ATLAS OF MINERAL RESOURCES OF THE ESCAP REGION

Volume 5

SRI LANKA

EXPLANATORY BROCHURE

UNITED NATIONS

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

1989

ATLAS OF MINERAL RESOURCES OF THE ESCAP REGION SERIES

(Separate booklets prepared by the secretariat of the United Nations Economic and Social Commission for Asia and the Pacific in co-operation with national geological agencies)

Volume 1. MALAYSIA (ST/ESCAP/339)

United Nations publication, non-sales, 1985. Explanatory brochure in English, 16 pp. with 3 atlas sheets in a back pocket comprising the Geological Map and Mineral Resources Map of Peninsular Malaysia, the Geological and Mineral Resources Map of Sarawak and Sabah at 1:2,500,000 scale and the legend.

Volume 2. SOLOMON ISLANDS (ST/ESCAP/392)

United Nations publication, non-sales, 1985. Explanatory brochure in English, 35 pp. with 2 atlas sheets in a back pocket comprising the Mineral Resources Map of Solomon Islands at 1:2,000,000 scale and the legend.

Volume 3. REPUBLIC OF KOREA (ST/ESCAP/481)

United Nations publication, non-sales, 1987. Explanatory brochure in English, 51 pp. with 3 atlas sheets in a back pocket comprising the Geological and Mineral Resources Map of the Republic of Korea at 1:1,000,000 scale and the legend.

Volume 4. NEW ZEALAND (ST/ESCAP/561)

United Nations publication, non-sales, 1988. Explanatory brochure in English, 28 pp. with 5 atlas sheets in a back pocket comprising the Geological Maps of North and South Islands, the Mineral Resources Maps of North and South Islands and the legend.

ECONOMIC AND SOCIAL COMMISSION
FOR ASIA AND THE PACIFIC
Bangkok, Thailand

ATLAS OF MINERAL RESOURCES OF THE ESCAP REGION

Volume 5

SRI LANKA

EXPLANATORY BROCHURE

UNITED NATIONS

ST/ESCAP/718

UNITED NATIONS PUBLICATION

Sales No. E.89.II.F.14

ISBN 92-1-119541-1

ISSN 1014-5451

01200

PREFACE

Volume 5 of the Atlas of Mineral Resources of the ESCAP region represents an updated inventory of geology and mineral resources found so far in Sri Lanka. The purpose of this volume and the accompanying maps is to show the distribution of mineral deposits in Sri Lanka and to provide information on their contained commodities, geographic location, their relation to geologic environment, tectonic and magmatic control of mineralization, chemical and mineralogical composition, genesis of deposits and other characteristics. The publication consists of the explanatory brochure and three atlas sheets, which incorporate the Geological map, the Metamorphic map and the Map of Mineral Resources of Sri Lanka at a scale of approximately 1:1,000,000.

The explanatory brochure contains a short description of geology and tectonics, up-to-date information on the metallic and non-metallic mineral deposits and the current status of their development.

The publication is based mainly on *Economic Bulletin No. 2* "Mineral Resources of Sri Lanka" written by J.W. Herath, the then Director of the Geological Survey Department of Sri Lanka, and published by the Geological Survey Department of the Ministry of Industries and Scientific Affairs in 1980. The April 1984 issue of Economic Review, devoted to the status of mineral resources development in Sri Lanka, was another source heavily used in the preparation of the explanatory brochure.

The maps were adopted from the geological, metamorphic and mineral resources maps of Sri Lanka, original scale 1:506,880, issued by the Geological Survey Department in 1982-1983.

The Mineral Resources Section of the ESCAP secretariat gratefully acknowledges the contribution of the Geological Survey Department to this publication, which it is hoped will be useful in further exploration and development of mineral resources of the country.

Blank page

Page blanche

INTRODUCTION

Sri Lanka possesses a fair amount of mineral deposits in spite of its small size. Based on some of these deposits, a good number of industries have been set up in the country during the last two decades. These resources, however, are still not fully exploited and it is accepted today that considerable growth potential exists in this sector.

In the early decades of this century it was thought that there were no minerals in Sri Lanka to possibly establish any mineral based industrial ventures. Prior to the Second World War, with the exception of graphite mining, salt production and traditional cottage scale pottery, brick and tile making, there were hardly any industries based on minerals in the country.

No serious effort was made to investigate whether Sri Lanka possessed the mineral resources to start any organized industries although there was evidence that certain minerals such as iron ores and clays had been exploited from the times of the early Sinhalese kings. The net result was that the country imported all its requirements of cement, ceramics, and even tiles and bricks from India and as far away as the United Kingdom, China, Japan. A basic reason for this situation was that no proper geological survey had been carried out and therefore no assessment was possible of the mineral potential and industrial possibilities in Sri Lanka.

The early 1940s may be regarded as a turning point in mineral resources development and the mining industry in Sri Lanka. Owing to the restriction of imports, and difficulties in shipping and obtaining supplies from abroad, several pilot factories were started in Sri Lanka for the production of ceramic ware, bricks and tiles using locally available raw materials. Mineral exploration and exploitation gained momentum from this point. The potential economic minerals such as the supperficial limonitic iron ores of the south-western part of the Island, the china clay deposits, the beach mineral deposits and the Muthurajawela peat deposits were identified.

Geological mapping also commenced on a reconnaissance scale and much information was gathered on the mineralization of rocks and guides to future mineral prospecting.

This work was accelerated over the years and the next step was in 1956 when under the Colombo Plan Programme of Technical Assistance the Government of Canada entrusted the carrying out of an aerial survey of the Island to a company. Stereopairs on the scale of 1:40,000 and mosaics on 1:31,680 were made available to a number of departments and the officers were trained in the techniques of photo interpretations.

This work was followed up the next year by an airborne geophysical survey covering 8,958 square miles of the south-western sector of the Island as a result of which nearly 40 important anomalies were noted and the more important anomalies numbering 25 were systematically studied by field magnetometer methods. In 1959 a ground magnetometer survey was carried out at Wilagedera where a banded magnetite-barite deposit was located during geological mapping. This discovery and the subsequent magnetometric and diamond drilling work which proved the deposit, marked two significant events in the mineral exploration work of the Island.

In particular, it indicated the results that could be achieved by scientific prospecting and that metalliferous deposits of a certain type of economic value were present in the Pre-Cambrian rocks of the Island. In the early 1960s the ground magnetometric survey and diamond drilling was completed and led to the proving of the largest known magnetic iron ore deposit known in Sri Lanka at that time. Further work was carried out in the subsequent years which showed that the tonnage of iron ore proved was as much as five million tons.

Work on the discovery of new mineral deposits in Sri Lanka has continued over nearly two decades since then and the surveys have revealed that there are many valuable mineral deposits in Sri Lanka which could be economically exploited. The minerals located over the past 60 years could be divided into two broad groups: (i) those found in *in situ* deposits in hard rocks; (ii) those found in alluvial deposits derived from the weathering rocks.

Minerals belonging to the first group are limestones, dolomite, magnetite, vein quartz, feldspar, mica, iron ore, graphite, rock phosphate and serpentine rock. Those belonging to the second group are clays, mineral sands, silica sands and gem stones.

Currently, industries based on mineral sands, graphite, salt and phosphate are in various stages of attracting foreign collaboration in order to expand production. As the present Government has created a very favourable climate for foreign investment, it could be expected that the other industries will follow this policy. As far as Sri Lanka's industrial minerals are concerned their full potential is yet to be realized.

This paper presents a short account of the important mineral deposits in Sri Lanka, a brief description of related industries, and prospects for further development.

CONTENT

CONTENT *(Continued)*

LIST OF FIGURES

LISTS OF TABLES

CONTENT *(Continued)*

EXPLANATORY NOTES

Conversion Factors

Conversion factors for units of measurement used in this publication are as follows:

To convert:	To:	Multiply by:
(Linear units)		
Inches	Centimetres	2.54
Centimetres	Inches	0.3937
Feet	Metres	0.3048
Metres	Feet	3.2808
Statute miles	Kilometres	1.6093
Kilometres	Statute miles	0.6214
(Area units)		
Square inches	Square centimetres	6.4516
Square centimetres (cm^2)	Square inches	0.1550
Square feet (ft^2)	Square metres	0.0929
Square metres (m^2)	Square feet	10.764
Aeres	Hectares	0.4047
Hectares	Acres	2.4710
Square miles (sq. mi.)	Square kilometres	2.5900
Square kilometres (km^2)	Square miles	0.3861
(Volume units)		
Cubic feet (ft^3)	Cubic metres	0.0283
Cubic metres (m^3, or kilolitres)	Cubic feet	35.314
Mcf	Cubic feet	1,000
Cubic feet	Mcf	0.001
U.S. gallons	Imperial gallons	0.8327
Imperial gallons	U.S. gallons	1.2009
Imperial gallons	U.S. barrels	0.0286
Imperial gallons	Kilolitres	0.00455
English barrels (40 imperial gallons)	U.S. barrels (42 U.S. gallons)	1.1437
English barrels	Kilolitres	0.1818
U.S. barrels	Imperial gallons	34.9734
U.S. barrels	English barrels	0.8744
U.S. barrels	Kilolitres	0.1590
Kilolitres (kl, m^3)	Imperial gallons	220.004
Kilolitres	U.S. gallons	264.200
Kilolitres	English barrels	5.5001
Kilolitres	U.S. barrels	6.2901
(Weight units)		
Pounds (lbs.)	Kilogrammes	0.4536
Kilogrammes (kg)	Pounds	2.2046
Short tons	Pounds	2,000
Long tons	Pounds	2,240
Metric tons (mt, kgt)	Pounds	2,204.6
Metric tons	Long tons	0.9842
(Weight to volume: multiply factor by Specific Gravity)		
Metric tons	English barrels	5.511
Metric tons	U.S. barrels	6.304
Long tons	English barrels	5.600
Long tons	U.S. barrels	6.405
(Pressure)		
Atmospheres	Pounds per square inch	14.696
Atmospheres	Kilogrammes per square centimetre	1.033
Pounds per square inch (psi)	Kilogrammes per square centimetre	0.0703
Kilogrammes per square centimetre (kg/cm^2)	Pounds per square inch	14.2230

Throughout the publication "ton" has been used to denote metric ton. The use of a dash (–) in a table indicates "nil" or "a negligible amount or not applicable". The use (N.A) indicates that the information was not available.

I. GENERAL GEOLOGY OF SRI LANKA

Sri Lanka is a tropical island and lies 20 miles to the east of the southernmost extremity of Peninsular India. It has an area of 25,332 square miles and is 270 miles long and 140 miles at its greatest breadth.

The Island may be divided into two main physiographic divisions:

1. The low lying coastal plain with little relief and traversed by rivers which have reached their base level of erosion in the coastal plain.

2. The central highlands with immature drainage pattern and marked relief abounding in numerous strike ridges, hills and mountains.

The coastal plain is narrow in the western and southern parts of the Island. The general level varies from sea level to about 500 feet and some erosion remnants may rise to 1,000 feet or more above sea level. The central highlands rise steeply from the coastal plain and the highest mountain (Pidurutalagala) attains an elevation of 8,292 feet above sea level.

Over 90 per cent of the surface area of the island is underlain by Precambrian rocks consisting of a complex series of high-grade metamorphic rocks, most of which have been derived from sediments and altered by one or more metamorphisms. Associated with these metamorphic rocks are granites and granitoid rocks of igneous origin. Figure 1 shows the outcrops of the main geological formations in the Island.

A. METAMORPHIC ROCKS

Metamorphic rocks which cover the major portion of the Island are of Precambrian age and some rocks are over 2,000 million years old. Two main groups are recognized.

(a) Charnockite-metasedimentary series, always referred to as the Highland Series or Khondalite Group. This series is characterised by the presence of metamorphosed sediments and charnockites. The main rock types exposed are quartzites, crystalline limestone (mainly dolomites); garnet-sillimanite-graphite schists, granulites and gneisses of various types including a variety of charnockites.

(b) Complex of gneisses and granites or Vijayan Group or Complex. This group is mainly composed of granites, gneisses and migmatites.

These rocks have been folded into a series of synforms and antiforms, generally trending in a north-west south-east direction. A good deal of controversy still remains about the nature, and indeed the philosophy, of the subdivision of the Sri Lanka Precambrian.

They are estimated to be of early Proterozoic or more probably of Archaean age from compatibility with similar formations in India where rediometric ages are well known. They have been formed mainly under granulite facies conditions and are predominantly metasediments such as quartzites, crystalline limestones, granet-sillimanite gneisses, graphite schists, granulites, charnockites and gneisses of various types associated with igneous rocks.

These rocks are more than 2,000 m.y. old. Several samples within the Highland Series have given much older age: of the order of 2,300 to 2,600 m.y. (Cooray, 1978). It should be noted that for high grade metamorphic rocks it is the age of the latest resetting event which is recorded but not necessarily the age of the original rocks.

The Vijayan Group rocks are about 1,800 m.y. old and consist mainly of granite gneisses, biotite gneisses and migmatites formed under amphibolite facies conditions. They are mostly confined to the eastern sector of the island.

B. IGNEOUS ROCKS

The igneous rocks occuring in Sri Lanka are mainly pegmatitic materials, zircon granites and some dolerite dykes. The dolerite dykes are confined to the Eastern Province (Maha Oya, Elahera, China-Bay and Kantalai). Zircon granites outcrops in the Balangoda, Loluwa and Parakaduwa areas. Pegmatites of economic value are known in the Rattota, Talagoda and Alutepola areas. Numerous

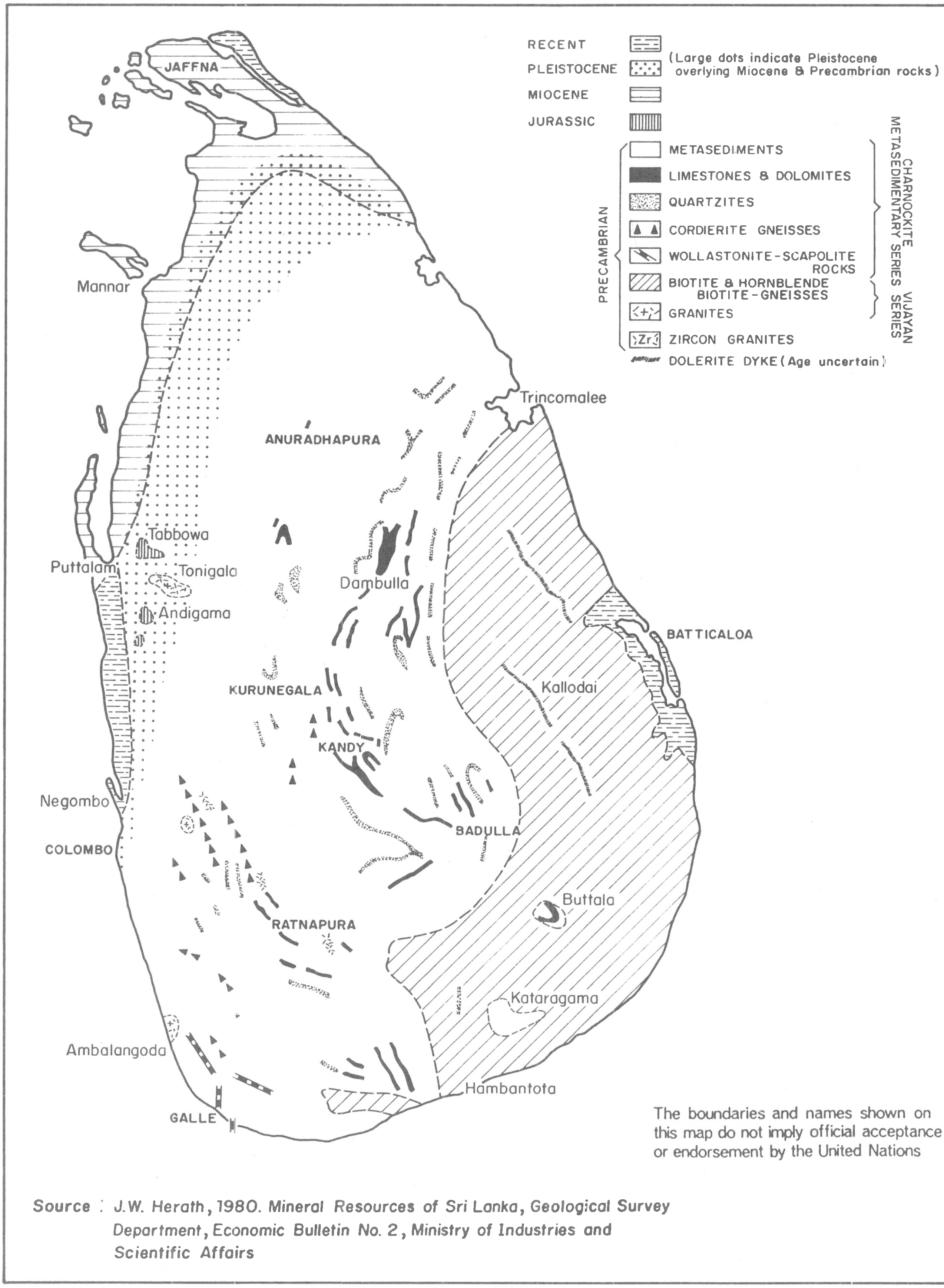


Figure 1. Geological map of Sri Lanka

other pegmatites have been observed in other parts of the Island.

C. SEDIMENTARY ROCKS

The main sedimentary formations observed include recent alluvial deposits, coral formations and coastal sandstone. The sedimentary rocks are mainly restricted to the north-western coastal belt.

Rocks of Jurassic age occupy two restricted outcrop areas in the north-west. They are exposed in the Tabbowa, Andigama and Pallama areas north of Chilaw. These sedimentary rocks are composed of sandstones, grits, arkoses and shales. Similar Gondwana (Jurassic) rocks occur below the Miocene limestones of the Mannar areas.

