contributing as much as 98 per cent of the All-India output in 1970. Magnesite accounted for 7·3 per cent of the total value of mineral production in the State.

5.5.2. *Occurrences.* The magnesite bearing rocks of Salem occur as two detached patches across the Salem-Omalur road and extend up to the foot of the Shevroys Hills. The occurrence of magnesite imparts a chalk white colour to the hillock and hence these are called " Chalk Hills". The deposit has been investigated and worked since British times. The Geological Survey of India in 1959–60 estimated on the basis of the data available for the then existing quarries in the two belts that the total reserves of magnesite available in the chalk hills area would be of the order of about 44 million tonnes for 30 metres depth of which about 11 million tonnes were considered to be of refractory grade. Earlier estimates had placed the total reserves at 80 million tonnes for an assumed depth of 400 feet. But the United Nations Development Project team, after detailed drilling operations has fixed up the reserves as 44 million tons as the veins below 30 metres (100 feet) become scarcer and thinner[1].

A number of small occurrences of magnesite are found in Salem and adjacent districts of North Arcot, Dharmapuri and Coimbatore. The reserves in all these occurrences together may not exceed six million tonnes bringing the total available reserves in the State to 50 million tons.

5.5.3. *Uses.* Magnesite has varied uses. They are as follows :—

1. The main use of magnesite is as a refractory material for making fire bricks which find extensive use in open hearth steel furnaces and other furnaces. The bricks can stand temperatures of over 2000°C. They find wide demand in the steel industry in India and abroad. It is estimated that for every ton of steel produced by the open hearth process, 12 kg. of basic refractories are required while for a tonne of steel produced by the L.D. process only 4 kg. of basic refractories are needed.

(2) The broken chips of magnesite are used for making mosaic floorings, tiles, etc.

(3) Magnesite also finds use in the manufacture of magnesia cement or " Sorel " cement.

(4) Another important use is for extraction of magnesium metal and for preparation of various magnesium salts and chemicals.

5.5.4. *Magnesite production.*

The main companies engaged in mining magnesite in Salem area are Burn and Co., Salem Magnesite Co. and Dalmia Cement Company.

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[1] A comment on the mode of mining these deposits may not be out of context. The mine owners adopt a crude method of mining as the companies are highly profit oriented. They do not seem to bother about the waste arising by simple hand mining, cobbing and sorting. Such low method of mining is quite prevalent in all most all the mines. In these mines only a fourth of the mined magnesite is recovered as suitable for refractories and often, lean blocks are left off as uneconomical. It is for this reason that out of the total occurrences 44 million tonnes only 11 million tonnes are considered useful as refractories.

Out of roughly 300,000 tonnes produced in 1970, Burn and Company produced 80,000 tons, Dalmia Cement Company produced 100,000 tonnes and Salem Magnesite Company produced 120,000 tonnes.

There are a number of other private firms also engaged in mining magnesite, but their production is limited.

The deposits are generally high grade, suitable for refractory, chemical and other purposes. The composition of the magnesite is uniform except for a slight variation in the amount of silica and iron oxide to the extent of about 3 to 4 per cent. The mine-run-ore contains about 95—97 per cent magnesium carbonate. Average samples from different parts of the belts have shown 43 to 48 per cent MgO, 0·05 to 2 per cent SiO_2, upto 0·5 per cent R_2O_3 ($Al_2O_3+Fe_2O_3$), upto 1 per cent CaO, and less than 0·2 per cent moisture. High grade mangesite suitable for refractory purposes should contain less than 2·1 per cent silica. Magnesite containing between 2·1 and 3 per cent silica is generally classed as second grade ore, and high silica magnesite containing about 3 per cent silica is generally rejected during the working.

Tests carried out at the National Metallurgical Laboratory have shown that it should be possible by froth flotation to reduce this silica by suitable benefication techniques, so that the entire quantity could be utilised for refractory purposes.

Magnesite is sold in the raw form as also in the calcined and deadburnt forms. The calcine form is obtained by controlled burning of magnesite at a temperature of about 1200°C so that it retains about 2 to 3 per cent of carbon-di-oxide. This form of calcined magnesite is highly reactive and like lime slakes in water. Deadburnt magnesite is obtained when magnesite is heated to above 1600°C and all the carbon-di-oxide is expelled. This is a dense non-reactive and inert product as the name suggests. It is eminently suited for use as a furnace refractory. It is estimated that 2 to 2·5 tonnes of raw magnesite is required to produce one tonne of deadburnt magnesite. While the raw magnesite may cost about Rs. 45 to Rs. 50 per ton, the calcined variety would cost about Rs. 220 and the deadburnt would be much more, probably between Rs. 350 and 400 per ton.

5.5.5. *Expansion programmes.*

The existing installed capacity for deadburnt magnesite in Salem area is about 100,000 tons per year. There are plants for expansion by two units to bring the total capacity to 160,000 tons per annum in the region by 1973–74. Similarly the installed capacity for calcined magnesite may go up from the present figure of about 16,000 tonnes to about 25,000 tonnes per year by 1973–74 as per a survey in 1969 by the Indian Institute of Foreign Trade. While Burn and Company utilise part of their production for making refractory bricks, the others sell the magnesite, either in the raw form or in the calcined form. Dalmia Cement Company sell calcined and deadburnt as well as raw magnesite. The Salem Magnesite Company sell raw magnesite to Belpahar Refractories where they are deadburnt.

About 85 to 90 per cent of the magnesite produced is consumed inside India.

5.5.6. *Requirements of new steel plants.*

The three new steel plants to be set up at Salem, Visakhapatnam and Hospet will be requiring considerable quantities of refractories made with magnesite. The expansion schemes in the other existing steel plants and the Bokaro Plant will also generate demand for more magnesite refractories. Perhaps more than 300,000 tonnes of additional magnesite of refractory grade would have to be produced to meet this requirement. Therefore, it is necessary to plan now for developing the mines to meet this additional requirement which would arise by the next five or six years.

For the manufacture of magnesium chemicals, the bittern got after the solar evaporation of sea water could be utilised.

5.5.7. *Magnesium Metal.*

Magnesium metal finds use in the preparation of magnesium-base alloys, particularly with aluminium, zinc, zirconium and manganese. These alloys are of value in sophisticated industries like manufacture of aircraft engines, missiles and of various forms of automotives, transport, electric and elctronic equipment. With progress of industrialisation the probable demand in India for magnesium metal would be roughly about 1,000 tonnes per annum.

Under a pilot project scheme jointly financed by the Tamil Nadu Government and the Council of Scientific and Industrial Research, the Electro-chemical Research Institute at Karaikudi have set up a unit which produces about 250 kg. of magnesium metal per day by elctrolytic method. The magnesite is treated with hydrochloric acid to produce $MgCl_2$. The magnesium chloride is then spray dried to remove water and then electrolysed.

5.5.8. *Recommendations.*

The magnesite deposits of Salem which rank among the world's best in quality form an important mineral asset to Tamil Nadu but they are by no means inexhaustible. The following steps are recommeneded for proper and effective utilisation of the deposits.

1. The magnesite should be properly mined, upgraded in quality and put to the best industrial uses. At present, only a fourth of the mined magnesite is recovered as suitable for refactories and the rest is wasted. No efforts are made to beneficiate the rest of the materials so that the entire magnesite that is mined can be used for refractory purposes. For this, effective pilot plant studies should be taken up immediately and a beneficiation plant set up either by the mining companies or by the Government at the Chalk Hills near Salem.

2. The mining of magnesite is wasteful and often lean blocks are left off as uneconomical to work. A more systematic and planned mining, keeping in view the conservation and utilisation of the entire deposit should be insisted upon. The fluctuation in

demand, the soft nature of the dunite and the irregularity of the magnesite veins make mechanisation difficult, costly and ineffective. However, a suitable blend of mechanised and manual mining can yield better results.

3. Effective plans should be drawn up early to meet the demands of the three new steel plants in the South and of the Bokara Plant, in the coming years. A large integrated refractory brick plant to produce magnesite, chromite, fire clay and silicon bricks could be located at Salem to meet this demand.

4. The possibility of locating a plant for producing magnesium metal in Salem ditsrict utilising the magnesite and probably chlorine gas from Mettur Chemicals, Limited if available should be investigated. There is sufficient demand for magnesium metal in the country. The processes already successfully employed by the Central Electro-Chemical Research Institute can be profitably utilised in the proposed plant.

5. In view of the location of the Madras Aluminium Company nearby it would be useful to produce magnesium-aluminium alloys in the region.

6. The possibility of manufacturing high temperature forsterite refractories utilising the magnesite rocks of the same region may be explored.

5.6. *Quartz and Feldspar.*

5.6.1. *General.* Quartz is a pure source of slica and feldspars comprise a group of minerals containing potassium, sodium, calcium and aluminium silicates and are the most common of the rock forming minerals. Quartz and feldspar occur together in nature in granites, syenites, gneisses and pegmatites. However, workable depsosits are confied to pegmatite veins consisting of coarse cystals of quartz and feldspar. Both quartz and feldspar are of widespread occurrences and are mined in almost all countries.

5.6.2. *Uses, Mining and Marketing.* Quartz and feldspar form the important raw materials besides clay in the manufacture of the body and glaze of several types of porcelain, China and earthenware and also in the preparation of glasses. Pure quartz is mainly used for glass making, in fibre glass manufacture, in the production of abrasives and for making fused quartzware. Feldspar is used as an improtant ingredient in the glass sand-batch, as a bonding agent in the manufacture of abrasives and high and low tension insulators. Feldspar is also used in the clay body of stonewares for making artificial teeth scouring soups, as roofing aggregate in the manufacture of white cement. For making high quality colourless glass, feldspar should not contain more than 0·1 per cent Fe_2O_3 and for enamels, iron oxide content should be less than 0·5 per cent. Glass and ceramic industries which are the major consumers of feldspar account for 95 per cent of the total production.

5.6.3. *Production and Demand.*—In India feldspar is mainly produced in Andhra Pradesh, Assam, Bihar, Gujarat, Madhya Pradesh, Rajasthan, Mysore and Tamil Nadu. Indian feldspar is exported to Japan, West Germany, East Germany, Phillipines,

Malayasia, France and Netherlands. Of these, Japan is the principal buyer. The export figures of feldspar to different countries from various States in India from 1960 to 1970 are given below :—

TABLE XXXIV.

Year.	*Quantity* (in tonnes).	*Value.* (in rupees).
1960	1,592	112,000
1961	1,268	81,000
1962	1,093	66,000
1963	1,369	77,000
1964	5,276	357,000
1965 ..	5,359	392,000
1966 ..	3,841	347,000
1967 ..	7,989	821,000
1968 ..	8,530	969,000
1969 ..	9,104	971,000
1970 ..	13,472	1,390,000

The output of feldspars in Tamil Nadu stood at 151 tonnes valued at 1,000 Rupees in the year 1960, Thereafter it has steadily increased to nearly 7,000 tonnes valued at Rs. 42,000 in the year 1970. The quantity and value of feldspar produced from the year 1960 to 1970 in Tamil Nadu are given below along with the corresponding All-India figures :—

TABLE XXXV.

	METRIC TONS.		THOUSAND RUPEES.	
	Total for the country.		*Tamil Nadu.*	
Year.	*Quantity.*	*Value.*	*Quantity.*	*Value.*
1960	10,613	107	151	1
1961	10,629	123	1,516	9
1962	21,744	219	4,790	21
1963	24,002	264	4,755	23
1964	25,249	259	5,837	37
1965	27,114	269	4,617	26
1966	27,972	254	4,787	22
1967	30,654	293	5,556	29
1968	35,261	311	5,026	25
1969	32,221	301	6,556	33
1970	29,625	275	7,536	46
1971 ..	36,388	332	9,138	51
1972 January	13,691	37	684	4

PRODUCTION OF FELSPAR DURING 1960-70 IN TAMIL NADU

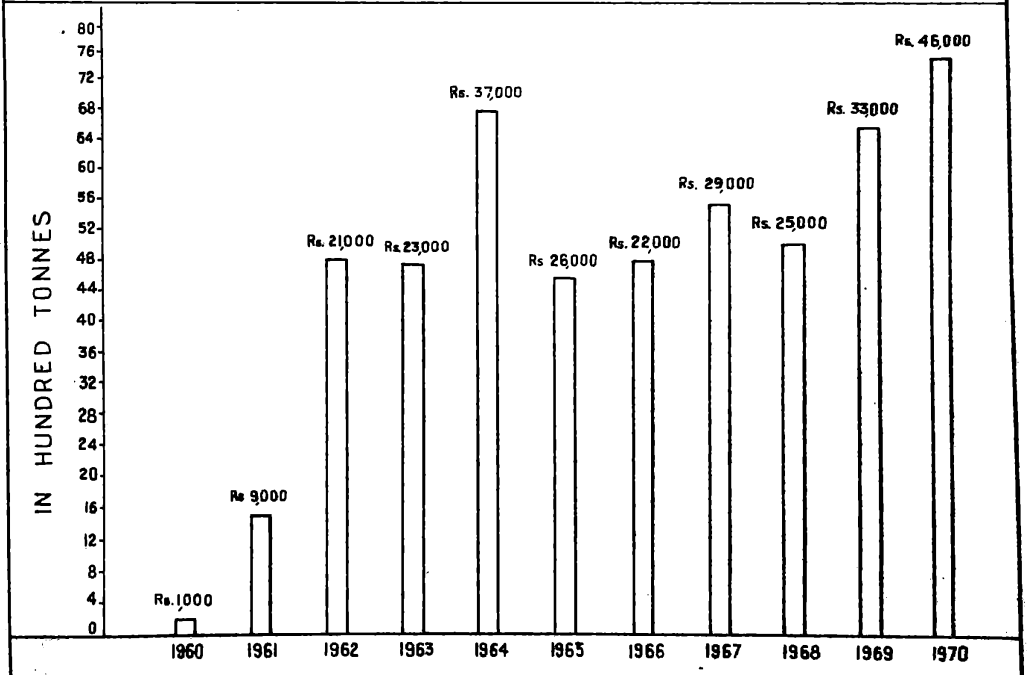

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TABLE XXXVI.