The largest development of sedimentary rocks occurs in the north-western coastal belt extending from Jaffna Peninsula in the north to the south of Puttalam on the west coast. This formation is of Miocene age and the rock type is a massive limestone of marine origin which is fossiliferous.

The Pleistocene deposits which are developed in the western and north-western parts of the island are mainly gravels and red earths while laterite is mainly developed in the south-west sector of the Island and is clearly a residual deposit.

Recent alluvial deposits are widespread along the major river systems of the island.

Table 1 shows the general succession of geological formations and the important mineral deposits in Sri Lanka.

D. TECTONIC SETTING

The rock formations in the Island are folded into a series of antiforms and synforms generally trending in a NNE, SSW direction in the north and in a N-W, S-E direction toward the south.

At least two, and possibly three, major deformations have been recognized in the Highland Series (Cooray).

Table 1. General succession of geological formations and principal mineral deposits in Sri Lanka

Principal geological divisions		*Principal formations*	*Important mineral deposits*
Era	*Period*		
ANTHROPOZOIC	HOLOCENE (RECENT)	Recent residual and alluvial deposits, blown sand, coastal sandstone, coral and shell formations, beach mineral sands, gem gravels.	Kaolin, ball clay, refractory bond clay, alluvial clay, silica sand, ilmenite, rutile, monazite, zircon, baddyleite, garnet, gems, thorianite, coral, shell, clay ochers.
	(QUATERNARY) PLEISTOCENE	Laterites (may extend from Recent to Tertiary Periods), gravels, red earths.	Laterites, limonitic iron ore, red sands.
CENOZOIC	(TERTIARY) MIOCENE	Limestone.	Limestone.
MESOZOIC	JURASSIC	Shales, carbonaceous shales and arkosic sandstone.	Shares.
PALAEOZOIC	–	Absent.	–
ARCHAEOZOIC	PRE-CAMBRIAN	Charnockite-metasedimentary belt. Gneisses and migmatites. Intrusives-granites, dykes and dolerites.	Serpentinite, limestone, dolomite, magnesite, quartz, allanite, felspar, graphite, mica, cordierite, apatite, chert, wollastonite, sillimanite, magnetite, copper.

Source: Geological Survey Department, Colombo.

A deep seated thrust zone, which runs for more than 400 km, exists at the contact between the two major lithological divisions in Sri Lanka's rocks: the Highland Series and the Vijayan Group (Figure 2).

This deep seated thrust is tentatively interpreted as an obducted ophiolite belt which has undergone a very high degree of alteration and deformation due to the collision and overriding of the Highland over the Vijayan (Jayawardena).

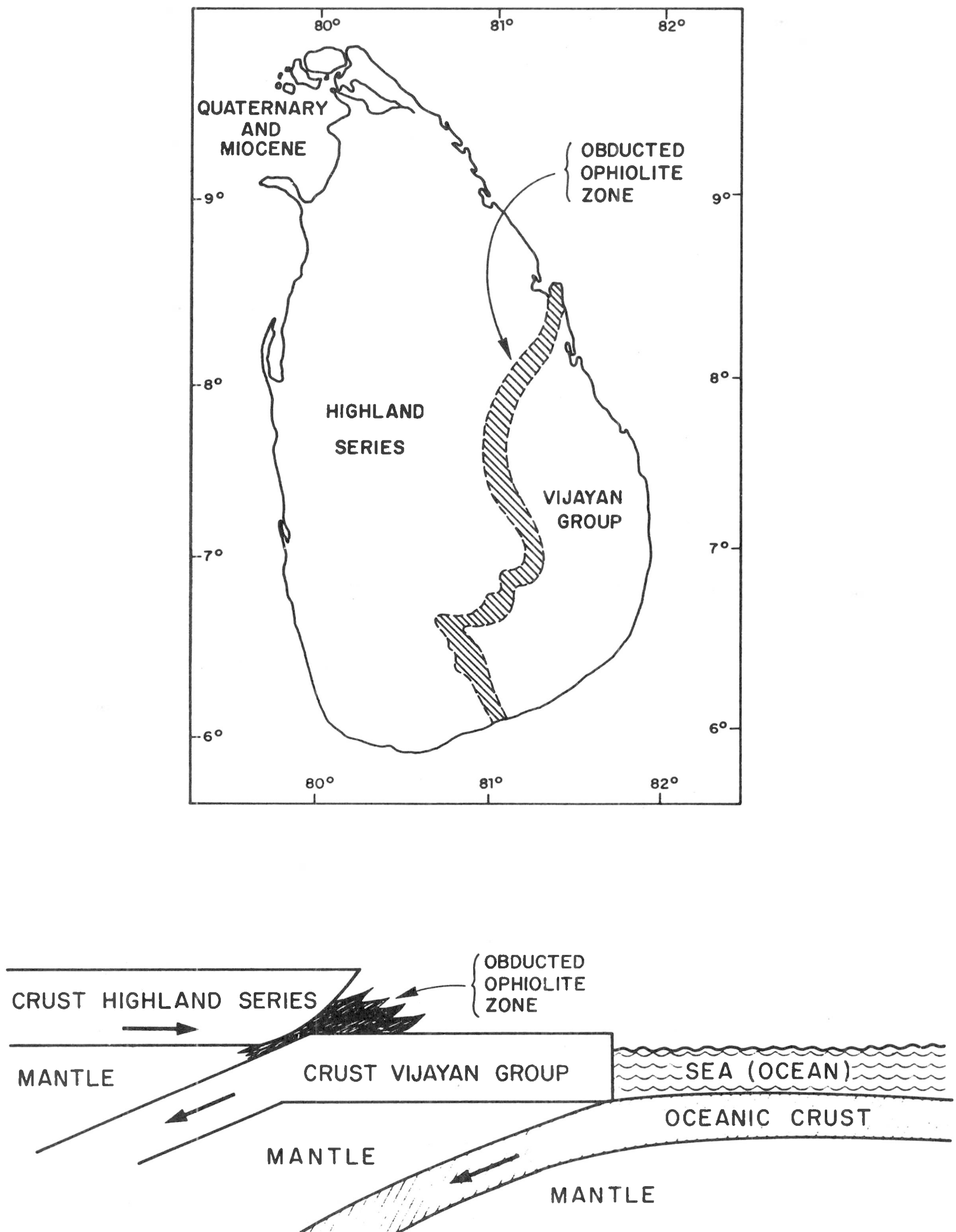


Figure 2. Plate tectonic model for Sri Lanka (after Jayawardana). The boundary between the Highland Series and the Vijayan Group is most probably an old continental plate margin that was reactivated during the breaking-up of Gondwana land 100 to 130 m.y. ago

II. MINERAL RESOURCES OF SRI LANKA

A. METALLIC MINERAL DEPOSITS

(i) Ferrous and base metals

Except for some very minor occurrences of a few of the minerals listed in this group, which are only of academic interest, economic deposits are not known to occur in the Island, and only iron and copper occurs as deposits of any economic value.

Iron ore deposits

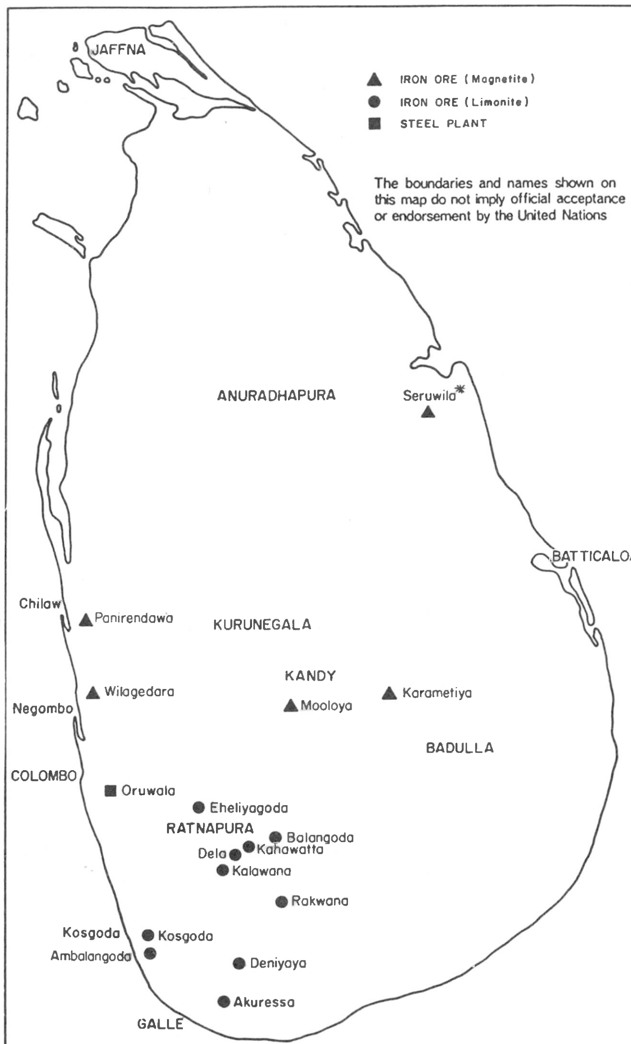
The Sri Lanka deposits of iron ore are negligible in relation to the world's large deposits. The total known iron ore reserves in the Island are of 10 million tons. However, the importance of the iron ore lies mainly in the fact that they can, given other favourable conditions, support a small scale local iron and steel industry.

The iron ore deposits fall into two broad categories (Figure 3):

(a) deposits of hydrated iron oxides (limonite, and goethite) occurring at or near the surface; and

(b) magnetite deposits within iron-formations.

The first type of deposit is mainly concentrated in the south-west of the Island, particularly in the Ratnapura District, and to a lesser extent in the Galle and Matara Districts, where the ore is found as hill cappings and in the form of scattered boulders of varying sizes at or near the surface. Some of these boulders may extend to 12 feet across or more and occasionally very large masses are found as for example at Godakele, near Ambalangoda. Generally, they have no great underground extension in depth. The deposits are small and forty to fifty scattered deposits of this type are known in the Ratnapura, Rakwana, Balangoda and Kalawana areas in the Sabaragamuwa Province and in the Galle and Matara districts in the Southern Province. Individual deposits vary widely in size from about 10,000 to 150,000 tons and the reserves are estimated in all these deposits as 2.2 million tons of exploitable ore. The most important of these deposits are Dela, Noragolla, Opata and Poronuwa in the Ratnapura district and



Source : J.W. Herath, 1980. Mineral Resources of Sri Lanka, Geological Survey Department, Economic Bulletin No. 2, Ministry of Industries and Scientific Affairs

* The Seruwila-Arippu deposit is identified now as iron-copper deposit.

Figure 3. Ferrous and base metals mineral deposits of Sri Lanka

Wilpita in the Galle district. The average iron content varies from 53 to 54 per cent (Table 2). The mining of these limonitic deposits does not present any serious problems other than those arising from the scattered nature of the ore deposits, and in most cases blasting and quarrying is all that is necessary. Although the material is high-grade for deposits of this nature, the content of metallic iron is well below the amount normally preferred in modern blast furnace practice.

In the second category are three magnetite deposits discovered at Wilagedera (1959), at Panirendawa (1962) and at Seruwila (1971). The first of these is too small to be of any economic interest. The second deposit at Panirendawa is much larger and has been estimated to contain 5.6 million tons of high-grade magnetite by an extensive programme of core drilling. The principal iron-bearing material at Panirendawa is a banded magnetite easily amenable to beneficiation by magnetic methods to give a plus 65 per cent Fe concentrate (Table 2).

Table 2. Analyses of iron ores from Sri Lanka

Constituents	*Dela*	*Panirendawa*	*Seruwila*
Fe_2O_3	80.11	73.21	94.66
SiO_2	4.25	18.70	0.86
Al_2O_3	2.22	5.59	3.34
MnO	0.94	0.69	0.02
TiO_2	–	–	0.12
P_2O_5	1.75	0.11	Tr.
CaO	0.11	0.73	–
MgO	–	0.74	–
S	0.19	0.17	0.70
Loss on Ignition	11.02	–	–
Total	100.59	99.94	99.70

Source: Geological Survey Department, Colombo 2.

Notes:

1. Dela Limonitic type – average Fe content 53%.
2. Panirendawa magnetite – average Fe content 50%. (Beneficiation possible – to plus 65% Fe).
3. Seruwila magnetite – under investigation-beneficiation possible. (Tentative figure over 65% Fe).

Unfortunately, the deposit is broken up into four separate blocks as a result of structural disturbances, which means that the deposit cannot be mined as a single unit. Three of the blocks are too small to be mined economicaly as separate units but the exploitation of the fourth with a tonnage estimated at 3 million tons may be economically feasible. The entire deposit, however, occurs at depths ranging from about 80 to 400 feet below the surface. As a result mining operations are expected to be costly.

Copper in iron ore deposit

The third iron-copper deposit occurs close to the Seruwila temple where occurrences of in-situ magnetite and copper mininerlization have also been observed. Country rocks include hornblende granite gneisses, calc gneisses and amphibolites. The magnetite is mostly disseminated in the country rock. A magnetometer survey was carried out and some trenching has already been undertaken. The chemical analyses of a sample of magnetite from the Seruwila area is shown in Table 2. The Seruwila iron ore deposit is perhaps the most promising outcropping deposit found so far which extends to depths (200 feet below surface) at certain points. The presence of magnetite together with pyrite, apatite and copper minerals reveal that the area is worthy of a very careful study, which involves geological, geophysical and geochemical work. Drilling commenced in March 1974 and the information gathered so far reveals that the deposit is a promising one. At present advanced exploration is in progress. A French team (BRGM), the Mining and Mineral Development Corporation and the Geological Survey Department are involved in this activity.

The metallic mineralization, revealed upon field observation of float ore and core samples, is represented by two major types of ore: massive magnetite-copper-apatite ore and disseminated magnetite-copper ore, both emplaced within the amphibolites and foliated hornblende diorite.

The ore minerals consist mainly of magnetite and chalcopyrite and are associated with abundant euhedral to subhedral, occasionally massive pyrite, chalcopyrite, commonly rimmed by covellite, is interstitial and, small blebs or films of malachite and azurite occur as secondary copper minerals, filling the vesicles or matrix between massive magnetite grains. The occurrence of bornite was also recorded. (Jayawardena and Padmasiri, 1977).

Pyrite and apatite are ubiquitous, occurring mainly as very fine aggregates but also as euhedral pyrite cubes and hexagonal apatite, scattered among magnetite aggregates. Amphibole with dark greenish colour and diopside are common gangue minerals.

According to the chemical analysis, a massive magnetite rich in copper ore from drill cores gave 0.48 to 3.80 per cent Cu and 63.95 to 70.80 per cent Fe, whilst disseminated magnetite-copper ore gave 0.21 to 0.63 per cent Cu and 20 to 30 per cent Fe. Preliminary ore reserves, based upon drilling results are estimated at 68,900 tons of metallic copper and 2.75 million tons of metallic iron. These results have indicated that the Seruwila-Arippu magnetite-copper prospects could be economically feasible to mine as magnetite-copper ore (Jayawardena and Padmasiri, 1977). The ore also contains apatite suitable for use as phosphatic fertilizer.

(ii) Light metals

Of the light metals magnesium (magnesite and dolomite) and titanium (ilmenite and rutile) occur as exploitable deposits and low grade aluminium ores (high alumina clays) are present in the Island.

Titanium minerals in mineral sands

Ilmenite and rutile

The two principal mineral sources for titanium are ilmenite and rutile. Ilmenite is used mainly for titanium pigment, but rutile is used for making pigment, metal and other products. Rutile (TiO_2) is at least 95 per cent titanium dioxide whilst ilmenite ($FeTiO_3$) contains between 50 and 60 per cent titanium dioxide. Two types of deposits contain titanium minerals of economic importance namely, rock and sand deposits. Ilmenite resources in Sri Lanka occur as beach mineral sands deposits. In the beach mineral sands ilmenite and rutile normally occur in the same deposit and other associated minerals include zircon, monazite, garnet, sillimanite and other heavy minerals. Some sand deposits containing less than 1 per cent TiO_2 are commercially workable especially if the principal titanium mineral is rutile. The TiO_2 content of rock deposits which are workable ranges from 17 to 35 per cent, mainly as ilmenite.

Although the minerals, ilmenite, rutile, zircon and monazite occur in the beach sands of Sri Lanka, it is only at certain points that the deposits are sufficiently concentrated for economic exploitation. Concentrated deposits are located at Pulmoddai north of Trincomalee, Kaikawela and Polkotuwa near Induruwa and Kudremalai point near Mannar (Figure 4). Of these the largest beach sand deposit is the Pulmoddai deposit.

Pulmoddai deposit

The Pulmoddai deposit is the largest known mineral sand deposit in Sri Lanka. The village of Pulmoddai is located at 8°57′N:80°57′E, about 70 km north of the large town of Trincomalee in the north-east of the country.

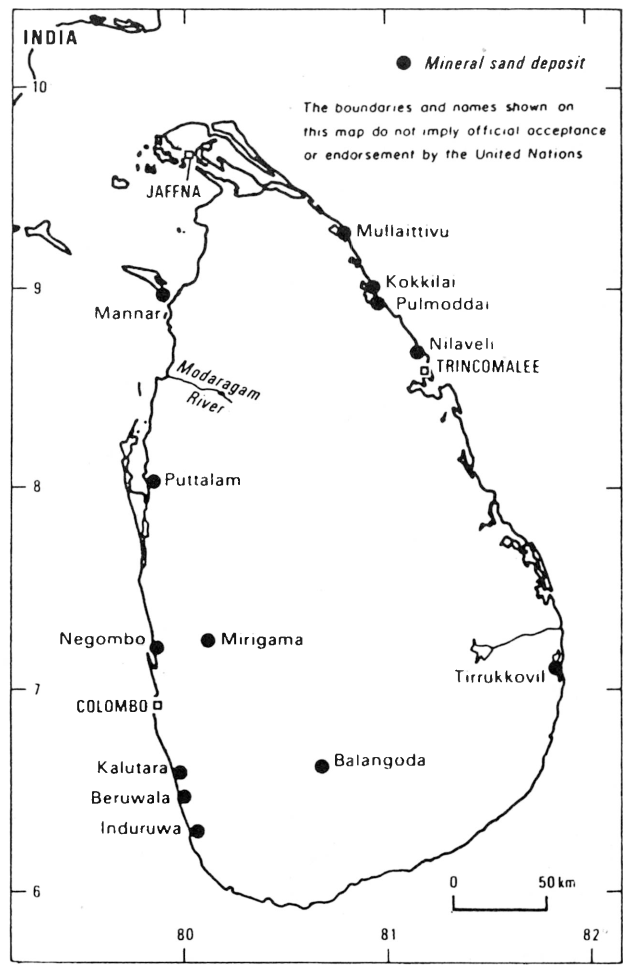


Figure 4. Location of heavy mineral sand deposits in Sri Lanka

The deposit extends along the beach for 7.2 km, with an average width of 50 m and a maximum of 250 m. It covers an area of 3.2 km^2. It has thickness of approximately 6 m over Precambrian crystalline rocks, with no overburden. The deposit is very high grade, with a heavy mineral content approaching 80 per cent, and a composition of 70 to 72 per cent ilmenite, 8 to 10 per cent zircon, 9 per cent rutile, 1 per cent sillimanite, and 0.3 per cent monazite. Other heavy minerals include spinels (mainly magnetite), garnet, tourmaline, and others, with quartz and shell fragments comprising most of the light fraction. The ore minerals are generally very fine-grained.

Total proven resources of the deposit have been assessed as 4 Mt, 3 Mt of which lie above the low-tide mark. Additional resources occur in silt and clay in the backshore areas 3 to 4 m above sea level, and are covered by scrub forest.

Monsoonal storms replenish the beach annually with additional high-grade heavy mineral sands. This allows repeated mining along the same stretch of beach, greatly reducing environmental problems that confront many beach-mining operations elsewhere. The beach is cleared of slimes during these monsoonal storms, which adds to the attraction of the mining operation.

The ultimate source of the heavy minerals is the (?) Precambrian rocks of the interior of the island, the intermediate source being the Pleistocene and recent sediments which occur along the coast. Material eroded from these rocks is transported mainly by the Ma-Oya river to the Kokkilai lagoon (8°59'N:80°57'E) north of Pulmoddai. It is then carried southward by coastal drift to the deposit area, a promontory at Arisa Malai forming a reef barrier which prevents the material drifting further south. The rich heavy mineral sands are thereby confined to the short stretch between Kokkilai laboon in the north and the Arisa Malai rocks in the south.

The chemical composition of the ilmenite, rutile, and zircon is shown in Table 3. Export grades for each of the minerals is given as: ilmenite, minimum 53 per cent TiO_2; rutile, minimum 95 per cent TiO_2; and zircon, minimum 65 per cent ZrO_2. The monazite usually contains about 55 per cent REO.

Table 3. Chemical analysis of ilmenite, rutile and zircon from Pulmoddai, Sri Lanka

Ilmenite		*Rutile*		*Zircon-standard grade*	
TiO_2	54.58	TiO_2	96.76	ZrO_2	66.46
Fe_2O_3	23.15	Fe_2O_3	0.89	SiO_2	32.60
FeO	18.11	SiO_2	0.64	Fe_2O_3	0.11
SiO_2	1.51	ZrO_2	0.38	TiO_2	0.50
ZrO_2	0.02	Al_2O_3	0.16	Al_2O_3	0.2
Al_2O_3	1.18	S	nil		
MnO	0.37	P	less than .001		
Cr_2O_3	0.07				
V_2O_5	0.09				
MgO	0.85				
CaO	0.08				
P_2O_5 Traces	(0.1)				
Total	100.01				

Source: Clark, 1983.

In 1979 the offshore areas adjacent to the Pulmoddai deposit were investigated by three companies from the Federal Republic of Germany in conjunction with CMSC. Substantial additional resources of heavy mineral sands were delineated in a narrow strip several hundred metres wide to a water depth of approximately 10 m. The average thickness of the sand is 0.73 m. These resources are considered to be an extension of the known beach deposit and do not indicate any major offshore accumulations.

The heavy mineral content in the sands nearest to the shoreline averaged 30.8 per cent by weight, with the highest values occurring in the southern part of the area. Further from the shoreline the heavy mineral content in the sands was lower and more diffuse, averaging 11.8 per cent by weight.

The heavy mineral suite averaged 68.7 per cent ilmenite, with an average TiO_2 content of 56 per cent. Rutile and zircon were generally important only in a 50 m wide strip adjacent to the shoreline; concentrations were 4.65 per cent and 5.80 per cent respectively. Monazite was estimated as less than 1 per cent.

Metallgesellschaft estimated total reserves in the offshore area to be: ilmenite 903,000 tons, rutile 9,500 tons, and zircon 39,000 tons (Meyer, 1983).

Other deposits

Heavy mineral concentrations have been reported in several other localities in Sri Lanka. However, little information has been published on the occurrences.

Prospecting by SIMEC LIMITED has outlined the existence of other deposits in the vicinity of the Pulmoddai deposit, Figure 4. These occur in an 80 km stretch from just north of Mullaittivu (9°15'N:80°48'E) south to Nilaveli (8°41'N:81' 11'E) (Clark, 1983). SIMEC LIMITED concluded that there were five potential deposits in this area, containing some 475,000 to 700,000 tons of rutile, 350,000 to 500,000 tons of zircon, and some 2.4 to 4.1 Mt of ilmenite. These are Mullaittivu, Nayaru, Kokkilai, Pudevakkadu and Periyakarachchi areas. SIMEC LIMITED also has found that the most important reserves can be found in the Pudevakkaddu area. This deposit however is relatively low graded. The major part of this deposit is found inland. The grades found at or near the beach are in general rather low and decreasing with depth.

The total volumes of the Pulmoddai-beach and the Nayaru deposit are far less, but the grades in these deposits are higher. It should however be noted, that the Pulmoddai deposit and the Nayaru deposit both are located at or near the beach.

Of the other three deposits only the Kokkilai deposit is interesting at cut off grades below 0.5 per cent eq. rutile (pes). This deposit also is confined to the beach and the area adjacent to the beach.

The Periyakarachchi deposit has a moderate volume but low rutile and moderate zircon grades. This deposit furthermore consists mainly of a clay which disintegrates rather difficult. The Periyakarachchi deposit can therefore most probably regarded as marginal.

The inland deposit at Pulmoddai is small and low graded. The only interesting part of this deposit are the surroundings of the creek at Arisimalai headland. Further investigation of that small area looks justified as it forms more or less part of the Pulmoddai beach deposit.

Further south along the east coast at Tirrukkovil (7°07′N:81°51′E), a deposit has been reported containing 25 per cent zircon (Siddiquie and others, 1984).

Heavy mineral concentrations occur also to the south of Colombo in the south-west of the island. An ilmenite-monazite-zircon placer occurs on the Kaikawela and Polkotuwa beaches near Induruwa, the sand containing 15 to 40 per cent monazite. The source of the monazite is believed to be pegmatite veins which crop out nearby. Monazite is also important at Beruwala (6°29′N: 79°59′E). Zircon and monazite have been produced from a pilot plant set up at Kalutara (6°35′N: 79°59′E) but now closed (Herath, 1977; Siddiquie and others, 1984; Clark, 1983).

Heavy minerals have also been recorded at Kudremalai Point to the south of Mannar (8°58′N: 79°54′E), the Negombo area (7°13′N:79°51′E), the Kelani River near Colombo (approximately 7°N:80°E), and the Modaragam River (approximately 8°30′N:80°E) (Lynd and Leford, 1975). They are present in substantial quantities in the "red and brown earths" found in the Puttalam, Mannar, and Jaffna areas in the north-west of the island (Dahanayaka and Jayawardana, 1979).

Zircon is a major constituent of heavy residues from the washing of gem gravels in various parts of the island. The mineral baddelyite occurs in some mineral sand deposits on the island, but no locality names are available. Zircon-rich granites, a possible source of zircon placer deposits occur in inland areas near Balangoda (6°38′N:80°41′E), and near Mirigama (7°15′N:80°08′E) (Herath, 1977).

No estimate of total resources of heavy minerals in Sri Lanka is available.

Aluminum ore in laterites

Although laterites are extensively developed in the south-west of the Island they do not approach bauxite in composition and true bauxite material has so far not been observed in Sri Lanka.

Magnesium

A number of minerals are used as raw materials for either magnesium metal or compounds production. Dolomite $CaMg(CO_3)_2$ contains up to 22 per cent magnesia (MgO), magnesite $MgCO_3$ has a theoretical magnesia content of 47.6 per cent and brucite $Mg(OH)_2$ contains up to 69 per cent magnesia. These are the main magnesium minerals. Sea water magnesite is also being produced in many countries where other resources are not available. Sri Lanka has very large reserves of dolomite, minor occurrences of magnesite and the possibilities of producing sea water magnesia is a distinct possibility. Sea water with a magnesium content of 0.13 weight per cent is an inexhaustible resource. Detailed description of dolomite deposits in Sri Lanka is given under non-metallic minerals heading.

Magnesite

Magnesite as such has little commercial use, but it is valuable for its magnesia (MgO) content. Magnesia has a high melting point, is chemically inert and is, therefore, suitable for many refractory purposes. Magnesite has in recent years become one of the most important ores of the metal magnesium. By heating magnesite to high temperatures dead-burned magnesite is produced, which is the material generally used for refractory purposes. Dead-burned magnesite is used primarily for lining furnaces, particularly in the steel industry, for which purpose the burned magnesite is often pre-formed as bricks of various shapes. For refractory purposes the calcined magnesite should contain a minimum of 87 per cent MgO and should be as free as possible from zinc, tin, lead, sodium and any other volatile metallic impurities.

Caustic burned magnesite is used chiefly in the manufacture of oxy-chloride (sorrel) cement. The chief use of this cement is in the preparation of composition flooring, in which the calcined magnesite mixed with magnesium chloride and fillers form a resistant, non-slip, fire-proof and durable floor. Heat insulator coverings for boilers, pipes and buildings are also manufactured from magnesite cement. Caustic calcined magnesite finds various uses in the paper, rubber, glass, enamel and porcelain industries. Other uses are for medical purposes in the preparation of magnesia and epsom salts and as a base for fire resistant paints.

Table 4 is presented to show some typical analyses of Sri Lanka dolomite, magnesite and dolomitic limestone. True dolomites have a composition CaO 30.4 per cent, MgO 21.7 per cent and CO_2 47.9 per cent (theoretical). From the analysis given it is seen that some material approaches true dolomite in composition. However, from a large number of samples analysed from various localities is revealed that the magnesium content varies from a trace to over 20 per cent and the majority of the deposits examined show a magnesium content from about 10-18 per cent. These deposits are termed dolomitic limestones. The majority of the so-called dolomites are therefore really dolomitic or magnesium limestones containing a smaller proportion of MgO than the theoretical 21.7 per cent although there are extensive deposits that approach true dolomite in composition. Magnesite deposits are rare and limited in extent and the only known deposit is the one at Randeniya. This deposit was tentatively estimated as amounting to nearly 4,000 tons by core drilling. The analysis of a typical sample of magnesite from this deposit is presented in Table 4.

Table 4. Analyses of dolomite, dolomitic limestone and magnesite from Sri Lanka

Constituents	*1*	*2*	*3*
SiO_2	0.75	2.45	–
Al_2O_3	0.27	3.60	–
Fe_2O_3	0.05	0.80	–
CaO	31.01	33.10	1.27
MgO	21.78	12.15	46.50
CO_2	46.10	48.10	51.28
Total	99.99	100.20	99.06

Source: Geological Survey Department, Colombo 2.

Note:
1. Type analysis for dolomites (Nalanda, Matale, Niriella, Kandy, Maratenna and other areas).
2. Dolomitic Limestones, MgO content varies (10 to 18 per cent common).
3. Magnesite from Randeniya associated with dolomitic limestone.

(iii) Nuclear-fuel metals

Uranium

Despite the fact that commercial deposits of uranium have so far not been found in Sri Lanka, the Geological Survey Department has identified six potential regions where further systematic and more detailed investigations might lead to a discovery of promising uranium mineralization in the Island.

Most of radiometric anomalies of high values up to a maximum of 2,200 counts per second (cps) where background is generally 150 to 200 cps were observed along the boundary zone between the Highland charnockite-metasidementary series and the Vijayan Group. (J. Becker, 1983). This boundary coincides with a tectonic zone as revealed by a gravity survey conducted near the entire island and tentatively interpreted as obducted ophiolite zone (Figure 2).

The Maha Oya, Rakwana – Embilipitaya – Kalawana, Dambulla – Minnerya – Polonnaruwa and Tanamalwila – Wirawila groups of radiometric anomalies are concentrated along this boundary.

Maha Oya-Kantalai-Arugam region

The Maha Oya-Kantalai-Arugam group of radiometric anomalies is located within the Vijayan Group rocks mainly made of granitic gneisses, hornblende biotite gneisses, minor charnockites and undifferentiated metasediments of amphibolite facies. In this area and around Siyambalanduwa all the samples collected have indicated uranium values above 20 ppm. This area is located just east of the Vijayan Group – Highland Series boundary which is suspected to be tectonically active.

Rakwana-Embilipitiya-Kalawana region

The Rakwana-Embilipitiya-Kalawana group of radiometric anomalies is located within undifferentiated Highland series rocks composed mainly of interbanded quartz-feldspar-garnet granulite, quartzite, intermediate and acid charnockite, garnet-sillimanite granulite, garnet-sillimanite-graphite schist, garnet-sillimanite-biotite gneiss, garnet-biotite gneiss, cordierite-bearing granulite or gneiss, basic charnockite, garnet-diopside-hornblende granulite and pyroxene amphibolite.

In this group, a high value of 1,200 cps was indicated by a sample of massive charnockite containing red garnets and flakes of graphite from the Ratnapura-Pelmodulla Madampe area, 5 km south of Pelmadulla. Another anomaly of a high value of 191 ppm was registered in the Timbolketiya-Embilipitiya area in a contact between the marble and a red garnet-amphibole pegmatitic gneiss with inclusions of large crystals of diopside, biotite and graphite.

Radiometric anomalies of between 800 to 1,000 cps were also indicated in Panamure-Middeniya-Wiraketiya-Tangalla area, 5 km west of Embilipitiya going to Panamure, where the rocks were formed of pegmatite, granulite, fine-grained aplite with red garnets and graphite, metasidements with graphite and fine-grained greeen charnockite with garnets and graphite.

Tanamalwila-Wirawila area

This area is within the Vijayan Group rocks composed of a banded, highly folded fine-grained biotite-hornblende gneiss containing probably some crystals of allanite.

The radiometric anomaly of 400 cps was registered at the outcrop of the above rock containing fairy abundant crystals of pyrite at the north and of Tanamalwila Village.

Dambulla-Minneriya-Polonnaruwa region

The bed-rock formations underlying the Dambulla-Minneriya-Polannaruwa region are all of Pre-Cambrian age and consist largely of metasediments. The scintillation counter values of 950 to 1,000 cps were indicated in the Dambulla-Kakirawa area, 10 km north of Dambulla in a small outcrop of whethered reddish brown granitic gneiss containing remnants of pegmatitic kaolinized quartz lenses. Still in the same neighbourhood, large faulted domes of banded granitic gneiss containing allanite have shown a radioactivity of 2,000 cps. The radiometric anomalies of 1,000 to 2,000 cps were also recorded in the Ganewalpola-Habarana-Minneriya area, 5 km east of Ganewalpola in a light brown granulite containing garnet, hornblende and pegmatites.

Tabbowa-Kala Oya-Anuradhapura region

This group of radiometric anomalies were observed within sedimentary rock overlying the basement rock of the Highland chornockite-metasedimentary series. The radiometric anomaly of 1,000 cps was registed in the arkosic sandstone of Upper Jurassic age in the Tabbora beds, 12 km E-NE of Puttalam (J. Becker, 1983).

Some prospects for uranium mineralization are regarded to the Eppawala Carbonatite Complex recognized now as potential area for apatite exploration and development. The paucity of the rare-earth minerals containing an appreciable quantity of Nb such as perovskite and pyrochlore put the Eppawala carbonatite into the apatite-magnetite category. (J. Becker, 1982)

From the general geological situation, further uranium exploration should be continued mainly in the eastern part of the Island with emphasis along the contact between the Highland Series and the Vijayan Group and its neighbourhood.

Thorium minerals

Most thorium in Sri Lanka occurs as a minor constituent in a rare-earth phosphate, monozite and uranium. Thorianite, thorite and monozite are principal minerals of thorium in the country.

In Sri Lanka thorianite has been found to occur in moderate amounts near Kondurugala in Bambarabotuwa (Sabaragamuwa) in the upper reaches of the Kuda Pandi-Oya in association with other minerals such as zircon, ilmenite and thorite. Other localities where the mineral has been observed include Maddegama (Hinidumpattu) – Galle

District, Niriella-ganga at Niriella, Denewakaganga near Malwela, Walawe-ganga near Balangoda and in various other points in the country. A total of 179 cwt. of thorianite valued at 74,315 rupees has been exported during the year 1905. Occurrences of thorite have been noted in the Balangoda, Avissawella and Ratnapura areas. Although monazite occurs in varying amounts in a number of localities, the best developed deposits occur as an ilmenite-monazite-zircon beach sand at Kaikawala and Polkotuwa near Induruwa. This beach sand is very rich in monazite some patches yielding as much as 40 per cent of the mineral monazite. Rich concentrates are only exposed at two seasons, in the intervals between the monsoons. The average concentrate of monazite in the beach sand is around 15 per cent. The beach sands of the Kaikawela and Polkotuwa areas have been exploited by the Geological Survey Department since 1952 and separated at the pilot plant established near Kalutara and small tonnages of zircon, monazite and baddeleyite have been exported over the years. About 12 tons of monazite were produced in 1973. It has been observed that there is no appearance of appreciable exhaustion of the deposit though the amount of concentrate formed annually showed a slight decline. Monazite also occurs at other points.