ANALYSES OF QUARTZ SAMPLES OF TAMIL NADU.

	Binnamangalam, Dharmapuri district.	*Bogampatti, Coimbatore district.*	*Kalipatti Road R.S., Salem district.*
(1)	(2)	(3)	(4)
SiO_2	99·98 — 99·97	99·74	99·99
Fe_2O_3	0·02 — 0·03	0·09	n.d.
Al_2O_3	0·04 — nil.	0·17	nil.
Moisture	n.d. nil.	n.d.	0·1

The quantity and value of quartz produced in India and in Tamil Nadu in the years 1960 to 1970 were as follows :—

TABLE XXXVII.

Year.	METRIC TONS. *Total.* *Quantity.*	THOUSAND RUPEES. *Total.* *Value.*	METRIC TONS. *Tamil Nadu.* *Quantity.*	THOUSAND RUPEES. *Tamil Nadu.* *Value.*
(1)	(2)		(3)	(4)
1960	123,852*	1,278	348	2
1961	150,196*	1,873	1,141	5
1962	217,624*	2,347	2,650	13
1963	249,966*	2,617	3,768	19
1964	247,662*	2,244	1,739	8
1965	97,408	790	2,063	10
1966	123,600	902	1,428	6
1967	105,410	891	7,305	45
1968	151,801	1,348	638	2
1969	200,921	1,708	1,143	5
1970	175,750	1,405	309	1
1971 ..	171,506	1,332	2,039	20
1972 January ..	11,286	83	..	..

* Quartz data from 1960 to 1964 are inclusive of quartzite and silica sand as separate figures for these years are not available.

The price of feldspar ranges from Rs. 23 to Rs. 26 per tonne f.o.r. loading station and the price of quartz ranges from Rs. 18 to Rs. 21 per tonne f.o.r. loading station.

5·6·4 *Deposits in Tamil Nadu.*—In Tamil Nadu, workable deposits of quarty and feldspar are confined to the districts of Salem, Tiruchirappalli, North Arcot, Dharmapuri, and Coimbatore. Of these, the deposits in Tiruchirappalli and Salem are extensively worked and a sizeable quantity is being exported to foreign countries, chiefly to Japan. The State Government owned ceramic factory at Vriddhachalam and the Clay Toy Unit at Perambur and the Quartz Crushing Plant located at Salem draw their requirements of feldspars and quartz from both the Salem and Tiruchirappalli areas. The various ceramic factories in the private sector located at Neyveli, Vriddhachalam and Ranipet also obtain their supplies of quartz and feldspars from North Arcot, Salem and Tiruchirappalli districts. A rough estimate of the size or reserves in the various districts is as follows:—

(In lakhs of tonnes).

	Quartz.	*Feldspar.*
Salem ...	1	0·5
Tiruchirappalli	1·5	1·5
Coimbatore	0·45	0·35

India is exporting feldspar (non-gem variety) and quartz since 1960. France, U.K., Germany and Japan are the markets for them. While Indian feldspar finds market in Europe, Japan is our market not only for feldspar but also for quartz. The trend in the quantity of exports from 1960 to 1971 is indicated below:—

TABLE XXXVIII.

	Feldspar Exports.	*Quartz Exports.*
	TONNES.	TONNES.
1960 ...	1,392	5
1961 ...	1,268	369
1962	1,093	4,012
1963	1,369	266
1964	5,276	306
1965	5,359	1,332
1966	3,841	2,652
1967	7,989	3,388
1968	8,530	3,052
1969	9,104	2,797
1970	11,842	6,142
1971	9,429	3,557

In India only Tiruchirappalli area is important for exports of Felspar and Quartz. There are no exports from other parts of India. Two firms in Tamil Nadu are exporting felspar and quartz since 1960 to Japan through an Agency (It is reported that albite felspar is used in Japan for the preparation of ampules and gauges).

TABLE XXXIX.

Year.	Number of days worked.	Production of		Exports to Japan through Agency.	
		Felspar Tons.	Quartz Tons.	Madras Quartz.	Felspar.
(1)	(2)	(3)	(4)	(5)	(6)
1960	236	98	203	458	
1961	298	846	265	92	
1962	..	..	..	..	..
1963	298	2,097	1,828	458	1,573
1964	293	3,137	1,247	1,103	3,030
1965	301	1,353	733		
1966	..	..			..
1967	303	3,108	..	..	2,610
1968	304	3,200	323	147	3,252
1969	303	4,795	446	470	3,840
1970	301	3,540	285	517	3,616
1971		7,247	1,690	1,344	3,791

It appears a little strange that Japan is importing so much quantity of the most common rock forming minerals, namely quartz and felspar. In fact, Japan is yearly producing within her own territory 2 lakhs tonnes of quartz and several lakhs tonnes felspar. Between Japan and India there are several countries very near to Japan who could equally well supply felspar and quartz. Despite these, why is it that there is a steady demand for India products i.e., Tamil Nadu quartz and felspar.

It is doubted that the quartz and felspar may contain the rare elements rubidium and cesium. The existence of cesium in traces ranging from 0·17 per cent to 0·51 per cent was confirmed by I.B.M. and they have also suggested to Tamil Nadu State Geology Branch that Tiruchirappalli felspar and quartz may be analysed for their rubidium and cesium content.

5·6·5. *Recommendations.*

The following recommendations are made :—

1. Manufacture of ferro-silicon may be tried.

2. The supply of quartz and felspar to the Bharat Electronics Limited for their proposed TV glass shells manufacturing units may be considered.

3. The possibilities of setting up plants for the manufacture of silica-gel, fibre glass and fused quartzware to be explored.

4. The Rubidium and Cesium contents in quartz and felspar of Tiruchirappalli area may be tested.

5·7. *Talc and Steatite.*

5·7·1. *General.*—Talc is an all inclusive term covering all gradations. The pure mineral, an aggregate of flakes and fibres is known as 'talc'. Steatite or Lava talc is the massive type with no grains. Soft impure talcose of variable talc content is called 'soapstone'. The hydrated silicate of aluminium is identified as 'prophyllite'.

In industrial applications, through the chemical composition is important, it is the physical properties and crystalline structure that give talc its commercial value. Grades are sometimes identified with end use like cosmetic, ceramic, pharmaceutical, etc. Others are identified by their crystal shape or structure—fibrous, massive, etc. Yet others by their softness, lustre, colour, etc.

The value of talc in commercial applications is due to its extreme, softness, whiteness, good opacity, good lustre, good retention for filler purposes, chemical inertness, high slip, high fusion point, high specific heat, degree of oil absorption, low moisture and low electrical and heat conductivity.

5·7·2. *Occurrences.*

The deposits in Tamil Nadu as outlined by the Geological department are almost entirely of the low grades of the soft impure variety of variable talc content, suitable for figurine work and for making domestic articles. Apparently, the State is barren of any talcum, paint, pharmaceutical, paper, textile and other grades. The industries in the State depend on talc resources outside the State. However, the extensive deposits outlined in North Arcot District, should be studied further for possible future applications as a carrier of insecticides and pesticides, and in the fertiliser industry.

5·8. *Vermiculite.*

5·8·1. *General.*—Vermiculite is a hydrous silicate of Aluminium, Iron and Magnesium and occurs chiefly as an alteration product of mica group of minerals. The mineral is shiny blackish brown in appearance and the individual layers are very soft, pliable and inelastic. The specific gravity of vermiculite varies from 2·3 to 2·8.

Vermiculite when heated suddenly to a temperature of about 900° to 950°C within 10 to 15 seconds exfoliates due to sudden release of steam (released due to the presence of water in the composition) which forces the laminae apart in an accordian-like fashion. This is also accompanied by considerable warping of the individual laminae and thus numerable voids are developed imparting to the exfoliated mass the great bulk and insulating characteristics which give a commercial value for the mineral.

The vermiculite of Tamil Nadu has the following characteristics. Shiny blackish brown in colour. On exfoliation develops a golden bronze colour. Average expansion on heating to 900.°—950°C for 10 seconds.

Particle size.	*Bulk density (lbs./ft.) Raw.*	*Exfoliated.*
$-\frac{1}{2}''+\frac{1}{4}''$ ..	31·21	5·11
$-\frac{1}{4}''+6$ mesh ..	31·21	5·40
−6 mesh+12 mesh	31·21	6·83
−12 mesh+18 mesh	31·21	9·37
−18 mesh+40 mesh	33·73	12·10
−40 mesh+60 mesh	33·73	14·96
−60 mesh	41·62	22·70

5·8·2. *Uses.*

Vermiculite, especially the exfoliated materials, finds use in a number of industries. As loosefill, vermiculite is used for the thermal insulation of roofs, industrial buildings, hot pipes, water heaters, galvanising baths, in air-conditioning plants, etc. It is also used for packing corrosive and inflammable chemicals. Vermiculite concrete which is made by mixing exfoliated vermiculite, portland cement and water in proper proportions is light, insulating and fire resistent. Vermiculite concrete is used in several prefabricated panel systems for external walling and internal partitions. Vermiculite is also used in sound proof partitions, fire protection, high temperature insulation, in fertilisers for the regulated release of the fertilizer to the roots and in pesticides.

5·8·3. *Occurrences.*

In India, deposits of vermiculite are limited and found mainly in Rajasthan, Andhra Pradesh and Tamil Nadu. In Tamil Nadu, the only occurrence of economic value is located in Sevathur and Elavampatti villages situated about 12 kilometres south of Tiruppattur town in North Arcot district. The total reserves are estimated to be around 3·5 lakh tonnes on the basis of the recent investigations carried out by the United Nations Development Programme. The Government of Tamil Nadu has sanctioned a scheme to set up an exfoliation plant near Madras utilising the above mineral. The plant will have a capacity of producing one tonne of exfoliated vermiculite per day.

5·8·4. *Marketing.*

The pattern of marketing Vermiculite is uniform in all developed countries without exception. The crude (raw) Vermiculite is graded after mining and then distributed to the exfoliation plants. These units are strategically located in close proximity to major consuming centres, covering consumers within a radius of 70—80 miles. There are strings of such exfoliation plants, essentially to save on freight costs and to make the exfoliated product economical to the consumers.

This pattern is repeated in U.K., Italy, West Germany, France, Spain, Sweden, Australia and Japan. The creteria apparently seems to be solely to minimise the frieght costs on the expanded ore, despite the plant costs involved.

As regards the market potential in India, the almost complete absence of any demand stands out like a sore thumb. The potential industries have not apparently so far recognised the versatile uses of Vermiculite. Or, possibly, the costs and other considerations dampen any initial enthusiasm. Nevertheless, in view of its varied uses, it may be hoped that as industries develop in the country, the demand for Vermiculite in its exfoliated form would go up making its processing commercially feasible keeping this in mind, the following recommendations are made.

5·8·5. *Recommendations.*

(1) The Vermiculite reserves of Tamil Nadu may be exploited for export subject to a ceiling.

(2) The Industries Department may carry out extensive and intensive research on Vermiculite and its applications and pioneer its propagation.

(3) The Tamil Nadu Government, after due assessment of demand, may help to set up exfoliating unit at Madras, and Coimbatore initially with the required grinding facilities.

5.9 *Minor Minerals.*

5.9.1. *General.* Ordinary sand, gravel, clay used for building purposes, are normally quarried away with not much of large scale development of mines. As the minerals do not have any sophisticated industrial application, these are described as minor minerals as different from major minerals that have distinct industrial uses. Minor mineral occurrences are widely distributed in Tamil Nadu and are extensively removed to meet the day to day demands of building activity. However the beehive of activity in this line is mainly confined to Chingleput, South Arcot, Tiruchirappalli, Madras, Salem and Coimbatore districts. In recent years the mining activity in respect of stones have made phonomenal strides, with the advent of several mammoth centrally assisted or sponsored projects like deep-sea harbour project, construction of bay walls and in general the huge increase in building activity seen in metropolitan capitals not to speak of the City Housing Schemes and several new industrial houses that have sprung up hugging the Madras City.

5.9.2. *Distribution of the minor minerals.*

(*a*) Sand and gravel are restricted in their occurrence, being mostly confined to the river alluvium and coastal tracts. Alluvial clay with a fair degree of plasticity finds application in the brick and tile industry. Such clays when fused develop a characteristic red-colour. The clays are to be found near tanks and when mixed with sand in suitable proportion form excellent material for brick making.

(*b*) Hard stones (building stones) have been from time immemorial used in masonry works. Their value as ornamental and decorative stones have been well appreciated by artisans who have chiselled out the world famous shore temples of Mahabalipuram and the equally well known stone masterpieces found in the great temple towers of Thanjavur and Madurai.

Most of these ancient works and carvings were all made on a variety of igneous rocks whose origin go back to the dawn of the earth (Archaean). These rocks are crystalline in nature depicting ideal building stone properties like hardness, toughness, strength and durability. Among the igneous rocks the even grained grey to dark granites have been mostly used in Tamil Nadu for such works. The other associated common building stones in the State are the charnockites, a variety of blue granite, syenite, diorite, gabbro and " black granite " or dolerite. Among the secondary rocks, or sedimentaries, mention may be made of the common building materials such as red stones, marbles and meta quartzites.

Besides application as building material, the above mentioned rock types are also largely quarried for use as road metal and as a ballast for the permanent way of the Railways.

(c) *Decorative stones.*—Polishing stone industry has been flourishing for several years in the State as evidenced from the decorative and monumental stone plates in very important edifices of architectual value. " Black granite " familiarly known in the trade as such is only the dolerite dykes that are very commonly seen as long linear ridges in several parts of North Arcot and Dharmapuri districts. Particular mention should be made of these large dimensional blocks near Karur and Krishnagiri that find a very lucrative market in East-European countries. Actually the polished stones of Tamil Nadu are very much prized in foreign countries and stand closely comparable with the counterpart material exported from South Africa. In recent years there has been a new demand for these black granites from countries like Japan that need them for making stone tiles and small slabs by " Diamond saw cutting ". In our country there is not much demand for the stones in view of the prohibitive cost involved in polishing. Kuppam, a town in Chittur district in Andhra Pradesh, adjoining this State is dotted with stone polishing units that make use of *the black granites of Tamil Nadu only* which have great export demand because of the pleasing colour, uniformity of grain size, compactness and equigranular, texture Encouraged by the spectacular success and demand for polished stones, the Government of Tamil Nadu have set up a departmental unit at Krishnagiri in consideration of its ideal location with reference to the raw materials.

Besides dolerite, pink granite and green quartzites are other rock types that take good polish for which there is bound to be demand in the immediate future. Green quartzites (Fuchsite) have been recently located near Satyamangalam in Coimbatore district.

5.9.3. *World demand.*

The main markets to which polished stones are exported are United Kingdom, West Germany, Italy, U.S.A. and Japan of which United Kingdom is the main intendor. West Germany imports a considerable quantity of both polished and raw stones. The major competitors for Indian polished stones are South Africa, Norway and Sweden.

The average value of exports from India of granite monumental stones during the period 1959–60, 1962–63 was 7.5 lakhs per annum. From the year 1963 onwards there was considerable increase both in terms of the quantum and unit value of the exports effected. Exports stood at Rs. 38 lakhs in 1967–68 against Rs. 21 lakhs in the year 1965–66 and have shown considerable increase since then. United Kingdom alone takes about 90 per cent

of the total exports ; the remaining being exported to Italy and Japan. Small consignments are sent to West Germany and Ceylon. Andhra Pradesh contribute about 80 per cent of the All-India export and Mysore State accounts for the rest. Direct exports from Tamil Nadu so far have been negligible, despite the fact that the materials exported from Andhra and Mysore are from Tamil Nadu only.

The quantity and value of stones (building and monumental) exported to different countries from India from 1960 to 1970, are as follows :—

TABLE XL.

Year.	*Quantity.*	*Value.*
(1)	(2)	(3)
	(IN TONNES.)	(IN RUPEES.)
1960	41,645	24,36,000
1961	25,345	26,74,000
1962	2,608	17,47,000
1963	7,361	19,68,000
1964	4,244	26,04,000
1965	6,006	24,48,000
1966	2,302	22,90,000
1967	11,337	36,13,000
1968	4,920	46,84,000
1969	7,564	39,37,000
1970	14,914	57,46,000

5.9.4. *Problems in production and marketing.*

1. The indigenously available carborundum powder, felt bobs and angular steel grit are not of high quality to give the desired fineness of polish.

2. The available machinery employed in India for sawing and polishing is reported to be obsolete, rendering the polishing uneven and increasing the cost of production.

3. Usually slabs of over 3" thickness in the polished form and blocks of 6 ft. $\times$ 3 ft. $\times$ 2 ft. have been exported to be used as tomb stones, foundation stones, etc. Another form in which granites slabs are widely used are as blocks surfaces and stripes and the market for these forms have not been fully explored.

4. The importance in United Kingdom and other countries often complain about the fractures present in the large slabs exported from India.

5. Consignments are generally reported to get held up at the Madras Port for long periods as the foreign liners are usually reluctant to carry the heavy and bulky cargo. Indian ships also take it as low priority cargo with the result that the delivery schedule is affected and additional expenditure has to be incurred on siding charges.

5.9.5. *Export Prospects.*

The main problems faced by the stone polishing industry in the major importing countries are the high cost of production owing to increased wages and paucity of suitable granites and related rocks capable of taking fine polish. The demand for the polished stones has steadily increased in all these countries and countries which have comparatively cheap labour prefer to import them in the raw form as unpolished stones; and the converse is true of those countries where labour costs are on the increase. Japan prefers to import various types of granites and dyke rocks in the raw form. The United Kingdom mostly imports Indian granites in the form of worked monumental stones, building stones and articles thereof.

According to the Indian Institute of Foreign Trade, the shares of total imports as between India and South Africa in the United Kingdom markets from 1964 to 1967 are as follows :—

TABLE XLI.

	1964		1965		1966		1967	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				(PER CENT.)				
India	68	53	76	67	65	61	50	45
South Africa	15	23	10	10	15	30	16	22

The over-all decline in the imports in United Kingdom from 1964–1966 amounts to 40 per cent in tonnage and 35 per cent in value whereas the decline in the export from India to United Kingdom for the same period was 40 per cent and 27 per cent respectively. The main factors that contributed to the decline are credit squeeze and import surcharge, etc., during the years concerned.

5.9.6. *Recommendations.*

1. The State Government may consider the possibilities of entering into long term contracts with buyers in countries importing granite both in the polished and unpolished forms. The supplies could be made from the various quarries in and around Krishnagiri and dyke rocks occurrences in Sholingur in North Arcot district. It is reported that the Italian Trade Delegation to India had evinced keen interest in red coloured granites. Hence an attempt may be made for exporting these stones also.

2. The syenites of Tirupattur in North Arcot district and the dolerites, syenites, aplites and granites of Krishnagiri and Hosur area are more suited for the purpose of polishing industry in comparison with the rock type of other districts. Hence the State Government may concentrate on the development of polishing industry at present in Dharmapuri and North Arcot districts.

3. It is suggested that the Stone Polishing Unit at Krishnagiri is equipped with the latest sawing and polishing machinery for the production of thin slabs by importing them from Italy or Japan. These specially designed machinery could be imported against the export of unpolished granites to the machinery supplying countries. It is reported that the Italian Trade Delegation has expressed its willingness to consider this.

4. Mechanical handling of larger blocks may be introduced as far as possible at the factory site and in railway stations to ensure safe transit and despatch of the material and also to minimise handling charges.

5. The matter of ensuring availability of adequate shipping space for export of polished stones should be taken up by the State Export Promotion Advisory Board with the Directorate-General of Shipping so that the delivery schedule can be kept up and expenditure on siding charges can be minimised.

6. The possibilities of exporting the green quartzites of Satyamangalam area to Japan, Italy and other foreign countries should be explored.

7. There are also a few offers to enter into collaboration with the State Government for large scale exploitation and export of granites. These could be considered.

8. The possibilities of setting up other plants in Dharmapuri or North Arcot districts to produce finished polished stones and other decorative building materials like flooring tiles, etc., with foreign collaboration (either with Japan or Italy) within the State could be explored by the State Government.

9. The quarries of the Government Stone Polishing Unit in Dharmapuri district should be equipped with the latest type of diamond sawing and channelling machines, etc., from Japan or other countries so that the production of thin slabs and other oriented blocks could be started. This would also save wastage of rock during quarrying and dressing to a large extent and would facilitate the production of thin slabs in fractured and highly cleavable rocks.

10. Steps should be taken to prevent the illicit quarrying of minor minerals through State legislation or suitable Government Order.

11. The various hazards involved in unsystematic quarrying should be studied in detail and for this purpose a Working Committee may be set up that would go into the working conditions of the quarries and formulate draft rules.

12. The idea of the Director of Mines Safety regarding the granting of a long term lease for Minor Minerals as in the case of Major Minerals may be examined.

13. The occurrence of Moulding Sands in different places in Chingleput, North Arcot, and Kanyakumari districts should be studied in detail and their specifications fixed up.

14. It is understood that there is a thriving illicit exploitation of the moulding sands occurring at Ennore and their supply to the various Industrial Unit in Madras. Proper steps should be taken to prevent such illicit quarrying.

(*d*) *Minor building materials.*—Next in importance to the aforesaid stones are the category of natural stones locally styled as " Sukkangal ". This is nothing but " Kankar ", a calcareous material, concretionary or nodular in form rarely forming compact beds. These are altered products as a result of chemical weathering of certain rock types such as limestone, charnockites and biotite gneisses that form the main rock types in most parts of the State. CaO content usually is found to be between 20 to 35 per cent and often admixed with silica. Considering the low lime content and general impure nature, the kankar at best is used for local lime-burning in country kilns. Burned lime and colour wash are obtained in the process for whitening and colour washing in construction. Kankar occurrences are most common in North Arcot, Salem, Dharmapuri, Coimbatore, Madurai, Tiruchirappalli and Ramanathapuram districts.

5.9.7. *Exploitation.*

Minor minerals like sand, gravel, granites and clay are extensively quarried to meet the needs of the common man unlike major minerals the use of which is limited and specific and have therefore been a source of revenue to the State Exchequer. The Government of India by provision in the Mines and Minerals (Regulation and Development) Act 1957 have empowered the State Government to enact rules governing the exploitation of minor minerals in conformity with local conditions, demand and use. The rules permit any person to remove any of the minor minerals after duly remitting the prescribed lease amount and a seigniorage fee to the Panchayat Union or to the Tahsildar who has the authority to issue such local permits. But if the same materials is required for public purposes or departmental use, no seigniorage fee is to be charged and such works are exempted from the purview and regulations of the Minor Mineral Rules.

Grant of quarry leases for minor minerals by public auction often causes several problems on the administrative and legal sides. Quarry rights are liable to be challenged by aggrieved parties in an auction, which result in delay in the confirmation of lease. The Tamil Nadu Minor Minerals Concession Rules however made provisions for resolving such disputes either at the level of the District Collector or as the appellate authority at the level of the Director of Industries and Commerce and finally the State Government. There is besides provision in the said rules that enable aggrieved parties to resort to legal remedies in a Civil Court.

Taking into consideration the frequency of such appeal petition and court intervention, the State Government have recently brought about an amendment to the Tamil Nadu Minor Mineral Concession Rules whereby reauction prayed for by a petitioner is permissible only if he deposits two times the maximum bid amount tendered in the auction within 30 days from the date of original sale or prior to confirmation of the sale whichever is earlier.

There is yet another hardship experienced by parties in this sector, usually caused by protracted delay in the confirmation of leases, ultimately depriving the lessees of his quarry rights for the entire duration of the lease, and resulting in financial loss. Nevertheless the rules empower the District Collector to renew the lease of quarry without loss of time and in favour of a present lease, provided such a renewal is in the interest of Mineral Development.

At present, most of the quarries auctioned away are worked in an unscientific manner unlike in the case of mines where from major industrial minerals are extracted. In practice, it poses really a problem to bring about a systemic working of these quarries in view of the wide disposal of the same covering various parts of the State. The desultory mining resorted to by leases is perhaps influenced by a native desire on the part of the leases to achieve maximum exploitation with little attention paid to satisfactory working. This is indeed a very alarming situation calling for strict enforcement of rules by the concerned authority such as the Directorate of Mines Safety. It is gratifying to note that the Government of India have rightly been seized of the various hazards involved in unsystematic quarrying and have set up a working committee that would go into the working conditions of the quarries and formulate draft rules governing the open-cast workings. The Director of Mines Safety is in favour of long term lease for Minor Minerals as in the case of Major Minerals.

Besides these, there are certain other important minerals occurring in the State of which the more important are : Corundum in Dharmapuri District, Puzzalonic material in Tiruchirappalli district, Mica in Uttangarai taluk of Dharmapuri district, Gold in Aduthurai Tea Estate, Molybdenite in Karadikuttam in Madurai district and Sillimanite deposits of Tiruchirappalli district. Investigations on these by the Geological Survey of India are in progress.

The statistics presented in the various tables in preceding chapters are all drawn from the ' Mineral Statistics of India ', Volume 4, No. 1 January 1972, Indian Bureau of Mines.

ANNUAL PRODUCTION OF IMPORTANT MINERALS IN TAMIL NADU

Sl.No.	NAME OF THE MINERAL	1968		1969		1970		1971	
		PRODUCTION IN METRIC TONNES	VALUE IN THOUSANDS	PRODUCTION IN METRIC TONNES	VALUE IN THOUSANDS	PRODUCTION IN METRIC TONNES	VALUE IN THOUSANDS	PRODUCTION IN METRIC TONNES	VALUE IN THOUSANDS
1	LIGNITE	41,21,147	78,426	41,87,630	86,056	35,44,599	89,856	36,60,200	92,769
2	BAUXITE	77,942	1,028	72,183	1,245	84,800	1,427	73,560	1,282
3	LIME STONE	31,35,553	22,770	32,33,714	28,851	36,93,353	34,227	40,65,978	3,054
4	LIME SHELL	144	4	279	8	791	24	1,742	52
5	MAGNESITE	2,47,543	5,039	29,02,113	10,259	3,46,761	11,580	2,88,214	7,752
6	GYPSUM	1,29,551	2,395	13,36,117	2,803	95,271	1,936	1,04,980	2,150
7	CHINA CLAY (NON SALEABLE)	6,199	N.A.	13,568	N.A.	4,939	N.A.	7,720	N.A.
8	CHINA CLAY (SALEABLE GURD)	4,776	34	2,487	14	965	7	1,009	N.A.
9	CHINA CLAY (PROCESSED)	2,653	339	3,603	461	3,547	468	1,888	313
10	FIRE CLAY	19,848	118	20,770	100	25,146	147	24,882	117
11	QUARTZ	638	2	1,143	5	309	1	2,039	20
12	FELDSPAR	5,026	25	6,556	33	7,611	46	9,482	31
13	SILLIMANITE	N.A.	N.A.	N.A.	N.A.	940	410	311	150
14	VERMICULITE	126	3	500	10	N.A.	N.A.	243	5
15	MICA	64	63	63	72	89	137	90	5
16	GARNET (ABRASIVE)	737	41	150	8	N.A.	N.A.	5	N.A.

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CHAPTER VI.

THE PROGRAMMES AND PROJECTS FOR THE PERSPECTIVE PLAN PERIOD.

6.1 *General.*

After a critical assessment of the mineral potentials of Tamil Nadu, 82 schemes are suggested pertaining to about 20 minerals available in the state for the Perspective Plan Period (1972–1984). The schemes are categorised under the following heads :—

1. Explorative schemes (Mapping and surveying.)
2. Exploitation schemes (Mining and Utilisation).
3. Research and development schemes (Benefication and Fundamental research).
4. Pilot Testing Schemes (Feasibility study).
5. Marketing Schemes.
6. Administrative Schemes.

The accompanying tables gives the number of schemes in respect of each mineral and also the nature of the schemes. The details of the schemes along with their financial implications, priority ratings and job potentialities are discussed in the next chapter.