Monazite is found in-situ rather widely disseminated in the country rocks around Kamburupitiya (Matara District); in weathered pegmatites at Nuwara Eliya and in Nugatenne near Teldeniya and Denegama in Balangoda. The source of the rich monazite concentrates at the Induruwa beach are the veins of pegmatite outcropping in the vicinity and it is doubtless the weathering of various rock types through the ages that has contributed the bulk of the monazite in the beach sands. Table 5 is presented to show typical analyses of monazite, thorianite and thorite from Sri Lanka. These analyses show that the monazite contains about 10 per cent of thorite (ThO_2) which is much greater than the average thoria content of monazites from other parts of the world. The thorianite records a thoria content of over 70 per cent and a uranium oxide content of around 10 per cent.

Table 5. Chemical analyses of monazite, thorianite and thorite from Sri Lanka

Monazite			
Constituents	*Dondra*	*Ratnapura*	*Beruwela*
Thoria ThO_2	9.51	10.29	8.65
Ceria C_2O_3	28.70	27.37	27.35
Lanthanum La_2O_3	28.56	30.13	31.08
Yttrium Y_2O_3	1.05	2.14	0.95
Ferric Oxide Fe_2O_3	0.10	0.81	0.15
Alumina Al_2O_3	1.31	0.17	0.78
Lime CaO	0.89	0.41	0.20
Silica SiO_2	–	1.03	1.60
Phosphorus pentoxide P_2O_5	28.91	27.67	27.50
Titania TiO_2	0.05	–	0.15
Total	99.08	100.02	98.41

Source: Geological Survey Department, Colombo.

Thorianite and thorite		
Constituents	*Thorianite (Kondurugala)*	*Thorite (Kondurugala)*
ThO_2	76.22	66.26
C_2O_3	8.04	7.18
La_2O_3	–	–
ZrO_2	traces	2.23
UO_3	12.33	0.46
Fe_2O_3	0.35	1.71
PbO	2.87	–
SiO_2	0.12	14.10
CaO	–	0.35
P_2O_5	–	1.20
H_2O	–	6.40
Total	99.93	99.89

Source: Imperial Institute, London.

(iv) Rare and rare-earth elements

Monazite and allanite

Monazite is the principal mineral source of the rare-earth elements found in Sri Lanka. Allanite has also been observed in certain points. The mineral monazite is recovered as a by-product in the mining of beach mineral sands for the recovery of ilmenite, rutile and zircon. The composition of monazite from Sri Lanka is presented in Table 5. The percentage of contained REO in the monazite, (cerium, lanthanium and yttrium oxides) is normally around 55 per cent. The Pulmoddai beach sands of the Island contain up to 3 per cent monazite and approximately 300 tons of monazite per annum could be processed from the 140,000 tons of raw beach sands mined to recover ilmenite. Monazite concentrates occur also at other points in the Island. A minor deposit of allanite occurs at

Owella Estate (Matale) and the material contains 15 to 20 per cent rare-earth elements. The chemical analyses of this allanite is shown in Table 6.

Table 6. Chemical analyses of allanite from Sri Lanka

Constituents	*Owella-Matale East*		
	1	*2*	*3*
SiO_2	32.70	30.88	30.61
Al_2O_3	16.40	13.76	17.46
Fe_2O_3	5.10	4.44	6.01
FeO	10.73	12.08	10.38
TiO_2	0.30	0.88	1.21
MgO	1.02	0.76	0.95
CaO	8.90	13.56	11.45
MnO	0.51	0.20	0.30
ThO_2	3.18	1.54	1.98
U_3O_8	0.07	0.05	0.05
Ce_2O_3	6.38	8.30	7.04
$La_2O_3 - Y_2O_3$	7.66	8.36	7.38
P_2O_5	1.44	0.70	0.71
H_2O	5.35	4.75	3.95
Total	99.76	100.26	99.48

Source: Geological Survey Department, Colombo.

Cerium and mixed rare-earth oxides are used in the polishing of various types of glasses, in the glass and ceramics industry, television industry and in a variety of other industries.

Zircon and baddeleyite

The principal source of the element zirconium is zircon. Two zirconium minerals, zircon ($ZrSiO_4$) and baddeleyite (ZrO_2) are marketed commercially, however, zircon is by far the more important mineral. Zircon is recovered from beach mineral sands like for example ilmenite, rutile and monazite. In Sri Lanka zircon is a widely distributed mineral in the igneous rocks. It is an original constituent of some granites and occurs in massive form in some pegmatites. The best known localities for zircon granites are Massena Estate near Balangoda and Loluwa near Mirigama. The mineral is also a notable constituent in the heavy residues left after washing of gem gravels in various parts of the Island. The primary deposits of zircon are of no commercial importance. The Island is however rich in beach mineral sands and zircon occurs as one of the minerals which could be exploited commercially. Zircon is obtained as a by-product in the treatment of these sands for the recovery of ilmenite and rutile. Although zircon is not produced in large quantities at present, it is proposed to produce about 10,000 tons of zircon per annum from the Pulmoddai beach mineral sands. Zircon is also produced at the pilot plant set up at Kalutara. The mineral baddeleyite also occurs in the beach mineral sands of the Island. Table 7 shows the chemical analyses of zircon from Sri Lanka.

Table 7. Chemical analyses of zircon from Sri Lanka

Constituents	*China Bay (Concentrate)*	*China Bay (Concentrate)*	*Induruwa (M.P.S. Concentrate)*
SiO_2	32.49	32.41	32.27
ZrO_2	66.40	66.43	66.12
Fe_2O_3	0.18	0.16	0.41
TiO_2	0.73	0.61	0.68
Hfo_2	0.17	0.20	0.11
Al_2O_3	0.08	0.06	0.15
V_2O_5	0.02	0.02	–
Total	100.07	99.89	99.74

Source: Geological Survey Department, Colombo.

Zircon is mainly used for facings on foundry moulds and for refractory bricks. The oxide is used as an opacifier and pigment in enamels and glazes in the manufacture of ceramic products. Zirconium metal is of industrial importance in chemical processing equipment. Zirconium compounds are also widely used in industry and they are prepared from zirconium oxide.

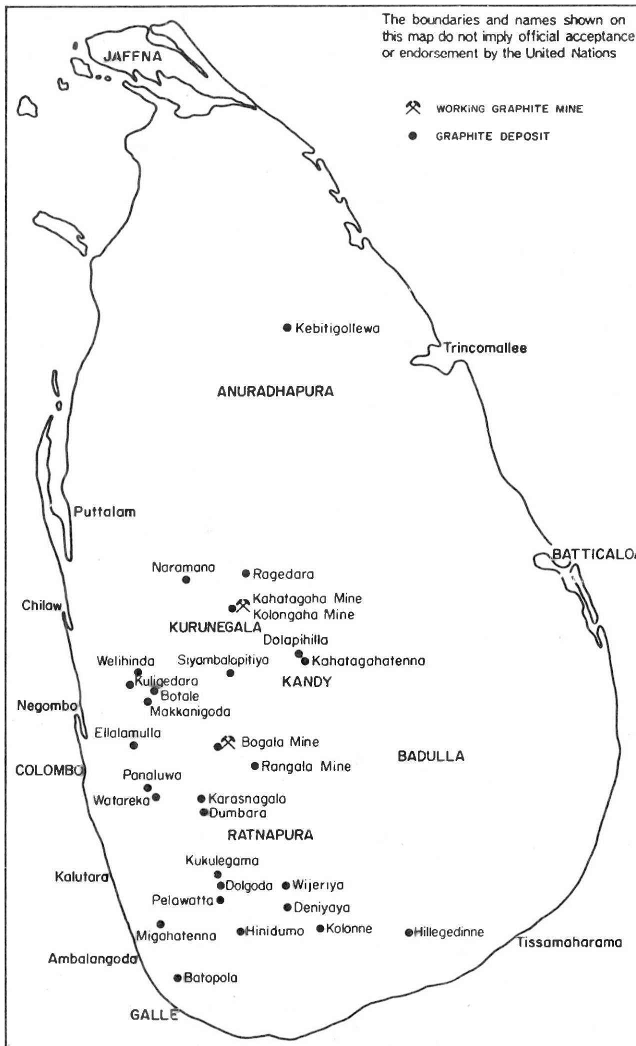
B. NON-METALLIC MINERAL DEPOSITS

Sri Lanka is fairly rich in the non-metallic group of minerals. These minerals range from bulk commodities as sand, gravel and stone down to gem stones which are measured in carats. The demand for this group of minerals has increased rapidly over the years due to an effort made to broaden the base of the economy by establishing manufacturing industries. There is however, a deficiency of local reserves of commercially acceptable grades of certain minerals and these have to be imported. The principal non-metallic minerals that occur in the Island include graphite, mica, industrial-clays, silica, apatite, felspar, limestone, dolomite, garnet, gemstone, cordierite, sillimanite, wollastonite and sand, gravel and stone. Salt is also produced on a large scale by evaporating sea brines.

Graphite

Graphite is crystalline carbon identical in composition with charcoal and diamond. It has been one of the main minerals mined and exported by Sri Lanka over the last 160 years. There are three principal types of graphite: they are vein-graphite, flake and amorphous. Sri Lankan graphite falls into the vein – graphite category which can be further sub-classified into cystalline and amorphous forms. Both these types occur in the country. Sri Lanka's graphite has a high percentage of carbon, the balance consisting of ash, grit and volatite matter.

Only the vein type deposits are exploited. The reserves of graphite in the Island are estimated to be very large and due to the nature of deposits (vein type) it is not possible to give any approximate figures for reserves. The veins normally follow a structural pattern and although the directions of the veins are variable in a given area, the major veins tend to follow one or two directions. East-west trending graphite veins are common with off-shoots following the joints and minor fractures in the surrounding rocks. The graphite deposits of the Island are mainly concentrated in anticlinal structures generally trending in a north-south direction. The best known areas of graphite occurrence in the various Provinces are as follows: (Figure 5).



Source : *J.W. Herath, 1980. Mineral Resources of Sri Lanka, Geological Survey Department, Economic Bulletin No. 2, Ministry of Industries and Scientific Affairs*

Figure 5. Graphite occurrences of Sri Lanka

Western Province – Botale, Kaluaggala, Kuligedara, Welihinda, Makkanigoda, Ellalamulla, Karasnagala, Migoda, Panaluwa and Watareka, Botalawa, Meegahatenna and Pelawatte.

Sabaragamuwa Province – Kukulegama, Delgoda, Weddagala, Dumbara, Karandana, Kolonna, Wijeriya, Werahera, Arukgammana (Bogala), Bolagama, Bopitiya, Indurana, Niwatuwa, Pussella, Siyambalapitiya, Siyambalawela (Rangala).

Southern Province – Batapola, Ampegama, Tiranagama, Magala, Karandeniya, Uragaha, Kottawa, Hiniduma, Panangala, Deniyaya, Kolawenigama, Idandukita, Daramitiara and Hillageainna.

North-Western Province – Ragedara, Mipitiya, Maduragoda (Kahatagaha-Kolongaha) and Naramana.

Central Province – Dolapihilla, Kahatagahatenna.

North Central Province – Kebitigollawa.

The graphite industry is now operated by the State Graphite Corporation which was established in 1971, and re-named the Mining and Mineral Development Corporation in 1979. At present the Corporation operates three mines, Bogala, Kahatagaha and Kolongaha.

With the vesting of mineral rights in the State under the provisions of the Mines and Minerals Law which came into effect in 1973, a lateral expansion programme at higher horizons in each of the three operating mines met with success as graphite deposits of economic widths were intersected. Shortly after nationalization the Kolongaha and Kahatagaha mines which are situated close to each other have been connected underground. This has considerably improved the ventilation of the two mines. The rationalization of haulage together with improvements in mining techniques have further resulted in a sound working environment for the miner underground. Electrification of the Kolongaha mine plans to de-water the Walakatahene workings located in between Kahatagaha and Kolongaha. Work in connection with the reclamation and rehabilitation of this abandoned mine is now in progress.

The Rangala graphite deposit was discovered by the Geological Survey Department at Siyambalawela in the neighbourhood of Bogala. The Graphite Corporation has now commenced initial exploration work to determine the extent of graphite mineralization at Rangala with a view to developing it into a working mine. Exploration operations in the abandoned mine locations at Ragedera (Malsiripura) is being undertaken by the Corporation at present. The Ragedera graphite is known to assay almost 100 per cent carbon, the graphite is unique for its purity and could undoubtedly be used in a number of industries. Other promising areas investigated by the Geological Survey Department and the State Graphite Corporation include Meegahatenne and Dumbara in the Sabaragamuwa Province. The Meegahatenne area cound be classed as the richest graphite bearing ground in Sri Lanka. Although several mines were operating in this region some years back, no working mines were observed during recent investigations.

Graphite mined in Sri Lanka from vein type deposits are generally high in carbon content, (97-99 per cent carbon). The graphite is classified into a number of grades for export purposes, depending on particle size (lump, chip and dust), carbon content and structure (bright large lump – BLL, Hard large lump – HLL and slaty). Grades over 99 per cent carbon are common.

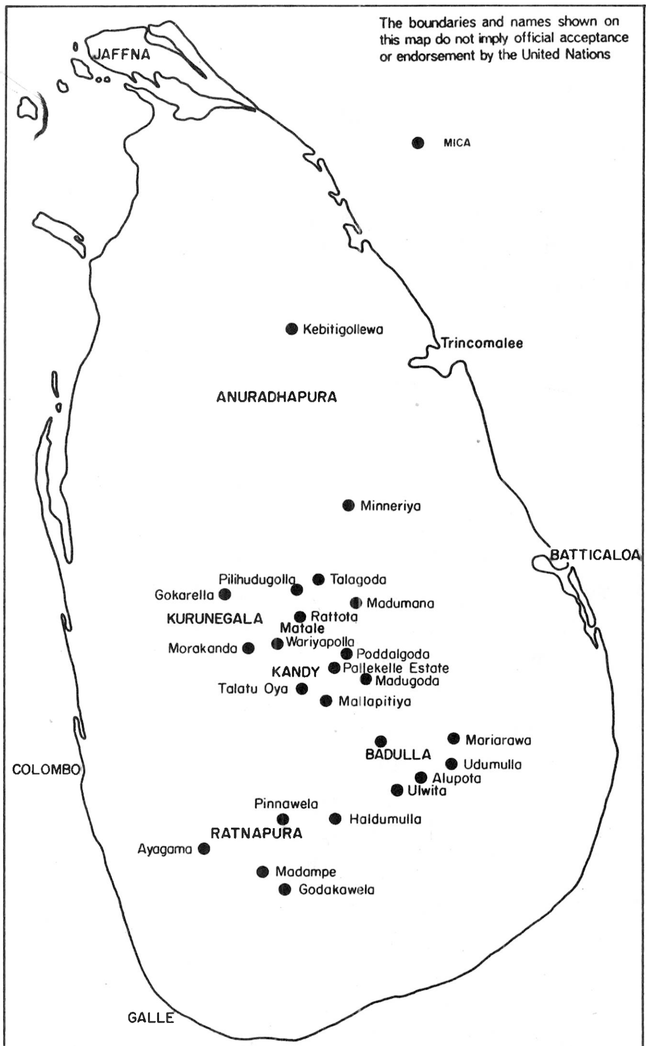
All graphite material is crystalline and the term "amorphous" graphite is normally used for microcrystalline varieties of graphite. Crystalline flake graphite is graphite which occurs disseminated throughout its containing rock and the Malagasy Republic widely exploits this type of material. Although the Island has some of the world's best graphite deposits with high carbon contents, graphite based industries have so far not been established except for the pencil industry which uses negligible quantities of graphite. In recent years consideration has been given to the establishment of a few graphite based industries and some products are the manufacture of graphic crucibles, electrodes, carbon rods and lubricants.

Higher grades of graphite are used for crucibles and lubricants and dust grades are used for foundry facings and polishes. Graphite is also used in dry cells, as a refractory material in steel making (to increase the carbon content), in electrical uses and in a variety of other industries.

Mica

The main types of mica found in the Island are phlogopite, muscovite and biotite. Phlogopite is widely distributed in parts of the Uva, Central and Sabaragamuwa Provinces associated with crystalline limestones and other rocks. Muscovite mica occurs in quartz-feldspar-pegmatites at a number of points while biotite mica is widely distributed in the gneisses and pegmatites of the Island. The principal deposits of known mica (Figure 6) are in the Talagoda, Madumana, Wariyapolla, Pallekalle, Talatu-Oya, Badulla, Maskeliya, Madugoda, Mariarawa, Udumulla, Ulwita, Haldummulla, Madampe, Mailapītiya and Kabitigollawa (Dutuwewa) areas. Two types of deposits are known to occur, a pegmatite type deposit and a normal vein type of deposit. Mining of pegmatites for mica is sometimes not economical due to the erratic nature of the pegmatite and the sporadic occurrence of mica. If however, two or more minerals are mined from pegmatites for examples, mica, quartz and felspar, mining becomes economical. Vein type deposits are more economical for exploitation purposes.

The mica industry in Sri Lanka dates back as far as 1896 when mining was carried on in the Badulla and Haputale districts. During the second World War mica mining was encouraged by the State and although the prices paid were favourable very little mica was offered for sale. Mica mining in Sri Lanka has so far been confined to shallow depths and invariably weathered material is obtained which would only be classed as scrap mica. Sheet mica is graded according to clear areas (without imperfections) that can be cut from mica sheets. The Indian standards show eight grades for sheet mica and the areas mentioned range from 1 square inch to 48 square inches. In Sri Lanka the mica obtained so far is confined to the lower grades. With deeper mining it has been revealed



Source : J.W. Herath, 1980. Mineral Resources of Sri Lanka, Geological Survey Department, Economic Bulletin No. 2, Ministry of Industries and Scientific Affairs

Figure 6. Mica occurrences of Sri Lanka

that good grades of sheet mica could be obtained. Exports of mica from the Island have been mainly confined so far to scrap grades. The quantities exported have been small.