PROGRAMMES AND PROJECTS SUGGESTED IN THE PERSPECTIVE PLAN PERIOD. (1972–84).

TABLE XLII.

Minerals.	*Total.*	*Explorative.*	*Exploitation.*	*Research and Development.*	*Pilot testing.*	*Marketing.*	*Administrative.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Apatite	7	3		4	..	—	—
2. Bartes ..	3	2	..	1			
3. Bauxite	3	1	..	1	1	..	—
4. Chromite	4	1	..	2	1	..	..
5. Clay ..	7	2	1			4	..
6. Copper, Lead ..	2	2	..			..	..
7. Graphite	2		1		..	1	—
8. Gypsum	2	..	1	...	1	..	..
9. Ilmenite	7	..	1	5	1	—	..
10. Iron Ores	4	..		1	1	..	2
11. Limestones	7	1	2	1	..	2	1
12. Dolomite	..	..		..	..	..	..
13. Lignite	2	1		1	..	..	..

TABLE XLII—(*contd.*)

Minerals.	*Total.*	*Explorative.*	*Exploitation.*	*Research and Development.*	*Pilot testing.*	*Marketing.*	*Administrative.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
14. Magnesite ..	6	..	1	3	1	1	
15. Minor Minerals	14	1	1	4		3	5
16. Quartz and Felspar ..	3			2		1	
17. Talc	..		..	..		..	
18. Vermiculite	3	..	1	1		1	
19. Other minerals and General.	6	5*					1
	82	19	9	26	6	13	9

* Prospecting for Molybdenite, Mica, Corundum, Sillimanite, Gold are being carried out by Geological Survey of India.

6.2 *Explorative Schemes* : (*I*).

6.2.1. There is need for a realistic estimation of the resources of rock phosphate in Tiruchirappalli. It is suggested that an intensive survey aided by a number of deep trenches and pits should be taken up in the places of its occurreance ..	APATITE AND ROCK PHOSPHATE.
6.2.2. Assess the exact reserves of apatite crystals in carbonatite syenite complex of Sevathur, Thirupathur, North Arcot District	Do.
6.2.3. During the extraction of Uranium from pyrocholore by the Automic Energy Commission, a planned method of exploitation of the associated apatite should be evolved	Do.
6.2.4. In the case of baryters as only preliminary prospecting by trenching and pitting was resorted to and a rough estimate of the reserve calculated, a detailed drilling should be undertaken. The United Nations Development Project Team may be requested to recommend a suitable method of Geophysical Survey for this mineral	BARYTES.

6.2.5. Barytes is invariably the gangue associated with lead mineralisation. Hence, it is a prerequisite that before detailed investigations for sulphide bodies are carried out, a comprehensive geophysical survey sholud be undertaken to demarcate or decipher the concealed bodies in the mineralised zone (i.e., lead) .. .. .. BARYTES.

6.2.6. Further discoveries of Bauxite by suitable survey methods .. BAUXITE.

6.2.7. A thorough and careful survey of the ultra basic formations of Tamil Nadu is to be undertaken to locate the new deposits of chromite .. CHROMITE.

6.2.8. The possibility of increasing the production of fire bricks from 10,000 tonnes per annum at present to the projected requirements of 30,000 tonnes, by locating area of availability CLAY.

6.2.9. The quality and quantity of individual deposit to be fixed Do.

6.2.10. All the zones of shear trending north east-south west should be carefully mapped .. .. COPPER, LEAD AND ZINC.

6.2.11. By proper geophysical method of the zone of sulphide mineralisation should be exmined by means of deep drilling operations Do.

6.2.12. A detailed assessment of quality and reserves of all the limestones, large and small in the State will have to be taken up .. LIMESTONES.

6.2.13. Intensive search in and around the coal horizon in Ramanathapuram district struck during 1965 should be undertaken .. .. LIGNITE.

6.2.14. The occurrences of Moulding sands in different places in Chingleput, North Arcot and Kanyakumari districts should be studied in detail and their specifications fixed up .. MINOR MINERALS.

6.2.15. Molybdenite prospecting at Karadikuttam, Madurai District .. .. MOLYBDENITE.

6.2.16*	Sillimanite Prospecting in Tiruchirappalli district	SILLIMANITE.
6.2.17*	Investigation of Gold deposits near Aduthurai, Nilgiris district	GOLD.
6.2.18*	Corundum Prospecting in Dharmapuri district — — — — — —	CORUNDUM.
6.2.19*	Mica Prospecting in Uthangarai in Dharmapuri district	MICA.

* Prospecting is being carried out by the Geological Survey of India and is likely to be continued during Vth Plan Period.

6.3. *Exploitation Schemes*—(II).

6.3.1.	Neyveli Lignite Corporation should be prevailed upon to give importance to the mining of white clay to support the suggested ceramic units. The State may set up Washing Units under its control	CLAY.
6.3.2.	Graphite exploitation at Sivangangai	GRAPHITE.
6.3.3.	No systematic evaluation of potential reserves of Gypsum has been made till date. This needs to be done as the first step towards the exploitation of this mineral ..	GYPSUM.
6.3.4.	Tamil Nadu Government should accord top priority to the commercial exploitation of the Ilmenite resources in the State and set in motion a crash programme for setting up a full scale plant for the production of Ilmenite, Rutile, etc., from the Beach sands.	ILMENITE.
6.3.5.	All cement plants in the State should be required to carry out detailed prospecting of the limestone reserves such a survey should be insisted upon before any scheme for expansion is sanctioned — — ..	LIMESTONES.
6.3.6.	All the high grade limestones in Cretaceous formations around Ariyalur in Tiruchirappalli district should be reserved for Salem Steel Plant	Do.

6.3.7. The mining of magnesite as at present done is wasteful and often lean blocks are left off as uneconomical to work. A more systematic and planned mining, keeping in view the conservation and utilisation of the entire deposits should be insisted upon. The fluctuation in demand, the soft nature of the dunite and the irregularity of the magnesite veins make mechanisation difficult, costly and ineffective. However, a suitable blend of mechanised and manual mining can yield improved results .. .. .. MAGNESITE.

6.3.8. There are a few offers especially to enter into collaboration with the State Government for large scale exploitation and export of granites. These could be considered MINOR METALS.

6.3.9. The vermiculite reserves of Tamil Nadu may be exploited for export subject to a ceiling .. VERMICULITE.

6.4 *Research and Development Schemes—(III).*

6.4.1. A proper large scale method of mining the Gypsum on modern lines may be evolved so that the associated phosphatic nodule may also be recovered at a reasonable cost APATITE.

6.4.2. In view of the growing demand for phosphatic fertilisers it is absolutely necessary that the indigenous resources of apatite and rock phosphate are developed to the maximum possible extent .. Do.

6.4.3. The RRL, Hyderabad and the NML carried out pilot plant benefication studies on low grade mixed apatite samples from Bihar. The results indicated that the low grade apatite sample can be upgraded to produce the desired apatite concentrate suitable for the manufacture of fertilisers. Since this method is available the estimation of the reserves of low grade deposits can also be made and benefication tests on these low grade ores can be carried out .. .. Do.

6.4.4.	The use of nitric acid instead of hydrochloric acid or sulphuric acid for decomposing rock phosphate resulting in the production of two valuable concentrated inorganic chemical fertilisers, viz., mono-ammonium phosphate and ammonium nitrate in solution, which can directly be utilised as fertiliser, appears to be attractive, this can be suggested to the manufacturing concerns of fertilisers. This procedure can be employed successfully even for utilising rock phosphate containing large amounts of calcium carbonate. The benefication of phosphatic nodules of Tiruchirappalli does not therefore pose a problem owing to its contamination of carbonate matter	APATITE
6. 4. 5.	The benefication possibility can be examined after the establishment of Mineral Testing Laboratory. Before that I.B.M. may be contacted as benefication tests on certain barytes have been carried out by them	BARYTES
6. 4. 6.	Benefication of low grade Bauxites—such an attempt has already been made by the Directorate of Mines, Orissa	BAUXITES
6. 4. 7.	A study for the extraction of sodium dichromate and a valuable bi-product aluminium from the low grade chromite ore to be undertaken, if more deposits are located. This may be accommodated either at the end of the V Plan or at the beginning of the VI Plan ..	CHROMITE
6. 4. 8.	The presence of platinum in the chromite bearing rocks of Sittampundi complex should be examined ..	Do.
6. 4. 9.	To direct the Geology Department to investigate the occurrence and rate of replenishment in the Vaipar-Kallar Delta ..	ILMENITE
6. 4. 10.	To arrange feasibility studies and report thereon ..	Do.
6. 4. 11.	To arrange project study and reports	Do.

6. 4. 12 A technical committee to visit the units working in India for studying production methods and cost involvements .. .. ILMENITE

6. 4. 13 The committee should visit Ceylon, whose plant is considered to be most modern and best suited for working the resources in India .. .. Do.

6. 4. 14. To study in detail the scope for establishing sponge iron plants on a regional basis to feed the continuous steel casting plants in the State. This could relieve the active threat to the iron supply position in this part of the country and the stress on our railways .. .. IRON ORES.

6. 4. 15 Possibility of setting up additional plants for calcium carbide can be explored .. LIMESTONES

6.4. 16. In advanced countries, underground gasification of lignite is generally favoured where other methods of extraction are uneconomic. Attempts to gasify coal *in situ* have been made in various countries, particularly in the U.S.S.R. and the U. K. In the former country, oxygen gasification of coal and lignite is practised for seems up to 10 metres thickness. At one time Messrs. Humphery and Glasgcow were entrusted with the preparation of a project report for undergound gasification of the Palana Lignite in Rajasthan. According to an excerpt from a report by the Director, Central Fuel Research Institute, Dhanbad this firm concluded that power generation costs would be of the order of 2.6 paise per KWH for Palana Lignite. This may be suggested to the Government of India .. .. .. LIGNITE

6. 4. 17. Effective plans should be drawn up now itself to meet the demands of the three new steel plants in the South and of the Bokara Plant, in the coming years. A large integrated refractory brick plant to produce magnesite, chromite, fire clay and silicon bricks could be located at Salem to meet this demand .. .. MAGNESITE

6. 4. 18.	The possibility of manufacturing high temperature forsterite refractories utilising the magnesite rocks of the same region may be explored	MAGNESITE
6. 4. 19.	In view of the location of the Madras Aluminium Company nearby it would be useful to produce magnesium-aluminium alloy in the region	Do.
6. 4. 20.	The syenites of Tirupathur in North Arcot District and the dolerites, syenites, aplites, and granites of Krishnagiri and Hosur area are more suited for the purpose of polishing industry in comparison to the rock types of other districts. Hence the State Government may concentrate on the development of polishing industry at present in Dharmapuri and North Arcot Districts.	MINOR MINERALS
6. 4. 21.	The stone polishing unit at Krishnagiri should be equipped with the latest sawing and polishing machinery for the production of thin slabs by importing them from Italy or Japan. These specially designed machinery could be imported against the export of unpolished granites to the machinery supplying countries. It is reported that the Italian Trade Delegation has expressed its willingness in this respect ..	Do.
6. 4. 22.	Mechanical handling of larger blocks may be introduced as far as possible at the factory site and at railway stations to ensure safe transit and despatch of the material and also to minimise handling charges	Do.
6. 4. 23.	The quarries of the Government Stone Polishing Unit in Dharmapuri district should be equipped with the latest type of diamond sawing and channelling machines, etc. from Japan or other countries so that the production of thin slabs and other oriented blocks could be started. This would also save wastage of rock during quarrying and dressing to a large extent and would facilitate the production of thin slabs in fractured and highly cleavable rocks ..	Do.

6. 4. 24.	The possibilities of setting up plants for the manufacture of silicon gel, fibre glass and fused quartzware to be explored ..	QUARTZ AND FELSPAR
6. 4. 25.	To assess the Rubidium and Caesium contents in Quartz and Felspar in Tiruchirappalli area.	Do.
6. 4. 26.	The Industries Department to carry out extensive and intensive research on Vermiculite and its applications and pioneer its propagation	VERMICULITE

6.5. *Pilot Testing Schemes. (IV).*

6. 5. 1.	Attention may be paid to fix up alternate sources for alumina as is being done in some foreign countries	BAUXITE
6. 5. 2.	In the light of 'Tatas' research on feasibility of using low grade chrome ores, the ores of Tamil Nadu gains importance and in view of the large reserves of dunite and magnesite available, a pilot testing can be undertaken for the manufacture of chrome-magnesia-forsterite bricks on the lines of 'Tatas'	CHROMITE
6. 5. 3.	A pilot project should be undertaken for testing improved methods of mining and recovery provided investigations establish the occurrence of sufficiently workable reserves. The recovery rate can be easily stepped up by 50 per cent and the cost substantially reduced by introducing elementary mechanisation ..	GYPSUM
6. 5. 4.	Vaippar-Kallar Delta may be considered for locating a separation plant. The advantages are close proximity to a major port, viz., Tuticorin, availability of extensive Government waste lands and the ready availability of high voltage electricity. The resources in this area are estimated to support independently a separation plant for processing of ilmenite and other heavy minerals with a rated capacity of 50,000 to 70,000 tonnes	ILMENITE
6. 5. 5.	Possibility of concentrating Tiruvannamalai ore may be examined on a pilot scale..	IRON ORES

6. 5. 6. The magnesite should be properly mined, upgraded in quality and put to the best industrial uses. At present only a fourth of the mined magnesite is recovered as suitable for refractories and the rest is wasted. No efforts are made to beneficiate the rest of the materials so that the entire magnesite that is mined can be used for refractory purposes. For this, effective pilot plant studies should be taken up immediately and a beneficiation plant set up either by the mining companies or by Government at the Chalk Hills near Salem	MAGNESITE

6.6. *Marketting Schemes (V).*

6.6.1. A Vitreous Glazed Mosaic Tiles Industry is to be established. The additional requirements for white and sanitaryware may be obtained by setting up additional washing capacity to the extent of another 20 tonnes a day. This would require an investment of Rs. 15 lakhs (NCAER)	CLAY.
6. 6. 2 Two Crookery units to be established	Do.
6. 6. 3. A high-tension, low-tension insulator unit to be put up	Do.
6. 6. 4. A market research organisation for ceramic and final products is to be established	Do.
6. 6. 5. A Graphite Crucible Plant may be set up	GRAPHITE
6. 6. 6. In view of the large demand for industrial lime, it is recommended that a number of modern machanised lime kilns be set up, wherever suitable deposits are available to produce high grade industrial lime	LIMESTONE
6. 6. 7. Two or three small units producing precipitated calcium carbonate can be set up in the State to meet the existing demand	Do.
6. 6. 8. The possibility of locating a plant for producing magnesium metal in Salem district utilising the magnesite and probably chlorine gas from Mettur Chemicals Limited if available should be investigated. There is sufficient demand for magnesium metal	MAGNESITE

in the country. The process already successfully employed by the Central Electro-Chemical Research Institute can be profitably utilised in the proposed plant and the possibility of producing MgO may also be examined .. .. .. MAGNESITE

6.6. 9. The State Government may consider the possibilities of entering into long-term contracts with buyers in countries for exporting granite both in the polished and unpolished forms. The supplies could be made from the various quarries in and around Krishnagiri and dyke rocks occurrences in Sholingur in North Arcot District. It is reported that the Italian Trade Delegation to India had evinced keen interest in red coloured granities. Hence an attempt may be made for exporting these stones also MINOR MINERALS.

6.6.10. The possibilities of exporting the green quartzites of Satyamangalam area to Japan, Itally and other foreign countries should be explored .. .. Do.

6.6.11. The possibilities of setting up other plants in Dharmapuri or North Arcot Districts to produce finished polished stones and other decorative building materials like flooring tiles, etc., with foreign collaboration (either with Japan or Italy) within the State could be explored by the State Government .. .. .. Do.

6.6.12. To explore the possibility of supply quartz and felspar to the Bharat Electronics Limited, for their proposed TV glass shells manufacturing Units .. .. .. QUARTZ AND FELSPARS.

6.6.18. As there is a prospective demand for the exfoliated vermiculite as well for a number of vermiculite products, it is proposed to manufacture various finished products in a phased manner .. .. VERMICULITE.

6.7. *Administrative Schemes (VI)*

6.7.1. Streamlining and Strengthening the Geology Branch, with a view to upgrading it into..

	a Directorate in the V Plan and Mineral Development Corporation in VI Plan period	GENERAL.
6.7.2.	To insist on the Government of India to utilise fully the local raw materials for the proposed steel plant at Salem ...	IRON ORES.
6.7.3.	In view of the large anticipated demand for special steel alloy, there is ample justification for setting up Salem Steel Plant on a much larger scale than is envisaged at present ..	Do.
6.7.4.	In view of the importance of limestones as an industrial mineral, suitable measures should be taken to prevent illegal mining or wastage of limestones by improper use.	LIMESTONES.
6·7.5.	The matter of ensuring availability of adequate shipping space for export of polished stones should be taken up by the State Export Promotion Advisory Board with the Directorate-General of Shipping so that the delivery schedule can be kept up and expenditure on siding charges can be minimised	MINOR MINERALS.
6·7·6.	To prevent the illicit quarrying of minor minerals through State legislation or suitable Government order	Do.
6·7·7.	The various hazards involved in unsystematic quarrying to be studied in detail and to effect this it may be suggested to set up a Working Committee that would go into the working conditions of the quarries and formulate draft rules governing the open-cast workings	Do.
6·7·8.	The idea of the Director of Mines Safety sanctioning a long-term lease for Minor Minerals as in the case of Major Minerals may be examined	Do.
6·7·9.	It is understood that there is a thriving illicit exploitation of the foundry sands occurring at Ennore and their supply to the various industrial units in Madras. Proper steps should be taken to prevent such illicit quarrying	Do.

CHAPTER VII.

FINANCIAL IMPLICATIONS AND PRIORITY RATING OF THE PROJECTS.

7·1· *Outlays.*

The outlay earmarked for the Mineral Sector under State Schemes is 157 lakhs in Fifth Plan—double the outlay of Fourth Plan Programmes. It should be remembered that this amount of Rs. 157 lakhs is exclusive of Central Government investments and outlays that may be financed by private industries and international agencies. In fact, efforts must be made to get the maximum benefit from Government of India for explorative schemes while similar such bulk grants may be expected from UNESCO, Private industries and other bodies for the Research and Development schemes as well as for the Pilot Testing and Feasibility Study Schemes. A part of the royalty that may be realised in another three or four years time from the exploitation of Salem ore by Salem Steels Limited may be allocated for the developmental programmes. In fact, in Gujarat, the royalty which the Directorate of Geology gets from Oil and Natural Gas Commission for the exploitation of oil in Anleshwar is being spent for the maintenance of Directorate and other developmental programmes in the mineral Sector.

The establishment of the proposed Market Wing in the mineral sector with certain production and sales units attached to it will be able to realise a good revenue through direct sales.

The details of the outlay are given in the following table :

TABLE XLIII.

	1972–73.	1973–74.	*V Plan.* 1974—79.	*VI Plan.* 1979—84.
		(RUPEES IN LAKHS.)		
1 Explorative Schemes	6·65	7·25	40	200
2 Exploitation Schemes	0·75	0·75	30	100
3 Research and Development Schemes.			10	[illegible]
4 Pilot Testing Schemes	1·75	1·75	20	100
5 Marketing Schemes			50	100
6 Administrative Schemes (Expansion of Geology Branch, etc.)	12·50	12·70	7	50
Total	21·65	22·45	157	600

The job prospects of the various schemes are included in the actuals relating to the different sections. Even though the schemes suggested are all of a capital intensive nature, they have significant direct and indirect employment generating effects. An abstract of the possibilities is in the following table :—

TABLE XLIV.

EMPLOYMENT POTENTIALS DURING PERSPECTIVE PLAN PERIOD IN THE MINERAL SECTOR.

	Skilled.	*Unskilled.*	*Technical.*	*Total.*
1 Explorative Schemes	75	75	50	200
2 Exploitation Schemes	70	300	30	400
3 Research and Development Schemes.	60		40	100
4 Pilot Testing and Feasibility Study Schemes.	80	60	80	220
5 Marketing Schemes	40	40	20	100
6 Administrative Schemes ..	50	150	50	250
Total	375	625	270	1,270

Thus the implementation of the various plan schemes will provide job opportunities to 1,200—1,300 persons at different levels. Apart from this, the various mining and mineral industries will be able to employ roughly about 20,0000 people. This number is likely to increase annually at the rate of 10 per cent during the period covered by the Perspective Plan.

7·2· *Explorative Programme suggested during Perspective Plan Period.*

Even though the Geological Survey of India and the State Geology Branch have been carrying on survey work for quite sometime, the entire State has not been fully covered so far. Our present knowledge relating to the mineral resources and the mineral reserves in the State, is, therefore incomplete. The aim should, therefore, be to fill up the information gap during the Perspective Plan Period.

It is suggested that by 1984 or at the end of the proposed twelve year plan, a thorough scientific, survey covering the entire state should have been completed. For such an effective work, the two imperative requirements are :—

(*a*) Scientific methods.

(*b*) Trained Personnel.

A radical change in the techniques of survey should be effected. The preliminary ground survey should be supplemented by continued exploration with the aid of Geophysical, Geochemical survey and mapping on aerial photographs. It is essential

that due to emphasis is laid on air-borne mineral surveys, though these are quite costly. The rough cost of Air-borne survey is as follows :—For Electromagnetic Surveys—Rs. 230 per line mile while for ordinary magnetic survey it costs Rs. 120 per line mile. A headway has already been made in this direction by the United Nations Development Programme Team by covering an area of 17,000 square kilometres. The sanctioning of the second phase is in the offing under which an area of about 20,000 square kilometres in parts of Salem and Coimbatore districts will be covered by an intense air-borne E.M. Survey : The availability of the United Nations Development Programme expertise should be taken advantage of to the maximum extent. Several ground survey explorative teams should be formed and they should specify the various tough and other terrains which need special investigation. These areas may be subjected to explorative survey by United Nations Development Programme team. After the completion of the UNDP scheme, the Geology Branch should be able to take up the explorative work independently. This depends on the availability of technically trained personnel to undertake the work.

Actually the vital element in the improvement of quality of survey is the systematic training of the various local personnel. A scheme should be drawn up to give training to the various personnel of the Geology Branch, including training abroad. The explorative personnel should know " why ore is where it is"? For this he should have a thorough knowledge of the terrain he undertakes to survey. Oftentimes due to the lack of knowledge of the geological and structural set up of the terrain in which he works, an explorative geologist misses the important economic deposits.

In the circumstances, several explorative units should be formed immediately. Each explorative units should have : (i) A Ground Survey Team (ii) Geophysical Team (iii) Geochemical Team (iv) Drilling Team (v) Air-Survey intepretation Team. During the Perspective Plan period the State will be divided into sectors and for each sector an explorative unit will be attached. For example, each district may be divided into 3 or 4 sectors, thereby the entire State can be divided to 40—45 sectors. So, by the end of the IV Plan about 40 explorative units will have to be formed. This should be adequate to complete the survey work of the entire State by 1984. An amount of Rs. 240 lakhs should be earmarked towards surveys during the next 12 years. The mapping and explorative work is concurrently done by Geological Survey of India also. The explorative works are, therefore, partly done by Government of India and partly by the State. It should be programmed in such a way to avoid any overlapping.

This outlay of Rs. 240 lakhs for the entire Perspective Plan Period of 12 years seems to be quite low. But some of the explorative schemes are to be undertaken directly by the Tamil Nadu Circle of Geological Survey of India. While some other schemes will be executed by United Nations Development Programme Team. Hence a very modest outlay of Rs. 40 lakhs only is suggested during the Fifth Plan period and a bigger outlay of Rs. 200 lakhs is suggested in the Sixth Plan period by which time the State should be able to undertake all sorts of sophisticated explorative survey including the air-borne Electronmagnetic survey by its own men and material. Hence a bigger outlay of Rs. 200 lakhs for the Sixth Plan period is justified.

The United Nations Development Programme Team has made the explorative work in Tamil Nadu easy. Recently in 1969 John C. Grady along with the other experts of the UNDP team undertook a photogeological survey on the Pre-cambrian shield of South India (of which Tamil Nadu is an integral part), part of the UNDP programme. This survey revealed the existence of eleven fault zones, some trending N 30° E and some trending N 45° E along which almost all the valuable mineral deposits of Tamil Nadu are concentrated. He suggested " that continued exploration with the aid of photogeology and geophysical survey will reveal more of the deep main-faults and possibly more ore bodies in South India". During the Perspective Plan Period, due consideration is to be given to the relationship of the structural elements to the localisation of mineral deposits. The various explorative units suggested should concentrate their survey along these major fault zones. As indicated by J.C. Grady these fault zones are really the zones o ' minerali sation; hence a careful search along these zones will certainly reveal fresh economic deposits of Tamil Nadu. Among the various explorative schemes suggested, the investigation on Limestone, Bauxite and Clay be taken up first, followed by base metals investigations. The investigations on apatite, rock phosphate, lignite, chromite, minor mineral and barytes may be taken up in that order next.

To sum up , the following programme is suggested during the Perspective Plan Period :

(1) The entire State should be covered by systematic surveying by 1984.

(2) Explorative units (40) may be formed—each unit consisting of geophysical, geochemical, ground survey, air-survey interpretation teams.

(3) State may be divided into sectors and each sector to be brought into the purview of one explorative unit.

(4) Primarily the various explorative units in different sectors should start an intensive survey along the zones of Fault systems discovered by Grady—these being the possible zones of mineralisation in Tamil Nadu.

(5) The order of priority of the investigation is suggested as follows :—
Limestone, Bauxite, Clay, Base metals, Apatite, Lignite, Chromite, Minor minerals and Barytes.

(6) An outlay of roughly Rs. 240 lakhs is envisaged.

(7) These programmes will create job opportunities for 200 people at various levels as follows :—

Skilled labourers	.. 75
Unskilled labourers	75
Technical personnel	50

7·3. *Exploitation Programme during the Perspective Plan Period* :

In order to ensure scientific explo tation of minerals, the Geology Branch should take the initiative and evolve norms which will automatically ensure that principles of mineral conservation are properly observed. The problem of conservation of mineral resources

arises particularly because they are irreplaceable wasting assets which are quite liable to be wantonly exploited. They do not reproduce like forests or whea . There is no mineral 'Crop'. Conservation involves:—

(i) Prevention of waste during production.

(ii) Intelligent using.

(iii) Utilising of lower-grade materials.

(iv) development of substitutes and preservatives.

(v) Reservation of certain minerals in the public sector.

These questions concern both public interest and private ownership. Conservation as applied to the prevention or elimination of loss or waste of mineral resources during mining is highly desirable. Again, too often rock below economic grade is sent to waste-dumps and intermingled with barren material, thus eliminating its possible future use. Instead, such material should be segregated and brought out when higher prices or lower costs might permit its utilisation.

The profitable winning of metals and industrial minerals involves one or more steps within the sphere of mining and metallurgical operations such as proper method of mining, ore dressing, smelting and refining. The wasteful method of mining of the two minerals.— Magnesite and Gypsum should be stopped immediately. A suitable blend of mechanised and manual mining can yield improved results. To ensure that the mining companies adopt a proper method of mining and to avoid the wasteful method of mining, a vigilant cell under the headship of a mining engineer may be formed and attached to the Geology Branch during the Fourth Plan period itself. Neyveli Lignite Corporation should be prevailed upon to give importance to the mining of white clay to support the ceramic industries. The State may set up washing units under its control.

Another important aspect of effective exploitation of mineral wealth lies in the decision to be taken about the reservation of certain minerals in the public sector. Generally, the following minerals should be reserved in the public sector :—

(*a*) Strategic minerals.

(*b*) Minerals, which require heavy capital expenditure.

(*c*) Minerals, the exploitation of which require a long gestation period.