In recent years the systematic development of the mica industry has been considered and as a first step the promising mica deposits have been studied and a few points selected for detailed investigations with a view to commercial exploitation. The development of the mica industry is at present a function of the State Graphite Corporation and steps have already been taken to establish a sound mica industry in the Island.

Sheet mica is mainly used in electrical appliance manufacture and in the electronic and electrical industries. As an electrical insulator both moscovite and phlogopite are used. Dry ground mica is used for a variety of purposes such as filling for various types of plastics, floor coverings, gramophone records and paints. It is also used for dusting purposes and for lagging steam pipes and boilers. Wet ground mica is used mainly for decorative work, in wall-paper, printing and paints, powdered mica is also used in lubricants and in the rubber industry.

Vermiculite is the name applied commercially to hydrated micas. When heated vermiculite expands into cellular granulites occupying up to 16 times the original volume. This expanded material is suitable for use as an insulating medium. The weight per cubic foot of vermiculite is commonly about 5 to 8 lbs. Mica approaching the composition of vermiculite occurs at some points.

Industrial clays

1. Laterites as a principal source of bauxite, clays and building materials

Laterites are mainly developed in the southwest sector of the country. They are mainly ferruginous laterites containing up to about 10 per cent free Al_2O_3 which occurs as the mineral gibbsite ($Al_2O_3H_2O$). Table 8 shows the chemical

Table 8. Chemical composition of laterites from Sri Lanka

Constituents	*Wet zone*		*Dry zone*	
	Colombo	*Colombo*	*Batticaloa*	*Batticaloa*
SiO_2	34.31	37.22	39.25	40.69
Al_2O_3	19.05	25.12	23.12	16.19
Fe_2O_3	32.58	24.76	23.13	30.88
TiO_2	1.27	1.61	0.51	1.21
MnO	0.32	0.28	0.26	0.19
P_2O_5	–	–	0.12	0.15
CaO	0.33	0.28	0.82	0.38
MgO	0.89	0.48	1.19	0.66
K_2O	1.26	1.25	1.23	0.17
Na_2O	0.86	0.92	2.03	0.57
Loss on Ignition	8.76	8.21	8.32	8.62
Total	99.63	100.13	99.98	99.62

Source: Geological Survey Department, Colombo 2, Sri Lanka.

composition of some laterites from Sri Lanka. They are mainly kaolinitic clay materials with a small percentage of gibbsite (less than 15 per cent), considerable amounts of goethite ($Fe_2O_3H_2O$) and appreciate quantities of silica.

Included in the Pleistocene deposits of the Island are the red earths and gravels confined mainly to the north-west and the laterite deposits which are well developed in the south-west sector of the Island. The red earths are old soils with a flat to undulating topography; they are highly sandy soils (over 95 per cent quartz), brick red in colour and occur to depths of 50 feet or more with a distinct lack of horizon differentiation. Tests carried out reveal that these red earths could be used as moulding sands. Laterites are extensively used for building (in the form of hand-cut bricks). The majority of the alluvial clay deposits contain varying amounts of lateritic material. The warm climate and abundant rainfall alternating with dry periods, is geologically favourable to the development of laterite and lateritic soils. The thickest laterite occupies an erosion surface about 100 feet above sea level between Negombo, north of Colombo and Kalutara, south of Colombo. Inland it thins out and with increase of elevation passes into lateritic soils.

The laterites overlie a variety of rock types and are largely laterites developed in-situ. In addition there are secondary laterites but their recognition is difficult unless good sections are available from surface to bed-rock. However, some of the evidence available such as rounded quartz pebbles underlying a layer of laterite indicates a secondary origin. The laterites appear to have been more extensively distributed in the south-west lowlands in former geological periods than that which is observed at the present day. Absolute certainty as to the identity of the rock which has given rise to a particular laterite deposit is not always possible as outcrops of rock may be rare; the Pre-Cambrian complex is composed of a variety of rock types which vary rapidly both along and across the strike, which thus makes the problem even more difficult.

The laterites and lateritic soils of the Island are classified into three broad groups on the basis of differential thermal curves as follows:

1. Massive highly ferruginous laterites rich enough in iron hydroxide (mainly goethite) to constitute iron ore.

2. Laterites with a vesicular appearance and widely used as a building material (gibbsite-kaolinite, or gibbsite and/or goethite-kaolinite mixtures).

3. Lateritic red earths – relatively rich in gibbsite together with goethite and kaolinite. Soils mainly associated with the intermediate slopes and the highlands.

The typical laterite is usually separated from its parent rock by a considerable thickness of intermediate decomposition products. The laterite layer may vary in thickness from a few feet to 40 feet or more. The lower beds are soft lithomarge-like material whilst the upper layers are more hard and compact and suitable for building material. In the uppermost layers iron oxides get segregated to form surface ferruginous crusts. Some lower zones may show pockets of ferruginous material in the kaolinite layers. The laterite layer is usually close to the present surface, but in some areas the laterite may be buried under varying thickness of later sediments that conceal the lateritization surface. The skeleton of the cellular laterite is composed of quartz grains, iron and kaolin whilst the cavities are filled up with clayey matter and quartz. In the top-most layer the ferruginous material breaks down to form nodules of limonite. Sometimes this fragmental material moves down slope and in its new surroundings may overlie fresh rock, clay or other soil materials. Variations from the typical laterite profile have been observed. The hard laterite layer is normally absent in low lying areas; while sometimes the soft laterite layer is also missing. In certain parts the soft lateritic material has been almost entirely converted into kaolinite. Where the hard laterite layer is used as a building material the over-burden is first stripped and the laterite is cut into blocks by hand. Although many houses are recorded as built of "stone" especially in the south-west sector, the material used has been largely laterite. It is also fairly certain that many houses recorded in the recent census as "brick" are in fact of laterite (unburnt lateritic blocks). Typical lateritic profile is presented in Figure 7.

Kaolinitic clays are widespread in Sri Lanka and some clays contain up to 35 per cent Al_2O_3 (Figure 5). The alumina is combined with silica to form kaolinite ($Al_2O_3.2SiO_2.2H_2O$) and does not occur as free alumina as in bauxite (gibbsite). Although techniques to produce alumina from such materials have been studied the processes

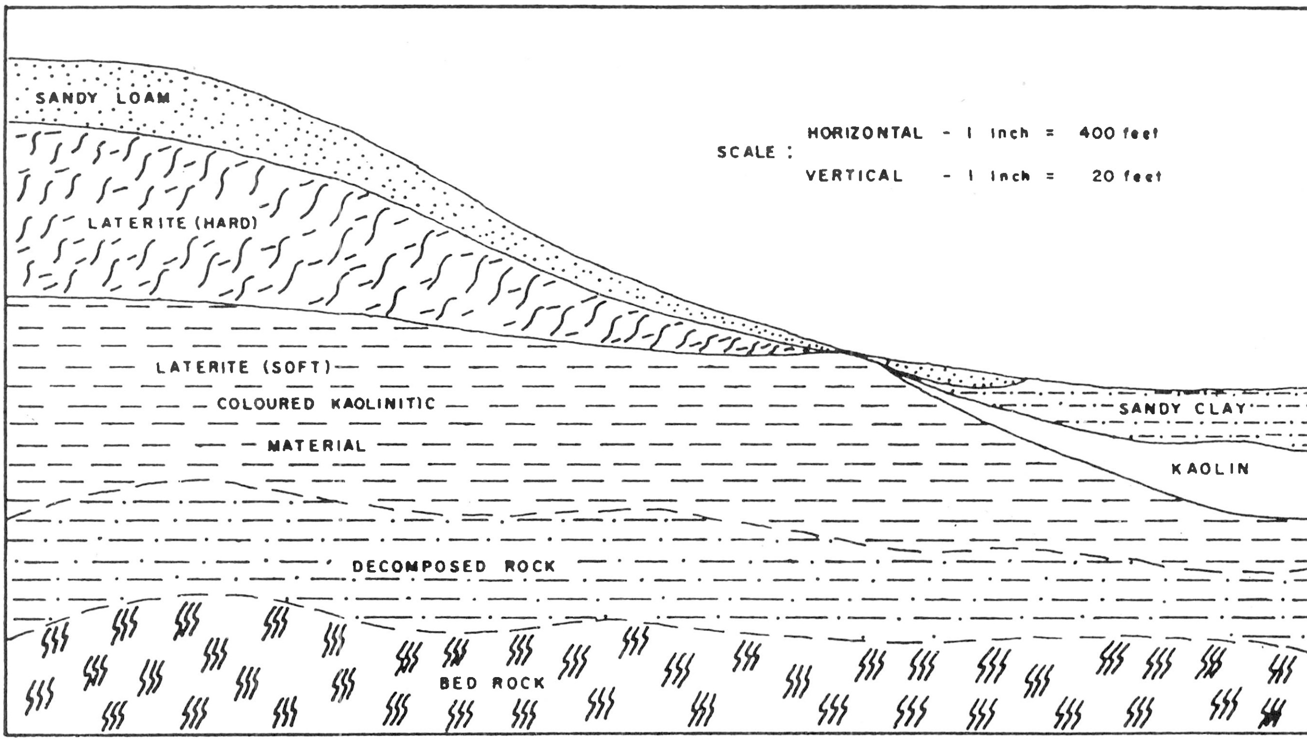


Figure 7. Lateritic profile in Sri Lanka

have not been perfected. However, some countries have installed plants to produce alumina from kaolinitic clay materials. The Andigama shales may also be suitable for producing alumina. The by-product of the process is portland cement.

2. Clays

The type of clay mineral that may occur in a clay material affects the ceramic behaviour. It is well known that kaolinitic clays are the least plastic and the most refractory; montmorillonite clays are the most plastic and the least refractory and the hydrous mica clays are of intermediate plasticity and low refractoriness. Sri Lanka is divided into three clay mineral provinces based on the frequency distribution of clay and associated minerals in the alluvial soils (Figure 8). The constitution of clay materials from the various provinces may be listed as follows:

GROUP I

Wet zone clay mineral province

(i) Mainly kaolinitic clay (china clay).

(ii) Kaolinite – gibbsite – boehmite clays with mixed layer mineral and vermiculite (ball clay).

(iii) Kaolinite – gibbsite – goethite clays with mica, mixed layer mineral and vermiculite (brick and tile clays).

GROUP II

Dry zone clay mineral province

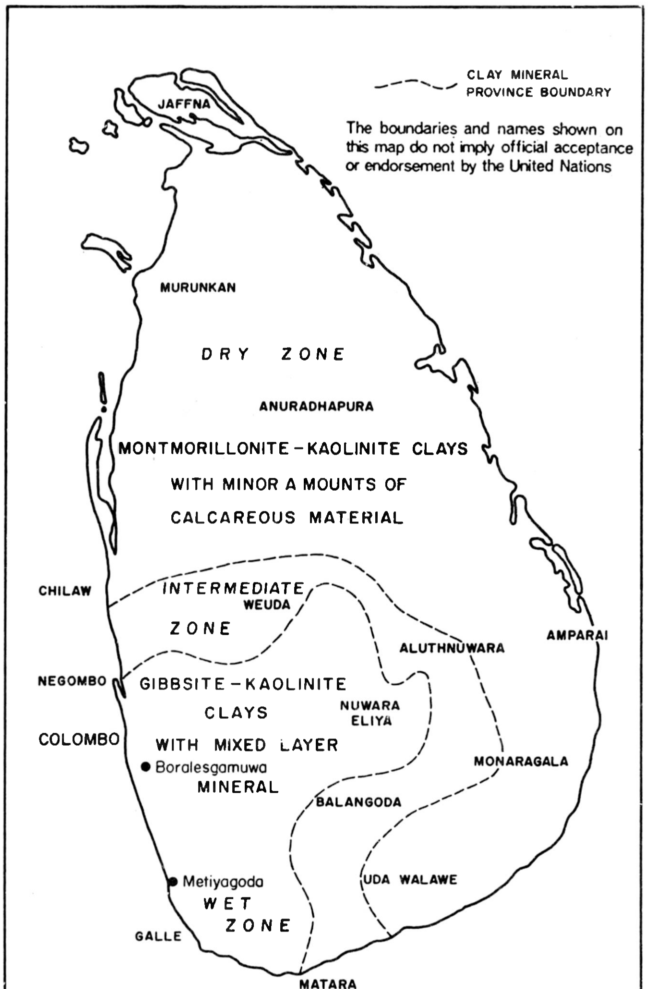
Kaolinite – montmorillonite clays devoid of gibbsite but with calcareous material (brick and tile clays).

GROUP III

Intermediate zone clay mineral province

Kaolinitic clays relatively low in gibbsite and montmorillonite.

The clay mineral provinces closely follow the climatic zones of the Island (Wet, Dry and Intermediate Zone) and this feature points out to the fact that climatic conditions have played an important role in the nature of clay mineral development in Sri Lanka soil materials. The characteristic feature of this classification is the progressive development of montmorillonite from Wet to Dry Zone areas, the progressive development of gibbsite from Dry to Wet Zone areas, and the progressive disappearance of calcareous material



Source :

J.W. Herath, 1980. Mineral Resources of Sri Lanka, Geological Survey Department, Economic Bulletin No. 2, Ministry of Industries and Scientific Affairs

Figure 8. Clay mineral provinces of Sri Lanka

from Dry to Wet Zone areas. The entire classification is based on the presence or absence of the mineral gibbsite which is highly diagnostic for it to be used as a reliable indicator mineral.

Brick and tiles making is the main consumping area for clays from all three clay-producing provinces.

Clay materials are also used for the manufacture of a large number and variety of other products, for example refined kaolin or china clay is used as fillers and coatings for paper, fillers and extenders for paints, fillers for rubber, textiles, oil cloth, toilet and tooth powder, soaps and gramophone records. Kaolin is also used in soft polishing, medicines, pharmaceuticals, cosmetics and for many other purposes. Coloured varieties of kaolinitic clays (clay ochers) contain varying amounts of iron oxides and hydroxides. In Sri Lanka these clays occur as lateritic clays. "Samara" a yellow clay ocher is a common variety. Clay ochers are used for paints, ceramic stains and for a number of other purposes.

Since about nine-tenths of the island is occupied by Pre-Cambrian crystalline rocks, the Island, except for some Jurassic shale, is devoid of true consolidated clays, upon which so much of the ceramic industry of the world is based. However, the surface of the Island has remained above sea level for the greater part of its geological history: this has resulted in a long period of intense weathering and erosion, with subsequent laying down of considerable amounts of alluvium in the intermediate slopes and the coastal regions. Sri Lanka has therefore to depend mainly on the unconsolidated alluvial clays along the lower reaches of the major river valleys for the raw materials used in the structural clay products industry.

Jurassic shales which are well developed in the Andigama area are a source of raw material for the manufacture of heavy clay products including refractories. Included in the Pleistocene deposits are the red earths and gravels confined to the north-west and the laterite deposits which are well developed in the south-west sector of the Island. The red earths have been found suitable for use as foundry moulding sands whilst the laterite deposits are mainly used to cut bricks for building purposes.

The occurrence of china clay or kaolin in the low lying areas around Colombo have been known for a long time. The reserves available at Boralesgamuwa are estimated to be well over a million tons. No detailed investigations have been undertaken to prove the estimated reserves of raw kaolin. Other deposits occur in the deep residual weathered zones of the central highlands and in other areas, specially in the lowlands of the south-west sector (Meetiyagoda area). Clays which approach ball clay in composition are known to occur in the flood plains of rivers confined to the south-west sector. The best known deposits of ball clay occur widespread in the Kalutara area. The proved reserves in this area amount to over 500,000 tons, although the actual reserves are very much larger. The Dediyawala clay could also be classed as a refractory bond clay or a fire clay (fusion point 1,700°C). The Dry Zone Clay types are ideal for the manufacture of expanded clay aggregate for concrete and very large reserves of cement clays are available in the Murunkan and other areas.

Alluvial clay deposits used for brick, tile and pipe manufacture vary considerably in character. Table 10 is presented to show the characteristic physical properties of brick, tile and pipe clays from the three clay mineral provinces of the Island, and Table 9 shows the chemical analyses of different types of clays from Sri Lanka. A scientific assessment based on a carefully planned programme of field investigation is therefore an essential requirement to disclose the extent and quality of the clay materials. A temporary high water table and liability to flooding is characteristic and a problem over most parts of the island. Many deposits, if they are to have any economic value must be worked to depths much below the apparent water table. This usually is not the practice and a large acreage of land goes to waste, due mainly to unsystematic mining in most areas. Accurate records of the quantity of raw materials mined by the cottage industry are not available. Assuming that approximately 500 million units are produced by the cottage industry about 1,300 acre feet of clay is required per annum. The modern brick and tile industry (private and public) consumes about 270 acre feet of clay for the manufacture of 90 million units per annum. The total annual requirements would therefore be in the region of 1,500 acre feet. At an average working depth of 8 feet this will involve a land use of 186 acres per annum. The reclamation of such land mined needs careful consideration. The total value of various clays used in industry is considerable and amounts to nearly 20 million Rupees.