(*d*) Minerals, for the exploitation of which the required capital is not forthcoming.

Under this programme, all the high grade limestones in the cretaceous formations around Ariyalur in Tiruchirappalli District should be reserved for Salem Steel Plant. The iron ores of Kavuthimalai and Vediappan Malai may be reserved for State exploitation. In the Fifth Plan a concentration plant with plans to develop the same as pellitisation plant later is suggested. The Government have sanctioned a scheme for exfoliating vermiculite in G.O. Ms. No. 3498, I.L.H., dated 23rd November 1967 with a total provision of Rs. 3·75 lakhs. The lands to the extent of about 60 acres in Sevathur and Ellavampatti villages were acquired for mining purposes. At present about 35 to 40 tonnes of Vermiculite is being mined every month. The exfoliation Plant with a capacity of one tonne has been set up in the Industrial Estate, Ambattur. The requisite machinery and equipments have been erected and trial runs are being conducted to study

the different aspects of the process and also to work out the cost of exfoliation. The plant will have a capacity of one tonne of exfoliated vermiculite per day. It is proposed to manufac ure the various finished products in a phased manner (the details of these are given under the section on Marketing). The vermiculite scheme is mostly a labour oriented scheme in the sense that the mining work as well the work at the plant are not mechanised and thus give a scope for employment of local labourers. At present about 60 labourers (40 males and 20 women) from local villages are being employed in the mines and the strength is likely to be increased gradually to cope up with increased production. Similarly, suitable number of labourers will be employed in the plant for processing, packing an marketing. The employment potential of this scheme is indicated in the Table XLIV.

The Geology Branch through its Directorate has submitted a proposal to the Government recently to exploit the graphite deposits of Sivagangai and to establish a cruciable plant at the same place with an initial capacity of 300 to 350 tonnes per annum. An outlay of Rs. 22·25 lakhs towards non-recurring expenditure and Rs. 1·75 lakhs per annum towards recurring expenditure has been proposed.

There is great demand for graphite crucible in the country. Even the present demand in the country estimated at 7,000 tonnes per annum is not fully met with the result that the country is still importing large quantities of graphite from South Korea, Uganda and Greece. Besides crude graphite, about 400 to 600 tonnes of graphite crucibles are being imported every year. There is an immediate need to exploit the known occurrences of graphite. This fact has been rightly taken note of by the Government of India.

East Ramanathapuram is a backward area so far as the development of industries is concerned. The exploitation of the graphite deposit near Sivagangai will provide scope for the employment of a good number of labourers in and around this region. The deposit which occurs in the form of linear bands stretching over a length of five kilometres has to be mined in open workings. Since the width of the zones varies between 3 and 13 metres and as the zones are often intervened by non-mineralised zones, no large scale mechanisation may be possible in minings. Thus the mines will offer good opportunities for employment of the local labourers. The plant has also been proposed to be set up near the mines so as to avoid the transport of raw materials over a long distances. The crucible plant as such may not employ a large number of unskilled labourers. The setting up of this plant will to a great extent meet the requirements of crucible within the State and also the neighbouring States.

The two plants, Vermiculite exfoliation plant and Graphite Crucible Plant have to be put up in the Fifth Plan period.

The exploitation of Granites can be taken up during the middle of the Fifth Plan period, after modernising the equipment at the existing granite polishing unit at Krishnagiri.

The crash programme for setting up a full scale plant for the production of Ilmenite, rutile and garnet from the Beach sands may be taken up during the Sixth Plan after studying in detail the Vaipar and Kullar deposits.

The total outlay for the exploitation schemes is Rs. 30 lakhs in the Fifth Plan, the Vermiculite exfoliation Plant (4·5 lakhs) and the Graphite Cruciable Plant (24 lakhs) alone consuming 28·5 lakhs, the balance is allocated to modernise the equipments at the Granite Polishing Unit at Krishnagiri. The outlay for exploitation during the Sixth Plan is Rs. 100 lakhs. The development of the Granite Polishing Industry and the separation plant for the beach sands and the concentration plant utilising Kavuthimalai iron ores at Tiruvannamalai are the three major schemes suggested in the Sixth Plan period. The job potentialities of these schemes are as follows :—

Skilled—70.

Unskilled—300.

Technical.—30.

7.4. *Research and Development Schemes suggested in the Perspective Plan period.*

The establishment of reaserch laboratories is quite essential for the proper development of the mineral sector, Presently the Geology Branch has in its fold a number of precision equipments for conducting research on rocks, minerals and ores. The procurement of these costly equipment is possible because of UNDP operation. All these equipments are imported under the United Nations Development Programme. After the cessation of UDNP'S work the host institution becomes the owner of these equipments. Hence for the establishment of these research wing, much money need not be spent initially. Hence only a modest outlay of Rs. 10 lakhs is suggested in the Fifth Plan. During the Sixth Plan an outlay of Rs. 100 lakhs is suggested. This wing will undertake several research programmes and the programmes which deserves testing on Pilot Scale will be worked out and recommended. Bearing this in view, several research programmes have been suggested for the Perspective Plan period. The following priority rating may be observed. Recommendations made with respect of Bauxite, limestone, may be taken up during 1972–1984 while the schemes pertaining to iron ores, ilmenite, magnesite, lignite, quartz and feldspar, minor minerals, vermiculite, chromite and barytes may be taken up serially in that order.

The Research and Development Wing would work in close colloboration with certain CSIR laboratories like Central Electro-chemical Research Institute, Karaikudi, National Mettallurgical Laboratory, etc., Geology departments of Presidency College and University thereby adequate funds for research projects can be procured. The funds can be procured from bodies like UGC., UNESCO for certain projects of national and international importance.

This scheme will provide jobs for 100 people under various levels such as skilled 60, unskilled Nil, technical 40.

7.5. *Pilot Testing Schemes suggested in the Perspective Plan period.*

During the Perspective Plan period, greater emphasis needs to be laid down on Pilot Plant Studies with a view to proving the commercial viability of the processes developed in the laboratories, so that these would be readily accepted for utilisation by industry.

A scheme for the establishment of a Pilot Test Unit has been put up by the State Geology Branch. The scheme involves a non-recurring expenditure of Rs. 18 lakhs towards land and building and a recurring expenditure of Rs. 1·60 lakhs per annum towards staff, reagents, for processing units, spare parts, etc. This is to be accommodated in the Fifth Plan period. Taking into consideration the fact that Salem is centrally situated as regards minerals in the State, the Pilot Testing Laboratory has been proposed to be set up at Salem for which the land and building of the former Quartz Crushing Plant (a State Government undertaking) have been taken over with a few assets. The important machinery readily available in the plant are Jaw Crusher, Rotary Breaker, Conical ball-mill, Rotary Sieve, Electromagnetic separator, Roller Crushers, Belt and Bucket Wheel Elevators and H.T. sub-station. Some of these require reconditioning before being put into use. It has been planned to procure additional machinery equipments for the proposed laboratory besides the available machinery so as to equip it well for carrying out the bench tests. The money allocated in the Fifth Plan, viz., Rs. 20 lakhs will be used mostly for capital expenditure like purchasing of land, building and machineries and the plant may not be able to undertake the work of some private business entity in the initial stages. Also small schemes belong to the State sector may be taken up during this period. During the Sixth Plan period an outlay of Rs. 150 lakhs is envisaged in which the schemes relating to Bauxite may be given top priority followed by ilmenite, Iron Ore and Magnesite, in that order.

It should be emphasised again that the Pilot Test Plant shall operate in close collaboration with Central Electro-chemical Research Institute, National Mettallurgical Laboratory and other research laboratories. It is understood that CSIR is keen on setting up a pilot scale ore dressing laboratory in their campus in Adyar. While equipping the pilot Testing Plant, the purchase of equipment that are likely to be available in the proposed ore dressing laboratory to be set up by CSIR may be avoided so that there will not be any duplication in the equipments. The two laboratories may function efficiently as complimentary to each other.

These schemes will create job potentialities for 220 people of the following categories.

Skilled	80
Unskilled ..	60
Technical	80
	220

7.6 *Marketing Schemes suggested in the Perspective Plan period.*

It is proposed that after a stage, when the Geology Branch is upgraded to Directorate and then on to a Mineral Development Corporation, a Marketing Wing can be established under the control of this Corporation. It has already been suggested that there are going to be a Vermiculite Exfoliation Plant and a Graphite Crucible Plant—both of which will reach production stage during the middle of the Fifth Plan period. Provision has already been made for the manufacture of finished products from the exfoliated Vermiculite under a phased programme. The marketing of the products and the graphite crucibles may be taken up by the State itself. The activities of the marketing wing will be

increased gradually during the perspective plan period. The scope for such expanded activities is large. This would add to the earnings of the minerals sector and help in executing the policy and programmes of mineral development without any impediments for want of finance. With this object in view, certain trading schemes to be undertaken by the State are suggested. There are three schemes based on clay, two based on limestone, one on magnesite, three on Minor Minerals, one each on quartz-felspar and Verminulite.

Based on the availability of raw materials, a Vitreous Glazed Mosaic Tiles Industry is recommended.

The Vitreous Glazed Mosaic Tile when introduced will be the most modern building materials in India. This will have an edge over the conventional glazed tiles by their superior quality and attractive colourful designs. By being fully vitreous those tiles do not require frequent replacements like the conventional glazed tiles. The proposed factory will be capable of manufacturing 300,000 square feet monthly Out of this quantity 50 per cent will be glazed and 50 per cent will be unglazed. The plant will employ 130 workers made up of 80 men and 50 women. The project cost is estimated to be roughly Rs. 50 lakhs. But a Japanese firm is willing to enter into collaboration with such venture either in the State or in the private sector. This appears to be an attractive proposition, for, an initial share could be given in the shape of land, building, etc, for the proposed factory with minimum financial commitment. Hence this scheme deserves consideration.

The programmes of rural electrification, public lighting, tele-communications, etc., have all boosted up the demand for L.T. insulators. The additional annual generating capacity anticipated in the Perspective Plan period in the power sector will increase the demand of H.T. insulators. So high-tension and low-tension insulator units are suggested to be put up during the Fifth Plan period.

Besides these, two crockery units are suggested. To cater to the needs of the people in an effective manner, a market research organisation for ceramics and final products is also suggested.

Small units for the manufacture of much required high grade lime and precipitated calcium carbonate are also recommended.

The production of MgO and Metal Mg from the low grade rejects in the magnesite mines of Salem in collaboration with the Central Electro-chemical Research Institute, Karaikudi on the lines suggested by Thiru Aravamuthan may be considered.

The possibility of exporting the polished and unpolished slabs of granite and green quartzites of Sathyamangalam may be investigated as these materials have excellent demand in Foreign countries like Japan, Italy and U.K. The pre-requisites for the manufacture of such slabs like equipping the factory with modern equipments and mechanical handling of huge block of granite have all been discussed under Exploitation and Pilot Test Schemes.

This scheme should be given top priority because of the following reasons :—

(1) The Italian Trade Delegation is prepared to send modern machineries as exchange for the granite slabs, thereby saving foreign exchange.

(2) It promotes Export Trade.

(3) The resources are extensive and the implementation of the Scheme would bring in additional resources to the State.

Besides this, the possibilities of setting up a plant in Dharmapuri or North Arcot districts to produce finished polished stones and other decorative building materials like flooring, tiles, etc. with foreign collabortaion—either Japanese or Italian—within the State could be explored.

The possibility of supplying quartz and feldspar to the Bharat Electronics for their proposed TV glass shells manufacturing units may be studied.

The schemes relating to Vermiculite and Graphite may be taken up at the beginning of the Fifth Plan period. As regards, the other schemes, the granite export scheme should have top priority for the reasons already mentioned and may be taken up in the early years of the Fifth Plan itself.

Next, the establishment of Vitreous Glazed Tiles Industry can be taken up, for this is also to be done with foreign collaboration.

At this stage, the basic policy in regard to foreign collaboration and foreign investment should be clarified. In the detailed application of this policy care has to be taken to ensure that foreign collaboration is resorted to only for meeting a critical gap and that it does not adversely affect the maximum utilisation of domestic know-how and services. In order to identify the fields in which foreign collaboration is required and to streamline the procedure for acceptance or rejection of foreign collaboration proposals, a Foreign Investment Board has been set up by the Government of India. The broad guide lines indicated by this Board regarding the terms of which foreign collaboration might be permitted must be strictly adhered to while implementing the schemes involving foreign collaboration.

A total outlay of 50 lakhs is suggested in the Fifth Plan for the schemes under the marketing wing. In this, an outlay of Rs. 24 lakhs is earmarked towards the establishment of Graphite Crucible Plant at Sivagangai, Ramanathapuram district out of which a sum of Rs. 22·25 lakhs towards non-recurring and a sum of Rs. 1·75 lakhs per annum towards recurring expenditure has been proposed. A balance of Rs. 26 lakhs is leftover for the other schemes. But the final allocation of this amount to various schemes cannot be made at this stage, for the exact level to which the foreign components will collaborate in each of these schemes is not known. Hence the final allocation will be made only after the preparation of project report at least of a preliminary nature, are prepared, for these schemes.

These scheme will provide job opportunities for 100 people as detailed below :—

Skilled—40.

Unskilled—40.

Technical—20.

7.7. *Administrative Schemes suggested in the Perspective Plan period.*

The administrative schemes suggested in the plan document can be considered under the following broad heads :—

(i) Streamlining and strengthening of the Geology Branch.

(ii) Upgrading the branch into a Directorate.

(iii) Setting up a Mineral Development Corporation.

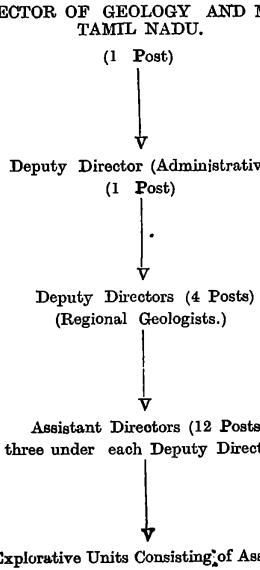
(iv) Enforcement of the policy of conservation and proper utilisation of minerals.