Sri Lanka is well provided with ceramic raw materials. The cottage industry manufactures about 450-500 million bricks per annum: unglazed tiles of the mangalore pattern type are being made in about 50 modern factories; the Ceramics Corporation also operates 10 tile factories and together they produce over 75 million tiles per annum. Earthenware pipe and floor tiles are also produced. The State operates a series of pottery centres. Two kaolin refineries are operated by the Ceramics Corporation which produces nearly 7,000 tons of refined kaolin per annum. This Corporation also operates two ceramic factories, one at Negombo and the other at Piliyandala. These factories produce over 7,000 tons of ceramic ware and the products include domestic crockery, sanitary-ware, wall tile, mosaic tile, electroceramics and miscellaneous ornamental and fancy ware. A factory manufacturing porcelain ware (Lanka Procelain Limited) mainly for export is situated in Matale. A refractories factory at Hanwella, a second kaolin refinery at Meetiyagoda, a ball clay plant near Kalutara, a modern lime plant at Hungama, and a graphite crucibles plant at Gampola have

Table 9. Chemical analyses of clays from Sri Lanka

	CEY. 1	*CEY. 1a*	*CEY. 2*	*CEY. 8*	*CEY. 20*	*CEY. 6*
SiO_2	70.54	47.58	49.10	46.12	48.40	45.12
Al_2O_3	20.92	38.89	31.10	25.26	20.27	29.95
TiO_2	0.43	0.42	2.39	1.11	1.05	1.13
FeO	–	–	0.61	0.46	0.64	0.96
Fe_2O_3	0.18	0.42	0.16	9.73	8.85	9.10
MgO	tr.	tr.	0.62	0.90	1.27	1.14
CaO	–	tr.	tr.	0.76	1.41	0.68
K_2O	0.96	0.06	0.84	1.49	0.83	1.32
Na_2O	0.22	0.02	0.23	0.63	0.52	0.46
H_2O†	6.49	11.96	11.79	10.72	9.17	8.61
H_2O-	0.40	0.51	2.05	2.48	7.53	0.94
Total	100.14	99.86	99.69	99.66	99.94	99.26
Groups	1–i	1–i	1–ii	1–iii	II	III
Al_2O_3/SiO_2	.296	.815	.649	.547	.418	.570

Source: Geological Survey Department, Colombo 2.

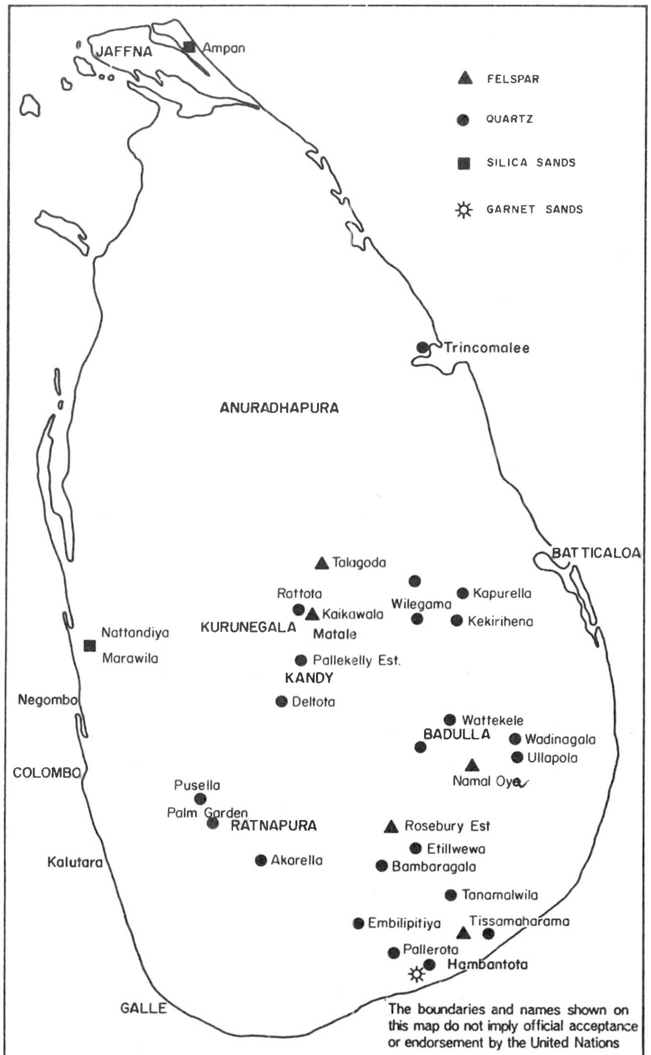
CEY. 1 = Unwashed kaolin.
CEY. 1a = Refined kaolin – without chemical treatment.
CEY. 2 = Ball Clay.
CEY. 8, 20, 6 = Brick and Tile Clays.

Table 10. Characteristics of physical properties of Sri Lanka's clays

	Properties	*Wet Zone I*	*Intermediate Zone III*	*Dry Zone II*
General	Mineralogy	Kao. Gib. Goe M.L. Min.	Kao Minor Gib. and Mont.	Kao. Mont. and Lime
	Clay – 2 microns	Range 12-49 Average 24	Range 24-57 Average 40	Range 40-65 Average 52
	Moisture (%)	Range 1.62-3.80 Average 2.52	Range 2.75-3.39 Average 3.63	Range 4.00-6.48 Average 5.23
	Total Cation, E.C.	Range 6.8-10.8 Average 9.4	Range 12.3-26.8 Average 17.6	Range 32.5-52.2 Average 40.2
Dry	Atterberg Plasticity Index	Range 9.7-19.4 Average 13.3	Range 20.4-38.4 Average 23	Range 41.3-49.0 Average 46.6
	Workability	Short to Normal	Normal	Excellent
	Bulk Density (gms. per cc.)	Range 1.38-1.61 Average 1.45	Range 1.55-1.81 Average 1.72	Range 1.80-1.97 Average 1.85
Wet	Weight Loss (%)	Range 13.5-29.3 Average 20.8	Range 16.0-31.2 Average 24.5	Range 21.4-24.5 Average 23.3
	Bulk Density (gms. per cc.)	Range 1.38-1.64 Average 1.46	Range 1.55-1.83 Average 1.73	Range 1.93-2.15 Average 2.07
	Volume Contraction (%)	Range 13.1-27.0 Average 19.8	Range 15.4-33.2 Average 26.8	Range 25.3-33.3 Average 29.4
	Stability Cracking	No Cracks	No Cracks	No Cracks to Fine C
	Compressive Strength lbs./sq. in	Range 224-545 Average 353	Range 520-832 Average 666	Range 537-1,052 Average 795
Fired-1050°C	Weight Loss (%)	Range 17.4-42.8 Average 32.0	Range 28.9-40.7 Average 34.5	Range 27.4-36.2 Average 33.3
	Bulk Density (gms. per cc.)	Range 1.39-1.68 Average 1.54	Range 1.92-1.98 Average 1.94	Range – Average above 2.00
	Volume Contraction (%)	Range 23.2-30.9 Average 27.5	Range 22.5-29.2 Average 32.8	Range – Average above 33.0
	Colour Hardness	Cream to Brick Red Soft to Fairly Hard	Pink Brown Hard to Very Hard	Light to Dark Brown Very Hard
	Stability Cracking	No Cracks to Badly C	Fine Cracks to Bad C	No Cracks to Extreme Cracking & Bloating
	Water Absorption (%)	Range 16.2-28.5 Average 22.4	Range 7.1-14.9 Average 12.2	Range– Average around 5.0
	Compressive Strength/lbs./sq. in	Range 434-963 Average 629	Range 2,460-4,910 3,283	Range – Average above 5,000
	Refractoriness	High	Intermediate	Low

Source: Herath, 1970.

also been established. A wall tiles plant (Lanka Wall Tiles Limited) mainly for export is situated at Balangoda. A second porcelain factory is also to be established. Figure 12 shows the location of ceramic and other factories in the Island.



Source : J.W. Herath, 1980. Mineral Resources of Sri Lanka, Geological Survey Department, Economic Bulletin No. 2, Ministry of Industries and Scientific Affairs

Figure 9. Occurrences of felspar, vein quartz, silica sands and garnet in Sri Lanka

Silica sand and stone

In Sri Lanka silica occurs as vein quartz, silica sand and quartzite.

Vein quartz deposits of extreme purity (over 98.8 per cent silica) are found in many parts of the Island. The best known deposits occur in the Opanaike, Pelmadulla, Pussella, Rattota and Ratnapura areas (Figure 9). Figures for reserves of vein quartz are not available, however, it may be estimated that over 500,000 tons of vein quartz could be recovered from mining the scattered surface outcrops that occur at various points in the Island. Vein quartz is mined at present for use in the ceramics and allied industries.

Deposits of silica sand are widespread in the Island and the best known deposits occur in the Marawila – Nattandiya and Madampe areas (Figure 9). A large deposit of silica sand occurs in the Ampan-Vallipuram area. The total extent of the Madampe deposit is approximately 875 acres and the Nattandiya deposit is about 640 acres. Both these deposits cover an area of about 1,500 acres. The average thickness of the glass sand is about 4 feet and no overburden occurs. The total reserve of glass sand in these deposits is in the range of 6 million tons. Chemical analyses show that the glass sand samples examined contain over 98 per cent SiO_2, less than 1 per cent Al_2O_3 and less than 0.50 per cent Fe_2O_3 and TiO_2. The sands are fairly well graded. The glass sands in the area are at present mined for use in the glass factory located at Nattandiya. It is also proposed to establish other glass factories in the Island. (Figure 9). The sands are normally associated with heavy minerals but these are in minor amounts and objectionable impurities could be removed by beneficiation.

A deposit of glass sand also occurs in the Jaffna Peninsula extending from near Vallipuram in the north to Ampan in the South (Figure 9). The deposits which are well developed sand dunes cover several hundreds of acres. The reserves available could be classed as very large.

Quartzites are well developed in the Island and they occur mainly in the highland areas. The pure quartzites are generally coarse, granular, or massive, whitish rocks in which no foliation of bedding is visible. In the felspathic varieties kaolinised felspar is present which often is stained and give the whole surface of the rock a brownish appearance. Quartzites are not utilized for any local industry in the Island although the pure varieties may be considered for use in the ceramics and allied industries. Chert which is a finely crystalline siliceous material occurs at various points in the Island. It could be used as an ornamental stone.

High quality crystal quartz is used in precision instruments. Electronic grade quartz crystal occurs in Brazil. The use of silicon (SiO_2) in alloy form primarily ferro-silicon, is firmly established in the iron and steel industry. One of the largest uses for silica sand is in making glass for which purpose both chemical composition and grain size are important. Silica is widely used in fibre glass manufacture and in the ceramics and allied industries. Silica is used in refractories, building products, abrasives, moulding sands, fillers and for a variety of other products. In Sri Lanka silica is mined (vein quartz and silica sand) mainly for use in the glass and ceramic industry and for use as a moulding sand and abrasive material.

Felspar

Microcline felspar (potash felspar) occurs in pegmatites in various parts of Sri Lanka, such as Rattota, Talagoda, Kaikawela, Namaloya and Koslanda (Figure 9). In Sri Lanka felspar is chiefly used in the ceramics and glass industries and mining of felspar is carried out in the Matale area. The largest deposit of felspar is in the Owella Estate (Kaikawela) and the Ceylon Ceramics Corporation has commenced mining this deposit. Drilling investigations carried out by the Geological Survey Department revealed that the Owella felspar is an extensive and commercially valuable deposit. A number of drill holes put down in the area showed that felspar occurs to more than 600 feet from the surface. Weathered felspar occurs to a depth of about 40 feet and from this point downwards hard felspar is encountered. At depths the felspar occurs with other minerals such as quartz and mica. Fluorspar has also been observed to be present. The chemical analyses of felspar is presented in Table 11. The reserves available at Owella are fairly large and may be estimated to be in the region of over 3 million tons. The deposit is worked at present and supplies felspar to a number of industries. Felspar also occurs at other points and deposits in the Talagoda area have been worked for a number of years. The Talagoda deposit does not appear to be promising for large scale mining of felspar.

Table 11. Composition of felspar from Sri Lanka

Constituents	*Owella*	*Talagoda*	*Koslanda*
SiO_2	64.15	64.67	65.02
Al_2O_3	18.74	18.35	18.92
Fe_2O_3	0.06	0.10	0.08
TiO_2	tr.	–	–
CaO	0.35	tr.	tr.
MgO	0.04	–	–
Na_2O	2.80	0.20	0.34
K_2O	13.67	16.65	16.05
Total	99.81	99.97	100.41

Source: Geological Survey Department, Colombo 2.

Felspar is used principally in the manufacture of glass, pottery, vitrified enamels and special porcelain. Less important uses, include its employment as a flux or binding agent; in scouring soaps and in artificial teeth. For high class products it is generally considered that felspar should not contain more than 0.01 per cent iron oxide and that for most varieties of colourless hollowware the limit is about 0.03 per cent. These limits make it desirable that every effort should be made during the dressing of the felspar to remove iron-bearing minerals or iron staining. In Sri Lanka climatic conditions are such that iron staining is very common in felspar deposits and care has to be taken to remove these stains before the felspar is processed for industrial use.

Garnet

Garnets are chiefly found in metamorphic rocks, particularly schists and gneisses. The proportion of garnet present varies considerably but generally it is not economical to treat rock with less than 10 per cent garnet. Garnet also occurs as alluvial deposits which have resulted from the weathering of parent rocks. In Sri Lanka garnet is a widespread mineral in the gneisses and granulites and some rocks contain nearly 10 to 15 per cent garnet. Garnet however, is not recovered as yet from rocks and most of the garnet produced comes from the beach mineral sands. The beach sands of the southern coastal areas of Sri Lanka are rich in garnet and very large reserves are available for commercial exploitation. The beach sands in the coastal areas of Dondra and Hambantota have been investigated. The Dondra sands contain from about 9 to 24 per cent garnet and the Hambantota garnet sands are mainly concentrated in sand dunes and contain up to about 20 per cent garnet (Figure 9). Small quantities of garnet sands are produced at the pilot plant established by the Geological Survey Department near Kalutara. Garnet however, is not produced at present in commercial quantities although the prospects for establishing a plant to produce garnet are promising especially in the southern parts of Sri Lanka where the beach sands are rich in garnet.

Limestone

The limestone deposits of the Island fall into four main groups (Figure 10);

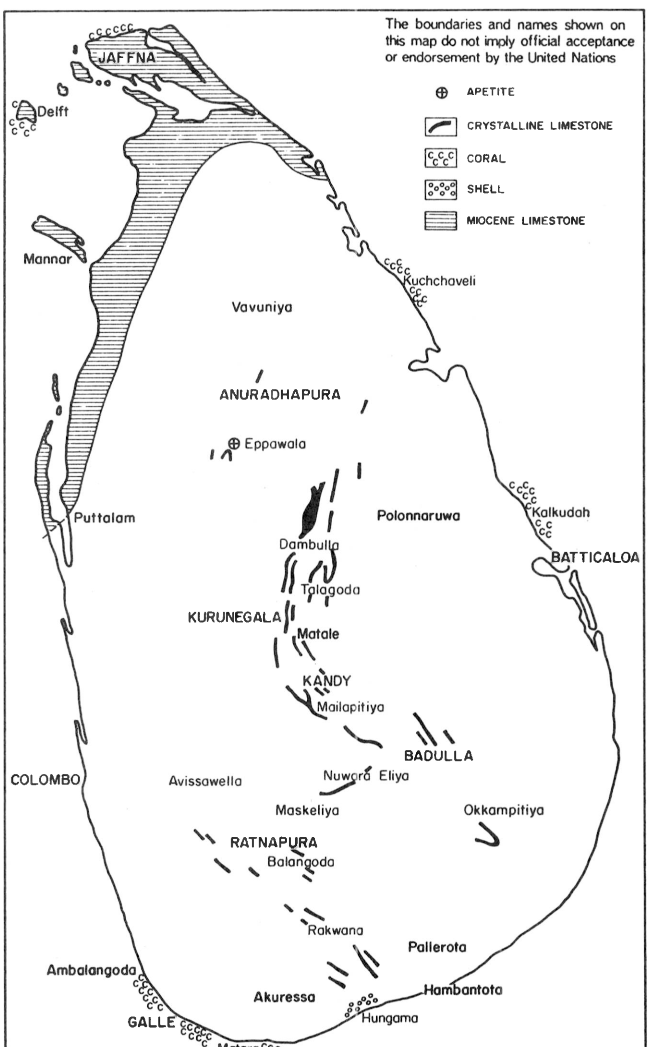
1. Sedimentary limestone deposits of Miocene age (over 95 per cent $CaCO_3$).

2. Crystalline limestone (marble) deposits of Pre-Cambrian age ($CaCO_3$ variable).

3. Coral limestone deposits along coastal areas (over 95 per cent $CaCO_3$).

4. Shell deposits along coastal areas (over 95 per cent $CaCO_3$).

Sedimentary limestone deposits of Miocene age are best developed in the Jaffna Peninsula



Source : J.W. Herath, 1980. Mineral Resources of Sri Lanka, Geological Survey Department, Economic Bulletin No. 2, Ministry of Industries and Scientific Affairs

Figure 10. Occurrences of calcareous material in Sri Lanka

where they occur as a hard compact limestone with a calcium carbonate content well over 95 per cent. These deposits which extend to great depths are also developed as far as Puttalam in the north-west coastal belt of the Island. The chief impurities in the limestone are varying amounts of clay and silica, and traces of magnesia. Two cement factories producing nearly 600,000 tons of cement per annum are operating in the area using Miocene limestone as raw material. Analyses of various types of calcareous material found in the Island are presented in Table 12.

Table 12. Chemical analyses of calcareous material from Sri Lanka

Constituents	*Shell (Hungama)*	*Coral (Akurala)*	*Miocene (Puttalam)**	*Crystalline-Precambrian (Kanadarawa)*
SiO_2	1.15	2.00	0.82	–
Al_2O_3	0.41	3.40	0.52	–
Fe_2O_3	0.33	0.50	0.08	–
CaO	54.89	51.50	54.20	45.72
MgO	0.02	–	0.70	0.79
Loss on Ignition	43.15	42.70	43.68	–
Total	99.95	100.10	100.00	–

Source: Geological Survey Department, Colombo 2.

* Siliceous varieties are common in the Puttalam area.

The crystalline limestones are confined to the central hills and are associated with quartzites and other metamorphic rocks and are generally found as narrow well defined bands which can be traced for many miles along the strike. In general they are more or less impure owing to the presence of various silicate minerals. In chemical composition the crystalline limestones vary from pure limestone through magnesium limestone to dolomites. The magnesium varieties are more abundant. Pure limestone deposits have been observed only at a few points (Kanadarawa) and these deposits are not of any commercial value except to mine small quantities of limestone ($CaCO_3$).

Coral limestone is found at various points along the coast of the Island, but these deposits are not of great importance. The best known coral beds are found along the south-west coast stretching from Ambalangoda to near Matara. The deposits consist of loosely-packed finger or stick coral with heavy blocks of massive coral. Coral deposits are also found overlying the Miocene limestone at the margins of the Jaffna Peninsula. Other areas where coral beds have been recorded are Kalkudah, Kuchchaveli area and Delft Island. The coral material is fairly pure limestone.

Extensive deposits of sea shells occur at Hatagala (Hungama). These deposits stretch parallel to the coast and extend for about 2 miles and are approximately a mile or two in width. The shells occur to a depth of 8 to 10 feet from the surface and are mixed with clayey matter, silt and other impurities. The Hungama shell deposits have been worked over the years and it is estimated that the reserves are now in the region of over a million tons. The chemical analysis of washed shell material from this deposit shows that it contains over 98 per cent $CaCO_3$. A modern lime plant has been established in this area (Figure 12).

Calcium carbonate is principally used in the cement industry, in blast furnaces and steel works and agricultural production. Lime is used as a metallurgical flux, in the manufacture of alkali, glass, paper and calcium carbide; in water and sewage purification; in soil stabilization and in the building industry in finishing lime, masons lime and mortar. Other industries using lime include textile, ceramics, manufacture of bleaching powder, sugar, varnish and carbon dioxide and in leather dressing and sand lime bricks. Whiting is used in paints, rubber, ceramics and putty. Precipitated calcium carbonate is also manufactured from lime. Lime in one form or other is used in a number of other industries. In Sri Lanka the cement industry consumes the largest amount of limestone.

Dolomite

Sri Lanka has very large reserves of dolomite and minor occurrences of magnesite.

Dolomite and dolomitic limestone deposits occurring in Sri Lanka are entirely confined to the belt of crystalline limestone deposits of Archaean age. They occur interbanded with other rock types such as quartzites, charnockites and gneisses as discontinuous but well defined bands, some of which can be traced for many miles along the strike. Most of the outcrops are found mainly in low lying land. The only magnesite deposit of crystalline variety so far investigated occurs associated with dolomite and limestone in Randeniya, near Wellawaya. Figure 10 is a map showing the occurrence of crystalline limestone, dolomite and magnesite. It will be clearly seen from the map that these deposits cover a very wide area extending from as far north as Vavuniya, through the Kurunegala – Kandy area to the southern regions near Ambalantota. Though the deposits do not appear to be continuous they nevertheless follow the regional strike of the country rock. They have a general trend or pattern and are largely confined to the central parts of the Island. The best known deposits occur in the Kandy, Matale, Nalanda, Habarane, Kanadarawa, Ratnapura, Balangoda, Badulla, Bibile and Welimada areas. Generally the deposits are of variable composition varying from a dolomitic limestone to a dolomite.

The dolomites are white in colour and the grain size ranges from rather coarse to fine. Large rhombs of dolomite are occasionally surrounded by smaller grains and this gives a texture resembling a porphyroblastic rock. Generally they are more or less impure due to the presence of various accessory minerals, the most common being fosterite and phlogopite with occasional diopside. Other accessory minerals include apatite, spinel, pyrite, pyrrhotite, graphite and rarely sphene, chondrodite, serendibite and tourmaline. The silicate minerals in association with other accessory minerals may be uniformly distributed or may occur as distinct layers and clots which stand out on weathered surfaces. Serpentinization of fosterite may impart a pale green colour to the body of the rock resulting in the formation of green marble. Dolomitic limestones are chemically stable substances and decomposition never occurs at ordinary temperatures. Decomposition can only occur at very high temperatures or through reaction with strong acids.

Detailed investigations have been carried out for dolomite, dolomitic limestone and magnesite in a number of localities. An investigation undertaken at Niriella proved a deposit of 150,000 tons of dolomite. However, more extensive, commercially valuable and easily workable deposits are to be found in many other parts of the Island, notably in the Matale – Nalanda areas. From investigations made in the field, it can be said that Sri Lanka is well provided with dolomites and dolomitic limestone. If dolomitic limestone with a magnesia content between 10 to 20 per cent is taken into consideration together with the deposits of true dolomite, very large reserves are available in the Island.

Most of the dolomite mines are situated in the Kandy, Matale and Balangoda areas and the mining is by open-cast methods which involve drilling and blasting. No special processing is needed other than crushing to the required size. The cost of production varies and the price at the pit head may vary from about 80-100 rupees a ton. No magnesite mines are operated in the Island.

Accurate records of present production of dolomite are not available, but is estimated to be in the region of over 15,000 tons a year. This material is largely used as crushed dolomite in agriculture and in the ceramics and allied industries. Dolomitic limestones are also mined in certain parts for the manufacture of lime. The local requirements of dolomitic limestones in the future should be fairly large taking into consideration the rapid industrial development of the country.

The uses of dolomite depend mainly upon its magnesia content and are in general similar to those of magnesite. Being cheaper and more abundant, it is used in preference to magnesite wherever its lower magnesia and its lime content permit substitution. Dead-burned dolomite obtained by calcining dolomite is used extensively for refractory purposes in basic open-hearth furnaces and in Bessemer converters. The most satisfactory dolomite for refractory uses should contain not more than 1 per cent SiO_2, 1.5 per cent combined AL_2O_3 and Fe_2O_3, and at least 38-40 per cent $MgCO_3$.

Dolomite is the raw material used to produce basic magnesium carbonate (magnesia alba) which is widely used in the manufacture of pipe and boiler coverings and for general heat insulation. Dolomite is an important ingredient in glass manufacture and as a flux in various manufacturing industries. The crushed rock may be used as a fertilizer, also in paint, putty and in the curing and fabrication of rubber. It is also used in the sulphide process of paper making. Dolomites make handsome building stones; they can be used for kerbing and guttering, pavement slabs, road metal and concrete aggregate and as a source of lime.

Phosphate rock

In Sri Lanka phosphate rock (apatite) was discovered by the Geological Survey Department in April, 1971 at Eppawala which is located in the North-Central Province (16th mile stone – Kekirawa-Talawa road). The deposit is estimated to occupy an area of 3 square miles. The apatite-bearing crystalline limestone (carbonatite) is well exposed and the surrounding country rock includes granite gneisses, charnockites, crystalline limestone, thin quartzites and biotite gneisses which belong to the charnockite – metasedimentary series. Drilling has revealed that the deposit extends to 400 feet or more from the surface. Initial studies reveal a leached zone (apatite in a matrix of iron oxides – also the phosphate rich ore zone) up to about 200 feet followed by fresh carbonate rock with apatite. The apatite is tentatively classed as a chlorine-rich fluorapatite. The average P_2O_5 content is 35 per cent or more for the phosphate rich ore zone. Samples containing 39 to 40 per cent P_2O_5 are not uncommon. The fresh carbonate rock at depths contain less than 10 per cent P_2O_5. Drilling investigations up to now (mid 1975) have proved about 25 million tons of ore. Taking into consideration that the apatite occurs to great depths and covers a wide area the inferred ore reserve may be over 50 million tons. Table 13 is presented to show the chemical analyses of the phosphate rock from the phosphate rich ore zone.

Table 13. Chemical composition of phosphate rock (apatite) from Sri Lanka

Constituents	*Phosphate rich ore zone*		
	EP/1/P	*EP/2/P*	*EP/3/P*
SiO_2	0.50	0.50	0.60
Al_2O_3	0.95	2.23	7.05
FeO	0.70	0.70	0.54
F_2O_3	3.72	2.30	7.70
TiO	0.78	0.78	0.60
P_2O_5	36.60	36.04	33.00
CaO	52.30	51.60	43.63
MgO	0.20	0.23	0.29
SiO	0.66	0.65	0.60
BaO	0.13	0.26	0.62
MaO	0.09	0.08	0.19
F	2.40	2.43	1.74
Cl	0.88	1.04	0.98
ThO	0.02	0.03	0.01
H_2O*	1.46	2.65	3.60
Total	101.39	101.32	101.15
Less O for Cl. and F.	1.23	1.34	1.08
Total	100.17	99.96	100.07

Source: Geological Survey Department, Colombo 2.

* Mineralogy: apatite (primary) insoluble, francolite (secondary apatite) partly soluble, martite (secondary iron) rutile and geothite.

Phosphate rock when finely ground has a limited use as a fertilizer because of its relatively slow availibility of the P_2O_5. The rock consists principally of tricalcium phosphate which is insoluble and therefore cannot be used by plants. By acidulation a large proportion of the material is converted into the monocalcium phosphate (superphosphate), a water soluble from which is readily available to plant life. Superphosphate is produced by mixing sulphuric acid with finely ground phosphate rock. The mixture reacts to form superphosphate with 16 to 20 per cent available P_2O_5. Triple phosphate is a much more concentrated fertilizer which contains from 45 to 50 per cent available P_2O_5. Triple phosphate is made by the action of phosphoric acid on the phosphate rock. The largest consumer of sulphuric acid is the superphosphate industry. This acid is used for so many different purposes that it has been called "the foundation of the chemical industry."

The present annual requirements of phosphate fertilizer in Sri Lanka is over 65,000 tons. This quantity would increase considerably during the next few years. With the recent discovery of the apatite deposit at Eppawala studies are now being made to establish a phosphate industry in the Island including the manufacture of superphosphates and other products. This activity is handled by the Mining and Mineral Development Corporation.

Sillimanite, Wollastonite and Cordierite

Sillimanite is a silicate of alumina (Al_2O_3. SiO_2) with a theoretical composition of Al_2O_3 63.1 per cent and SiO_2 36.9 per cent. Kyanite, sillimanite and andalusite have the same chemical composition but differ in crystal structure and physical properties. On heating around 1,500°C all the above minerals undergo conversion to mullite ($3Al_2O_3\ 2SiO_2$) and vitreous silica and in the calcined form they are used in refractory products. Sillimanite occurs in a variety of rock types in Sri Lanka. Appreciable quantities of sillimanite are found in the garnet-sillimanite-graphite schists which are well developed in the central highlands. Sillimanite also occurs in the beach mineral sands and the Pulmoddai sands contain up to 1 per cent sillimanite. Approximately 140,000 tons of raw sand are treated annually at Pulmoddai for the recovery of rutile, ilmenite and zircon and over 1,000 tons of sillimanite could be recovered annually from this deposit. At present sillimanite is not produced in Sri Lanka. Sillimanite is mainly used in the refractories industry on account of its ability to withstand high temperatures. The material is also used in the ceramics industry.

Wollastonite is a fibrous calcium silicate with the theoretical composition SiO_2 51.75 per cent and CaO 48.15 per cent. In Sri Lanka wollastonite-bearing calc gneisses occur in the Ambalangoda and Galle areas. The wollastonite occurs as segregations of coarse wollastonite crystals in the calc gneisses. Although these rocks are distinctive they are limited in extent and cannot be considered of commercial value at the moment. Wollastonite has a high fluxing action to bring down the maturing point of ceramic bodies and can be used in low temperature once fired products. Wollastonite is chiefly used in once-fired wall tiles. It is also used as a filler in paint, rubber and paper.

Cordierite ($2MgO.2Al_2O_3.5SiO_2$) is a rare mineral. Cordierite bodies are used in the ceramic industry and the development of synthetic cordierite is achieved by using the raw materials kaolin, talc and alumina. In Sri Lanka cordierite occurs in appreciable quantities in the gneisses in the Gampaha and Avissawella areas. However, cordierite is not extracted from these rocks at present.

Salt

Salt is recovered from a variety of deposits: sea water, saline lakes, bedded salt deposits and salt domes. In Sri Lanka salt is extracted from sea water by solar evaporation. The salt producing pans or salterns are located in three main regions and the state owned salterns are as follows:

Northern region	–	Elephant Pass, Kurunchativu, Kallundai, Irupalai.
Western region	–	Palavi, Mannar.
Southern region	–	Hambantota Maha Lewaya, Palatupana.

The National Salt Corporation operates the state owned salterns and a considerable amount of modernization and improvement work has already been undertaken by the Corporation. The local demand for salt is in the region of 98,000 tons per annum and in 1978 150,000 tons were produced valued at 25 million rupees. Salt is also used for the manufacture of caustic soda by the Paranthan Chemical Corporation. The Corporation has also plans to export salt.

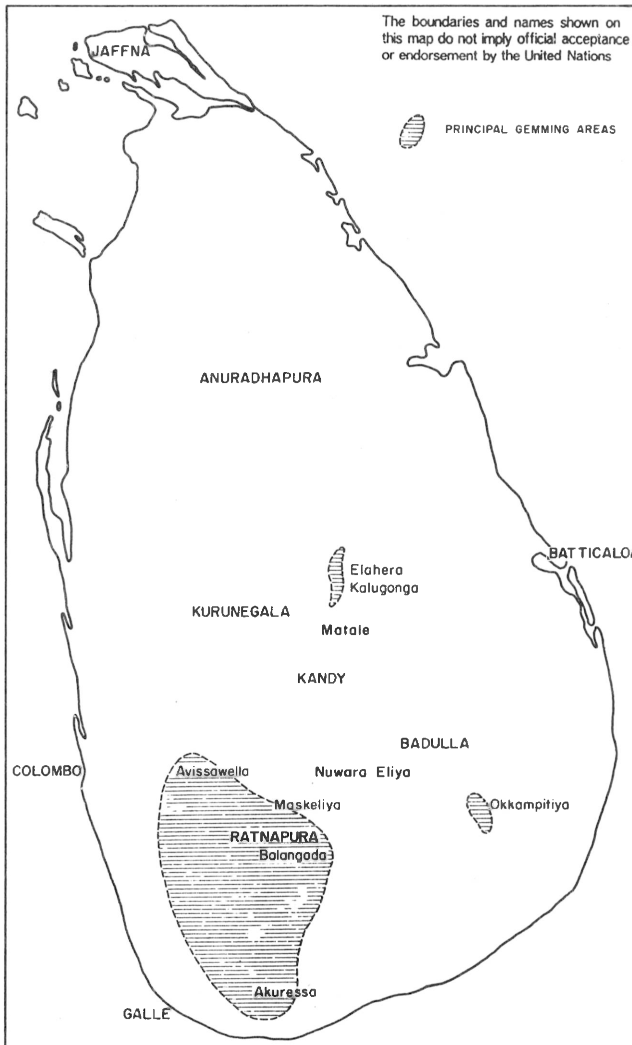
Gemstones

No other country in the world except perhaps Brazil produces a variety of gemstones as

Sri Lanka. The country has long been renowned for its gems and the industry is of the greatest antiquity. In the scriptures, mention is made to gems being brought to the court of Solomon, and the "Mahawansa" (historical records of the Island) refers to the reputation of the Island for its gems. Greek writers of the first and second centuries refer to gems in Sri Lanka. The Arabs in the fourth and fifth centuries and then the Persians exercised a considerable influence over the trade of the Island up to about the eleventh century. The reputation of the Island for its gems was also known to the Chinese from about the fourth century onwards when Chinese vessels called on Sri Lanka for purposes of trade. It is also believed that Sinbad's valley of Gems in the Arabian Nights is probably the Ratnapura gem fields. Perhaps nowhere in the world are so many minerals of the gem variety concentrated in a comparatively restricted area of mountainous country as the Ratnapura gem fields. The gems occur in such abundance and without any signs of apparent exhaustion of the gem fields.

Upto recent times the best known gem-bearing area was the Sabaragamuwa Province but during the last few years new gem-bearing fields have been found in the Okkampitiya and Elahera areas. Outside these areas extensive gemming has been carried out in the Southern Province while some gems have also been found in the Nuwara Eliya, Horton Plains, Maskeliya, Kandy and other areas (Figure 11).

The precious and semi-precious stones of Sri Lanka with the exception of moon-stones which are mined from fresh or weathered parent rock, are won from gem gravels which are found in river beds, buried river valleys and swamps. The gem-bearing gravels represent the residual minerals which have withstood the processes of weathering, erosion and transport over past geological ages. The gem minerals were once a part of the rocks of the surrounding country and due to their superior hardness and resistance to weathering have withstood disintegration and decomposition, while the alteration products of the other minerals in the form of clay and silt have been carried away. Associated minerals in the gem gravels include radioactive minerals such as thorianite and a host of rare-earth minerals. A few gemstones such as "Sinhalite" and "Ekanite" are new minerals species and there is every reason to expect that other new minerals will be found in the gem



Source : J.W. Herath, 1980. Mineral Resources of Sri Lanka, Geological Survey Department, Economic Bulletin No. 2, Ministry of Industries and Scientific Affairs

Figure 11. Principal gemming areas of Sri Lanka

gravels. Table 14 is presented to show the main gem varieties present in the gem gravels of Sri Lanka.