(v) Prevention of illicit mining.

Presently the Geology Branch is attached to the Directorate of Industries and Commerce. Right since its inception in December 1957, the Branch has been gradually expanding. The branch had grown up to a considerable size and extended its activities covering a major portion of the State by the close of III Five-Year Plan. It registered further growth during the Fourth Plan period. During the early years of the Fourth Plan period the Geology Branch was equipped with necessary technical staff, field equipments and chemical apparatus. The United Nations Development Programme was commissioned in April 1968. The active collaboration of UNDP has completely changed the composition of the Geology Branch. As beneficiaries, the Geology Branch received from the UNDP costly equipments such as Atomic Absorption Spectrometer, I.P. Electro Magnetic Equipments Gamma Ray Spectrometer, and Ore Dressing Equipments, which helped in the establishment of a modern research laboratory. With the aid of these sophisticated equipments both field and laboratory investigations can be undertaken, using modern techniques. The UNDP also included training of counterpart personnel in modern methods of surveys, in photo-geology, geophysics, geochemistry and field geology. Also training was given to a few officers overseas in the above specialised fields of geological exploration. The operation of UNDP second phase is in the offing and is under consideration of the U.N. Headquarters. This project is expected to be completed by the end of the Fourth Plan period (1974).

With the help of the existing UNDP experts the Geology Branch should be thoroughly reorganised. As has already been suggested the opportunity should be availed of to set up several wings such as Explorative, Exploitation, Research and Development Wing, Pilot Testing Wing and Marketing Wing. The details of these technical reorganisation have been discussed earlier. A good number of young persons should be trained by the experts here and also abroad to enable them to function competently in the different wings. The preliminary streamlining and strengthening of the Geology Branch should be carried out with a view to prepare the ground for the formation of the Directorate of Geology during the initial stages of Fifth Plan period. When this is formed, the districts may be divided into sectors and three or four districts may be brought under one Region. The region may be put in charge of one Deputy Director whose establishment will be situated in any one of the district headquarters which fall under his jurisdiction. Under each Region Geologist of Deputy Director Cadre, there will be three Senior Geologists of Assistant Director Cadre—one for Mineral Survey—one for Technical and Planning and one to deal with Licensing and other administrative problems. The Assistant Director (Mineral Survey) will have under his control an explorative unit consisting of the necessary staff of Assistant Geologists.

Besides this a Deputy Director will be stationed in the Director's Office at Madras to assist the Director in administration. The skeleton of the set up is as shown below :—



The other routine features like laboratories, library, publication unit, Museum, Drawing Branch, Store Branch, Accounts Branch should be attached to the Director's Office. There should also be a Statistical Cell.

The first four plans were mainly confined to mineral exploration. Having fairly assessed the mineral potentialities in the State, the State is now in a position to embark on more scientific and commercial exploitation of economic minerals and to promote mineral development activity with greater vigour. The formation of the Directorate will certainly go a long way towards achieving this objective.

Tamil Nadu must take every step to exploit fully the mineral resources by developing mineral-based industries. Besides scientific exploitation, successful planning of projects invariably depends on the commercial utilisation of the resources available. The State should come forward not only to take up extensive projects in the public sector but also to serve as Service Centre for such of those private entrepreneurs who may not be in a position to start new ventures because of lack of finance. The mineral concession statistic on record for the past few years clearly illustrate that there is a keen competition and earnestness on the part of the lesses to take up the mineral-based industries.

It is hoped that there will be greater rush for such activity from several quarters and areas where conditions are favourable for mineral production. Besides, the State has already taken up gigantic projects like Arasu Cements at Alangulam, Ceramic Centre at Vridhachalam, Mechnised Brick Plant at Thirumazhisai; not to speak of major projects like the Salem Steel Project, Tiruvannamalai iron ore complex, continuous Steel Cast at Arkonam, Cellular Concrete Plant at Ennore.

It is envisaged that organised large-scale mining activity is absolutely essential for the successful implementation of the various big industrial projects. In order to link up mining activity with industrial development, it is necessary to have a corporate body which could function effectively as an autonomous organisation and direct its activities along commercial lines. Such an organisation will be capable of taking quick and independent policy decisions with regard to mineral development and will not be bogged down by rigid bureaucratic formalities. Towards this end a Mineral Development Corporation should be set up in Tamil Nadu as an undertaking of the Government during the Sixth Plan period.

The functions of the Corporation could be confined to (1) Supply of mineral products to existing industries and captive mine belonging to State; (2) Owned mines and developed mines which are export oriented, as for example export of black granites, refractory articles and ceramic-wares. For discharging the day-to-day activities, the Corporation will have a sizeable band of technical personnel such as Mining Geologist, Mining Engineer Drilling Engineer, Assay Chemists and supporting crew and staff. The Corporation will have also its assests in the form of mining machinery and field earth moving equipments, drilling equipments, chemical equipments, etc.

Widespread illicit exploitation of several minerals in the State is another hazard which has to be looked into. At present the Geology Branch is processing about 150 applications of certificate of approval and about 75 applications for Mineral concessions in the State. Besides reviewing the opinions of the District Collectors the branch is also submitting to

the Government proposals for suitable amendments to the rules enacted under the Mines Act and the Mines and Minerals (Regulation and Development Act). As for the Mineral Concession Rules, though the Government sanction the lease it is the District Collector who by virtue of the powers vested in him exercises supervisory powers in the mines in the matter of total quantity of minerals removed, collection of royalty and deed rent, etc. Illicit mining in respect of both major and minor minerals is frequently reported. There is a leakage of revenue in this manner and improvement and reorganisation of the administrative machinery would help in solving this problem.

The long term Perspective Plan for Tamil Nadu will contribute to the attainment of the following objectives :--

OBJECTIVES.

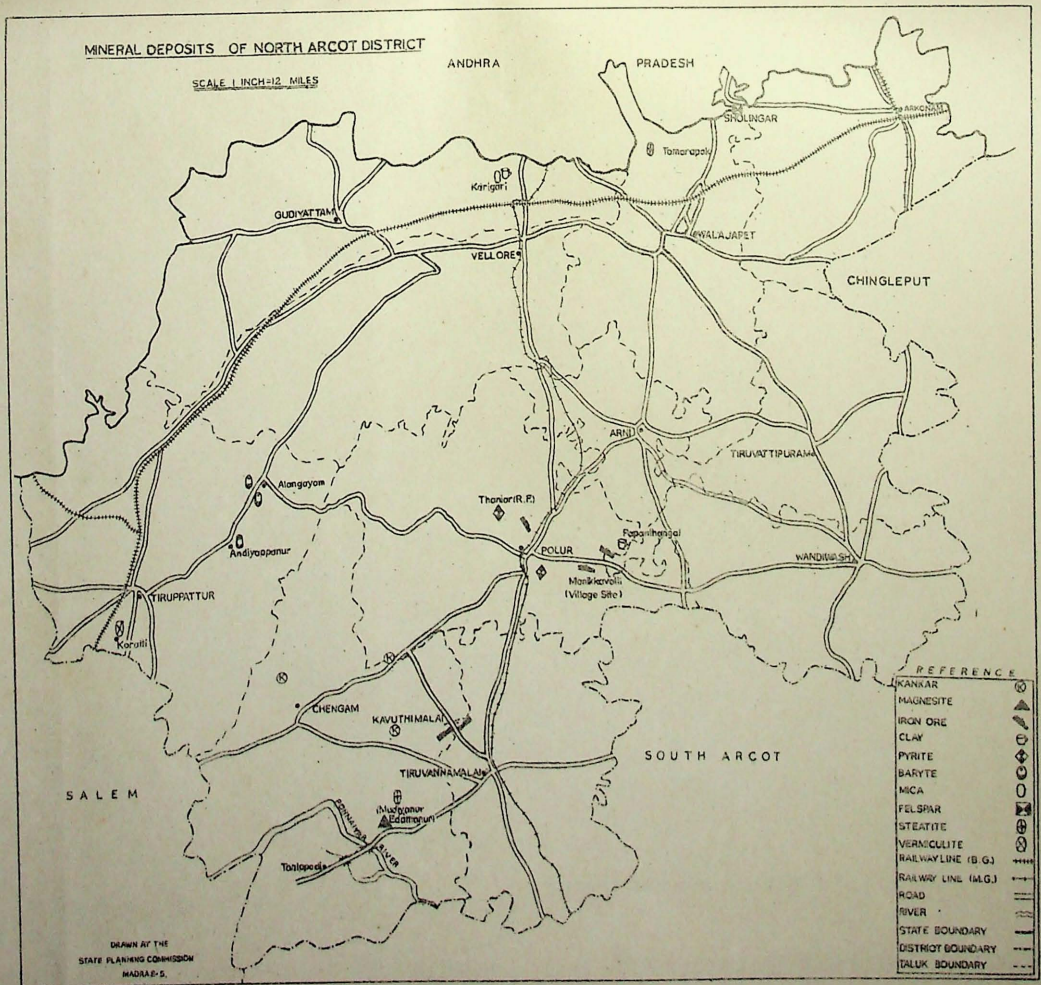
* By 1984 or at the end of the proposed Twelve-Year Plan, the entire State would be systematically covered by scientific geological surveys.

* Workable reserves of various mineral deposits of commercial importance would be located.

* The possibility of utilising the low grade ores will be explored by research and Pilot Testing.

* The policy of conservation and proper utilisation of mineral reserves would be enforced.

* These activities shoud culminate into schemes contributing to the establishment of mineral, metal and chemical-based industries in the State. It is needless to say that industrialisation would reduce unemployment, increase per capita income, accelerate the growth of the economy and contribute to the well being of the State.



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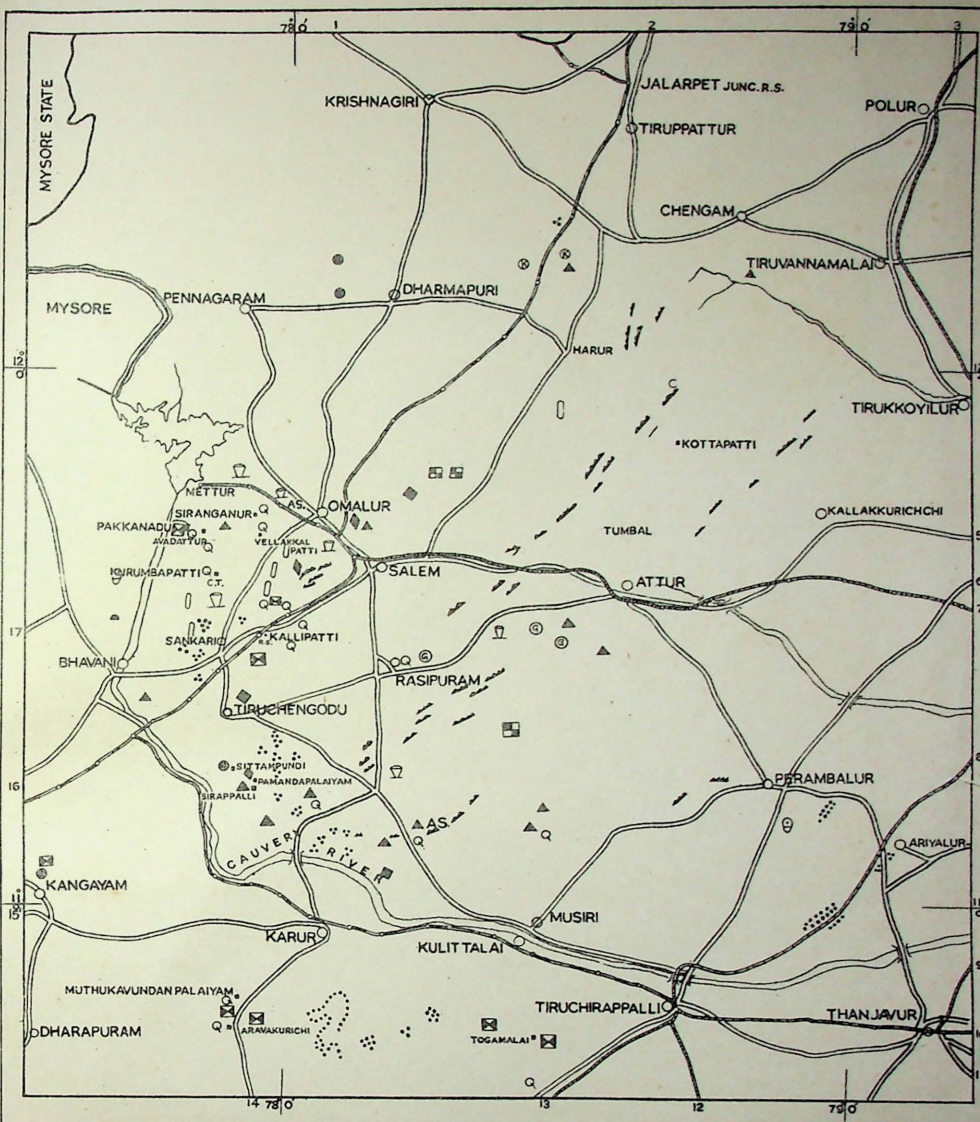

MAP SHOWING MINERAL OCCURRENCES IN AND AROUND SALEM

SCALE 1 INCH = 16 MILES

NOTE:-

The leading names for Roads and Railways indicated in the map by numbers are as follows:-

1. BANGALORE	10 NAGAPATTINAM
2&3 KATPADI	11 PATTUKKOTTAI
4&5 VILLUPURAM	12 KARAIKKUDI
6&8 MADRAS	13&14 DINDIGUL
7 VIRIDDHACHALAM	15&16 COIMBATORE
9 CUDDALORE	17 GOPICHETTIPALAIYAM

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REFERENCE

ASBESTOS	AS.	IRON ORE MAGNETITE	
BAUXITE		KANKER	⊗
		LIME STONE	
BERYL		MAGNESITE	
BARYTE		MICA	
CHROMITE		QUARTZ	Q
COPPER	C	STEATITE	
CORUNDUM		ROAD	
COLUMBITE TANTALITE	CT.	RAILWAY LINE (B.G.)	
FELDSPAR		RAILWAY LINE (M.G.)	
GARNET		STATE BOUNDARY	
GOLD		RIVER	

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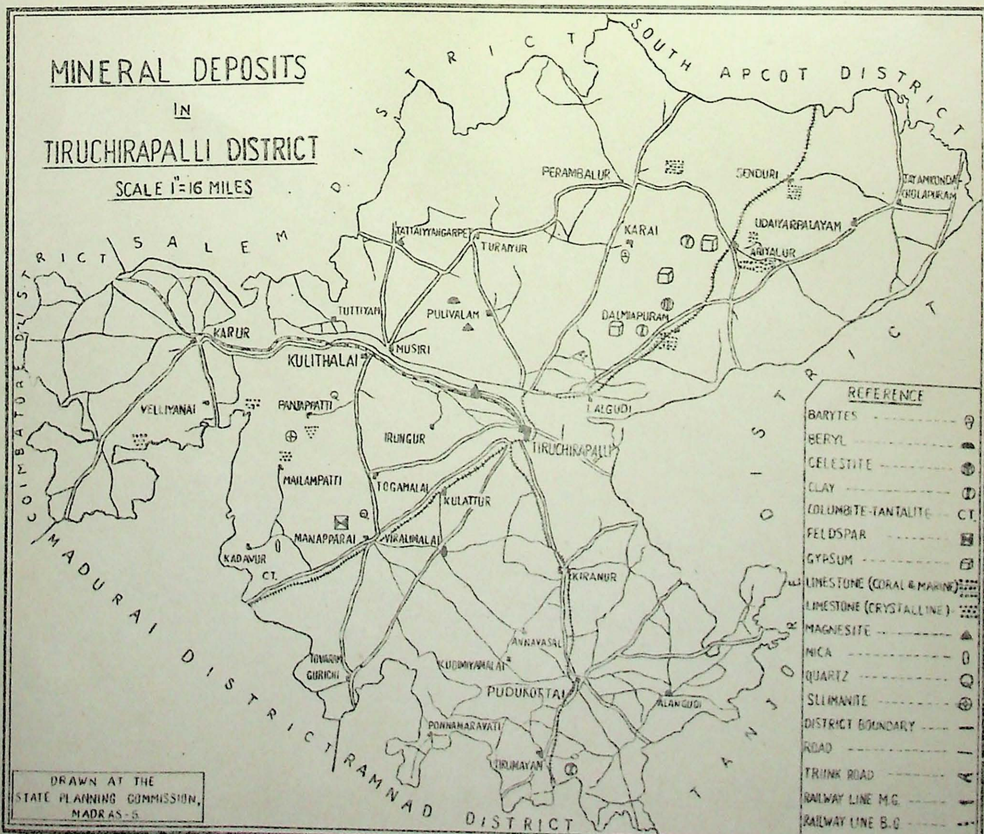

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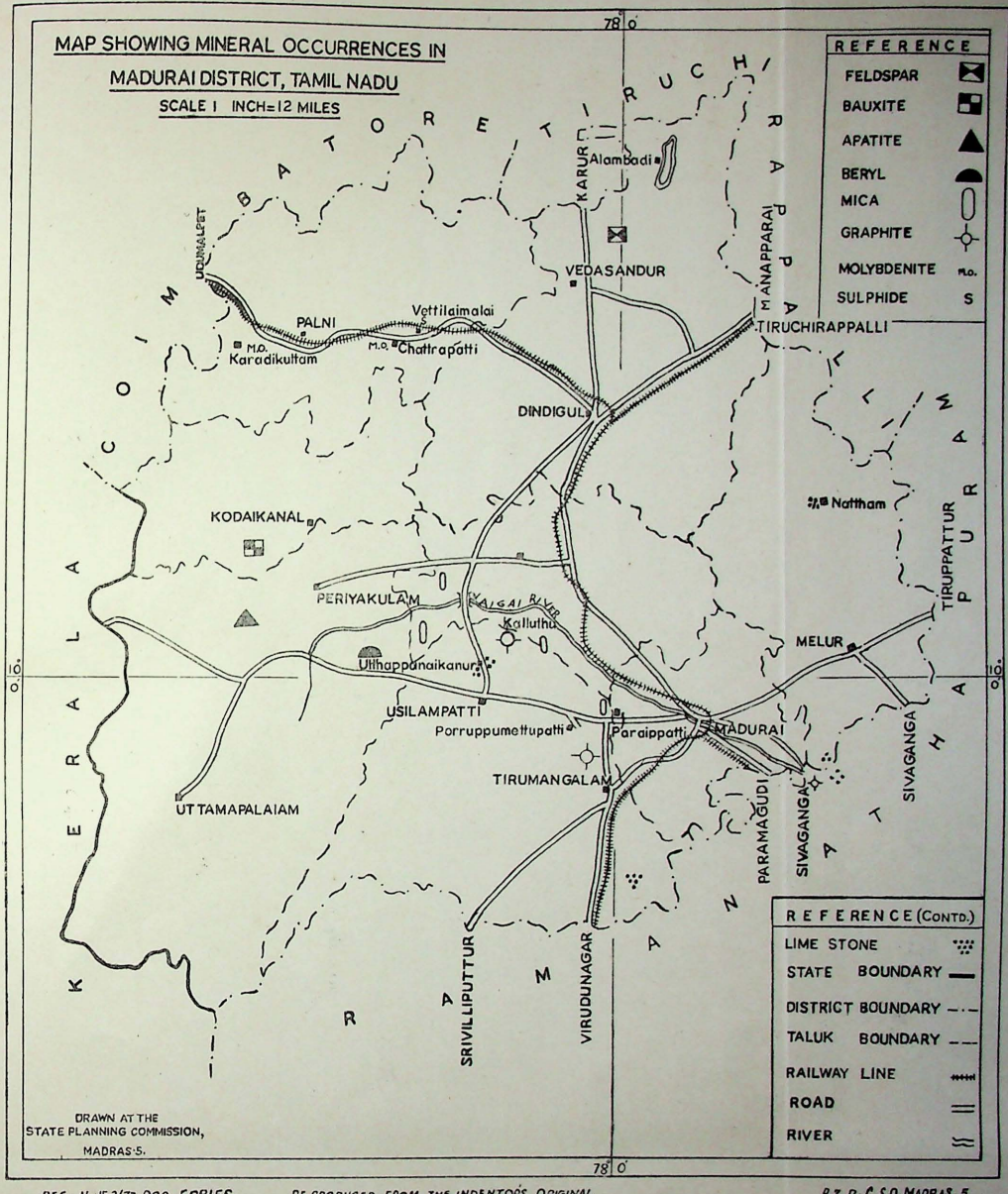

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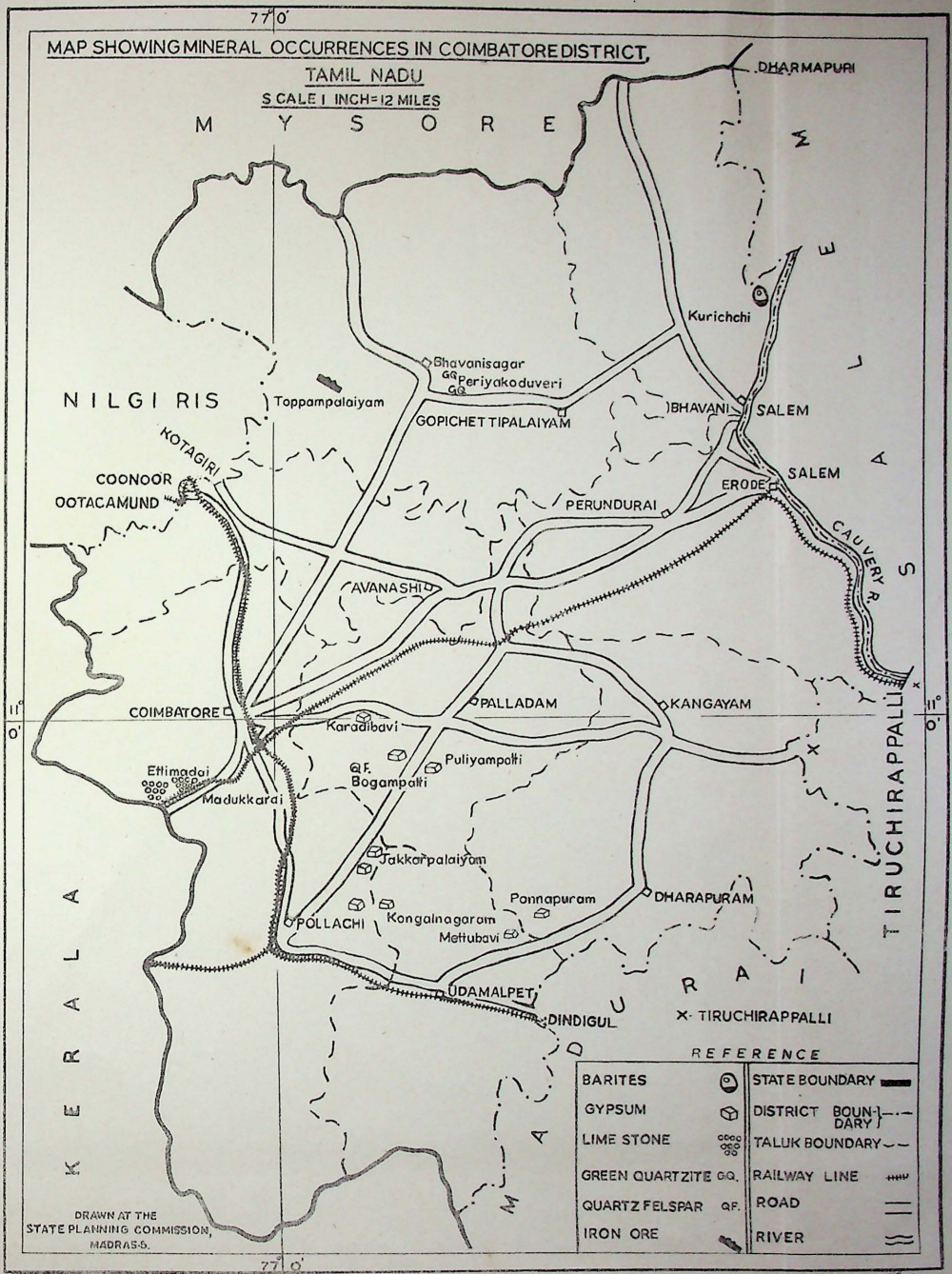

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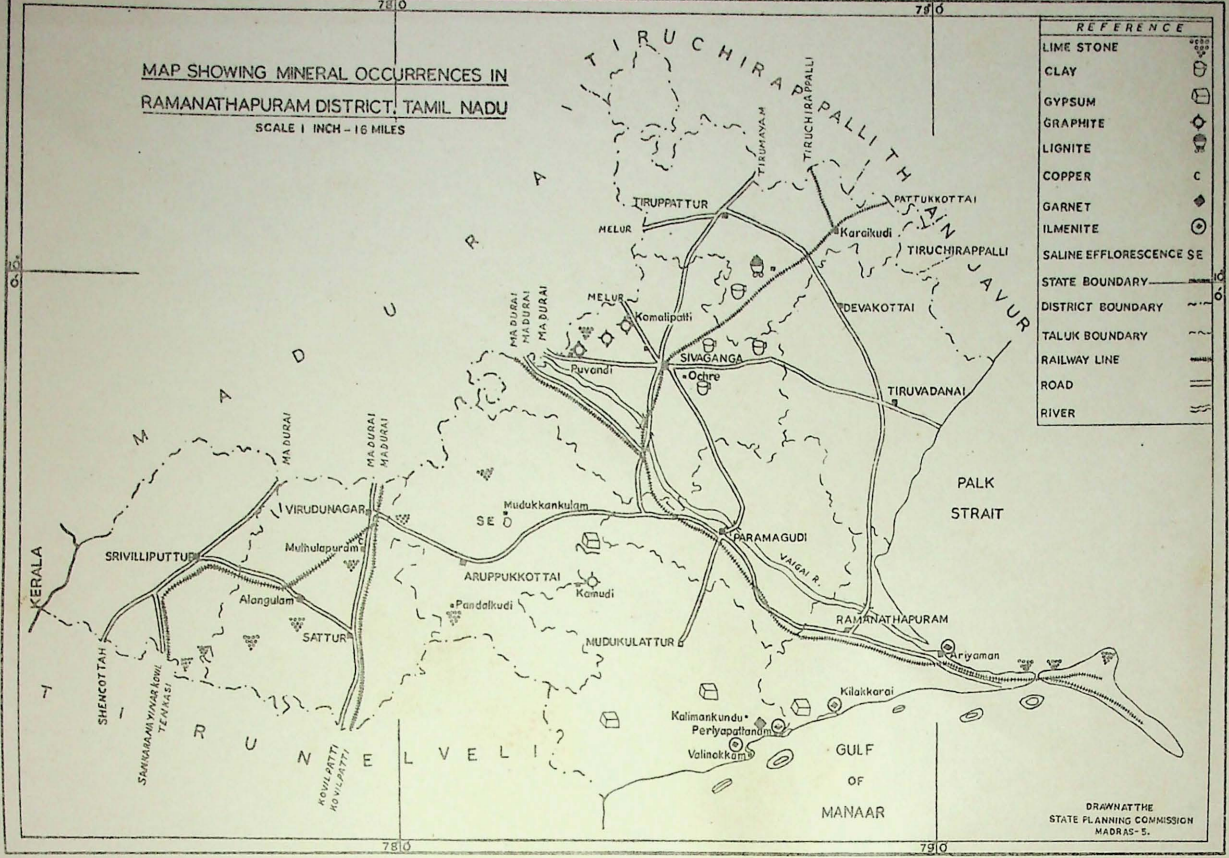
MAP SHOWING MINERAL OCCURRENCES IN RAMANATHAPURAM DISTRICT, TAMIL NADU

SCALE 1 INCH – 16 MILES



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