The depth, character and composition of the gem gravels vary from place to place and usually form narrow patches and lenses not more than a few yards in breadth and less than hundred yards in length in the alluvial profiles. This is reflection of the changing currents of the rivers and streams in which the gravels have been deposited; while transport was active in one location, deposition had been dominant at another. This explains the reason why the distribution of the gem-bearing gravels is variable and also why one pit may encounter rich gem-bearing gravels while another pit a few hundred yards away or less may encounter barren ground. The methods of mining are simple

Table 14. Gems of Sri Lanka

Mineral	*Gem variety*
Corundum (Al_2O_3)	Sapphire, Star-Sapphire, Ruby and Star Ruby, Yellow, Orange and White Sapphire.
Chrysoberyl C ($BeO.Al_2O_3$)	Alexandrite and Cat's eye.
Beryl C ($3BeO.Al_2O_3.6SiO_2$)	Emerald Aquamarine
Topaz (Al_2 $(F.OH)_2.SiO_4$)	White and Yellow Topaz. Blue, Green, Violet and Red topaz (pale tints).
Tourmaline (Complex boro-silicate)	Black, pink, rose-red, blue, brown and other coloured tourmaline.
Garnet Pyrope-Mg_3Al_2 $(SiO_4)_3$ Almandine-Fe_3Al_2 $(SiO_4)_3$ Grossularite-Ca_3Al_2 $(SiO_4)_3$	Pyrope-deep red to black. Almandine-deep crimson, red to violet. Grossularite-honey-yellow to brownish yellow. (Also known as hessonite or cinnamon stone).
Spinel ($MgO.Al_2O_3$)	Spinel-deep red, green, violet.
Zircon ($ZrSiO_4$)	Hyacinth-red, orange, brown and yellow varieties. jargon-other coloured varieties.
Quartz (SiO_2)	Rock-crystal, amethyst, rose quartz, smoky quartz, citrine (yellow), Cat's-eye quartz.
Felspar $KALSi_3O_8$	Moonstone, and amazon stone.
Cordierite $(Mg.Fe)_2$ $Al_3Si_5O_{18}$	Iolite.
Andalusite, Al_2SiO_5	Andalusite (bottle green)
Apatite Ca_4 (CaF) $(PO_4)_3$	Apatite.
Kornerupine Mg. Ai_2SiO_6	Yellow and brown varieties.
Sinhalite Mg. $Al.BO_4$	Brown (Shades of brown)
Taaffeite Mg. Be. Al_4O_8	Pale violet – Eheliyagoda.
Ekanite (Th, U) (Ca, Fe, Pb)$_2$ Si_8O_{20}	Dark Green – Found at Eheliyagoda.
Calcium carbonate ($CaCO_3$)	Pearl.

and although "primitive" are suited to local economic conditions and to the system of land tenure that prevails in Sri Lanka. The methods involve little capital outlay and except for pumps for de-watering, little mechanical equipment is used. Most of the mining is done during the dry season and up to the present there has been no large scale mining using dredges or other mechanical equipment.

Different mining methods are used in Sri Lanka depending on the disposition of the gem-bearing gravel. When the gem-bearing gravel is below 6 feet or so from the surface as in certain dry valleys or weathered slopes of hills, near-surface mining is done and the gem-bearing gravel is spread evenly over the area after which the material is sorted out and washed in running water when the lighter material is carried away leaving the heavier potential gem-bearing gravel behind. When the gem-bearing gravel is at considerable depth pits are sunk going down to a depth of 40 to 50 feet; the sides of the pit are supported with planks to prevent caving-in and with foliage to reduce the seepage of water while the pit is de-watered with pumps or buckets. The excavated gem-bearing gravel is brought up and once sufficient gravel is collected it is washed in large shallow wicker baskets and eventually the whole of the lighter gravel is washed away leaving only the gems and heavy minerals of high specific gravity which are then sorted for potential gem quality stones. Various other methods of mining are carried out in the beds of streams and rivers.

Until recently gemstones were mainly cut by hand machines of primitive construction. Although a few mechanically operated cutting machines have been imported by the trade still hand machines predominate. Except for cabochon cut gemstones such as the star-sapphires, star-rubies and cat's eyes which are of a high standard there is much improvement that could be made in the cutting of facetted stones and this requires in addition to skill and experience a knowledge of the elements of optics so as to obtain perfect symmetry, maximum colour, reflection and "fire" of the stones. It is said that local cutters excel in the cutting of the cabochon-cut stones and this is most evident in the cutting of the Sri Lanka sapphire in which the blue colour is not distributed evenly throughout the stone. It must be borne in mind that the value of a gemstone is enhanced many times depending on the quality of cutting.

The values and quantities of gemstones exported from Sri Lanka during 1963-68 indicate that the number of carats varied from 60,000 to 196,000 carats and that the value varied from 1.3 to 4 million rupees. The variation in the value depends on the quality of the stones exported each year but these figures are perhaps not accurate as in addition to exports it is well known that gemstones are taken out of the country by illicit methods and the value-fetched has been estimated by various authorities to be as much as hundred to two hundred million rupees a year. The gemstone has two advantages for this purpose in that the weight and volume is negligible but the value is high. The problem of the illicit flow of gemstones is not peculiar to Sri Lanka and in certain other countries it is estimated that at times nearly 75 per cent of the gemstones are taken out in this manner.

With a view to develop the gem industry of Sri Lanka, the State Gem Corporation was established in November, 1971. The Corporation now handles issue of permits for gemming, buys cut and uncut gems and all exports of gemstones from the Island have to be channelled through the Corporation. A modern gem testing laboratory has been established and the Corporation has already made a significant contribution towards establishing a sound gem industry in the Island. In 1971 exports of gems from the Island were valued at Rupees 3,446,293 and the export figures for 1978 were Rupees 526,411,326.00. These figures indicate the increasing confidence owners of gems are beginning to have in the Corporation.

C. BUILDING AND CONSTRUCTION MATERIALS

Stone and sand

In Sri Lanka as in most other countries the value of stone had been recognized and there is evidence of stone work which dates back to many centuries. Dimension stone and the magnificent carvings on stone are to be seen today in the remains of ancient ruined cities of the Island. Stone in various forms and sand are extensively used in the building industry all over the world. Stone which is specially cut or shaped for use in buildings and for other construction purposes is called dimension stone. Stone which is broken into required sizes is used in the construction of buildings and crushed stone is used as concrete aggregate and road-stone. In Sri Lanka the reserves of stone and sand are large and laterite is also used as a building stone and very large reserves are available.

Over nine-tenths of the Island is occupied by Pre-Cambrian crystalline rocks and except for a limited occurrence of Jurassic shales the rest is covered by hard Miocene limestone. Granites, gneisses of various type, limestones and dolomites, quartzites and charnockites are common rock types which are extensively developed in most parts of the country. The stone industry is one of the oldest industries in the country. Stone is used in Sri Lanka for building purposes, as road metal and as aggregate in concrete. Dimension stone and polished slabs are turned out in limited quantities. Grinding and pounding equipment is also turned out from stone for domestic use. Accurate estimates are not available as to the amount of stone consumed per annum but the quantities are very large. Stone is employed for building, engineering, roads and paving, decoration and monuments and a variety of fresh rock is available in Sri Lanka for most purposes.

Very large quantities of sand are used in the building industry. Most of the sand is obtained from rivers which drain the Island. Good quality sand is available in unlimited quantities in the lower reaches of the major river systems. Accurate estimates of the amount of sand consumed are not available. The sands are mainly composed of quartz (over 90 per cent). Accessory minerals present include mica, ilmenite, rutile, garnet, monazite and other resistant primary minerals.

III. CURRENT STATUS OF SRI LANKA'S RESERVES, MINERAL PRODUCTION, IMPORTS AND EXPORTS

Mineral resources of Sri Lanka are diverse, but for the most part, extraction is on a small scale. The main minerals produced in Sri Lanka in recent years except of mineral sands were non-metallic minerals: graphite, phosphate, mica, kaolin, limestone, feldspar, quartz and gemstones. Location of major industrial units and mines in Sri Lanka is shown on Figure 12.

A. SHORT HISTORY AND CURRENT STATUS OF MINERAL RESOURCES AND RELATED INDUSTRIES DEVELOPMENT IN SRI LANKA

Iron ore

Sri Lankan iron ore deposits can be broadly put into two categories. One of them is hydrated iron oxides (limonite and geothite) and the other is magnetite. The limonite variety has been located mainly in the Ratnapura district and to a lesser extent in the Galle and Matara districts.

Most of these deposits are found at or near the surface. The limonite reserves have been estimated at 2.2 million tons. The magnetite deposits have been discovered at Panirendawa and Seruwila. The deposit at Panirandawa is expected to contain about 5.6 million tons of magnetite of high grade. The most promising iron ore deposit is found at Seruwila. It is also a magnetite deposit. In terms of quality as well as quantity this deposit is assumed to be superior to any other iron ore deposits.

The Ceylon Steel Corporation was established in 1961 for the purpose of implementing the steel project which involved the setting up of a rolling mill and wire mill as the first stage. The rolling mill and wire mill were commissioned in 1967. The mill has a capacity of 80,000 tons per annum, (installed capacity on three shifts) and imported steel billets are fabricated in the mill to standard shapes to meet the requirements of the building industry. Cold twisted high strength ribbed torsteel for the purpose of reinforcing concrete is also produced. The wire mill has a capacity to produce 12,000 tons per annum. At present the steel project is wholly dependent on imported raw materials. Annually about 35,000 tons of steel billets are imported for this purpose. Stage II of the project commenced operation in July 1982, with the installation of a capacity of 25 tons. This stage II relied completely on local available steel scrap. The furnace was capable of producing 60,000 tons of finished products annually. The furnace and its accessories have been valued at Rs. 183 million. This stage of the project was capable of saving a vast amount of foreign exchange as it did not need imported material but scrap obtained from the CGR and some local industries.

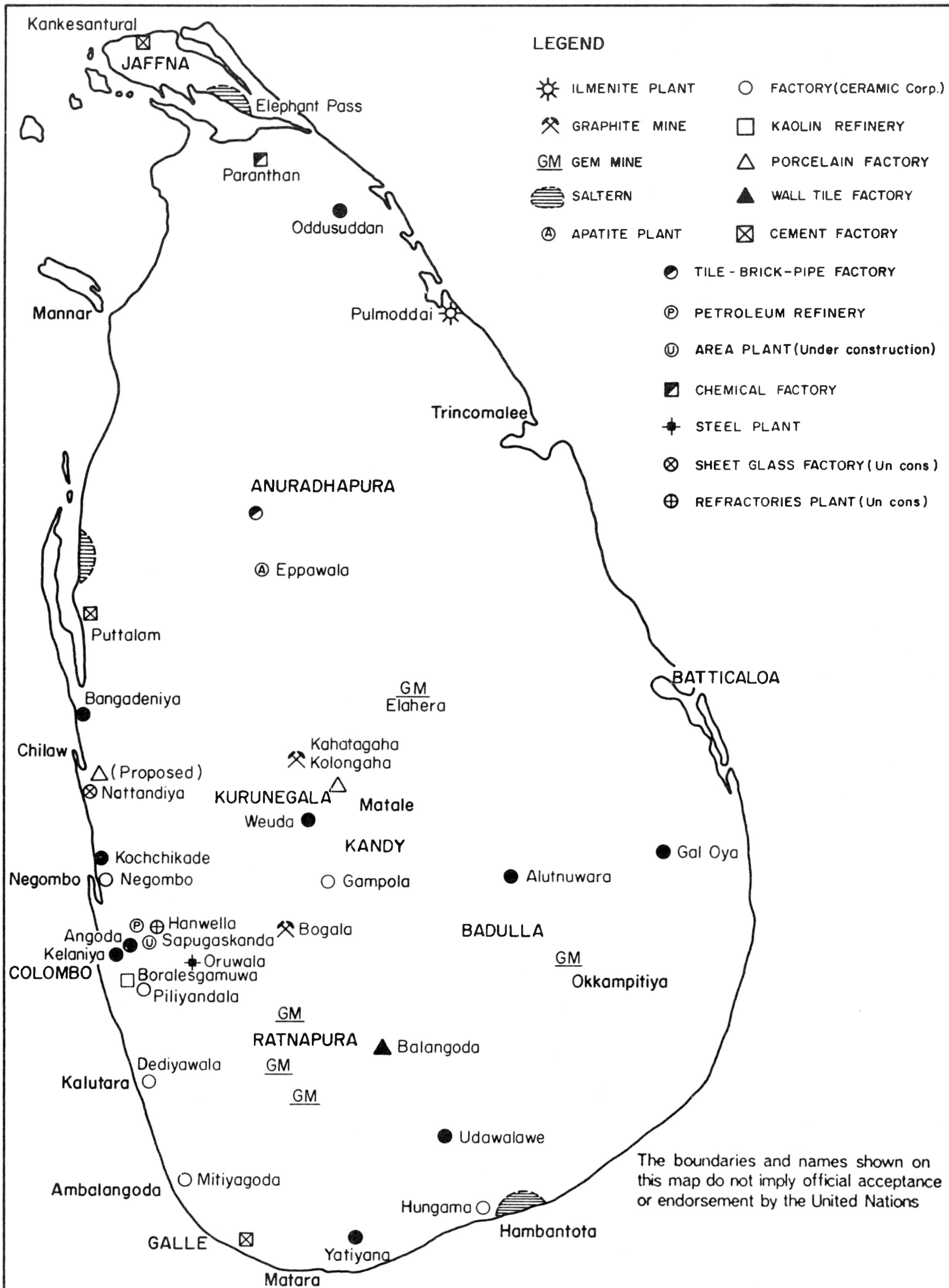
Production at the Steel Corporation during the year 1982 and 1983 has been below the budgeted amounts in respect of all items. When compared with the previous years performance production reached its peak in 1980 but since then there has been a gradual decrease. This was due to adverse market conditions. There has been a decrease in sales mainly due to increased competition from imports and the Corporation has been compelled to cut back on their production plans, as shown in Table 15.

Table 15. Local production of basic steel items in Sri Lanka

Products	*1978*	*1979*	*1980*	*1981*	*1982*	*1983 up to August*
Rolled Section (m.t.)	33 111	45 355	52 704	38 991	22 797	15 504
Steel Foundry (m.t.)	633	800	673	406	477	262
Fabricated Steel (m.t.)	251	338	457	257	203	152
Welding Electrodes (Kgs.)	–	–	–	–	–	17 682
Billets Local (m.t.)	–	–	–	–	–	7 188
Tor Steel Unit (m.t.)	–	–	–	–	–	13 183
Wire Mill (m.t.)	–	–	–	–	–	1 382
Value of Production (Rs.m.n.)	268.1	–	507.8	478.6	310.2	209.8

Source: Ceylon Steel Corporation.

Although Stage II was metallurgically successful, it had to be closed down in 1983 when its products could not compete with imported materials. In spite of difficulties the Corporation decided to re-start the operation in early 1984.



Source : *J.W. Herath, 1980. Mineral Resources of Sri Lanka, Geological Survey Department, Economic Bulletin No. 2, Ministry of Industries and Scientific Affairs*

Figure 12. Location of industrial units and mines in Sri Lanka

Mineral sands

Sri Lanka has earned an international reputation for its mineral sands. The country's beach placer deposit at Pulmoddai extends for about 4.5 miles along the coast and reaches about 250 yards in width and about ten feet below the low water mark. The other important concentrations of mineral sands deposits are at Kaikawela and Polkotuwa to the south of Colombo, and at Kudremala point to the south of Mannar. The Pulmoddai deposit is estimated to contain about 4 million tons of raw materials, whose composition is 70 to 72 per cent ilmenite, 8 to 10 per cent zircon, 8 per cent rutile, 0.3 per cent monazite and 1 per cent sillimanite.

Heavy mineral-bearing sands have been known for many years at several locations in Sri Lanka; however, it is only at Pulmoddai in the north-east of the country that any development has occurred. The Pulmoddai deposit has been known since the 1920s. In 1957, the Government of Sri Lanka established the Ceylon Mineral Sands Corporation (CMSC) to exploit the ilmenite, rutile, zircon, and monazite of this deposit.

Production at Pulmoddai by CMSC began in 1961, with an initial ilmenite capacity of 50,000 tons/year which was increased to 85,000 tons/year in the late 1960s. In 1968 the company established a processing plant at China Bay, near Trincomalee, 70 km south of Pulmoddai, designed to recover 2,000 to 3,000 tons/year each of rutile and zircon from the Pulmoddai tailings. Minor quantities of monazite was also extracted.

Pulmuddai plant was capable of processing 140,000 tpa of raw dry sand. Ilmenite is recovered using magnetic separators. In 1978 an expanded rutile and zircon recovery plant commenced operations. The rate of production of ilmenite was of the order of 40,000 tons per year. With the commissioning of the new plant in 1978 the annual capacity was increased to 80,000 tons for limenite, 14,000 tons for rutile and 8,300 tons for zircon. Annual production has been less, but in 1981 production of ilmenite was slightly over 80,000 tons and rutile production has also reached full capacity. Zircon production has been at less than 50 per cent of capacity.

In 1979 CMSC announced that it would expand its ilmenite capacity to 150,000 tons/year with financial assistance from the United Nations. These expanded facilities came on stream in 1984, when the ilmenite-processing plant was expanded from 85,000 tons year to 150,000 tons/year with the installation of a wet gravity and magnetic separation facility. The increased ilmenite production capacity is reflected in 1984 output (Table 16). Rutile, zircon and monazite are recovered from an ilmenite tailings treatment plant which did not undergo an increase in production capacity along with the ilmenite plant; it is capable of producing 14,000 tons of rutile, 9,000 tons of zircon, and approximately 300 tons of monazite. However, as larger quantities of non-magnetic tailings are now available, the capacity of this plant could be expanded (Adamns, 1984; Clark, 1983).

CMSC has restricted its ilmenite production to 150,000 tons/year because of shipping problems. Production levels of rutile, zircon, and monazite have varied between 50 per cent and 100 per cent of rated capacity in recent years. CMSC is considering extracting sillimanite from the ilmenite tailings. In addition, the production of small quantities of baddelyite has been recorded from an unlisted locality (Herath, 1977).

At present the mineral sand products are not upgraded, although plans for ilmenite benefication are being considered by CMSC (Adams, 1984; Clark, 1983). Plans provide possibly a construction of a titania slag plant to produce minimum 85 per cent TiO_2, or a synthetic rutile plant to produce minimum 92 per cent TiO_2. Financial assistance for such a programme was offered by the United Nations in 1980. The company has since been seeking foreign collaboration in such a project. A TiO_2 pigment plant is also under consideration (Adams, 1984; Clark, 1983).

Most of the heavy mineral production of Sri Lanka is exported. Port facilities at Pulmoddai have been improved recently with bulk shipment loading rates of 2,000 tons of concentrate a day now possible (Adamns, 1984).

The maximum size of ships loaded is 46,000 tons. Shipping of the concentrate is restricted to the dry season (April-August).

Exports during 1982 and 1983 were at a very low level, less than 15,000 tons; they increased sharply to 96,000 tons in 1984 (Table 16). The major markets are Japan (Ishihara), Federal Republic of Germany and the United States. The bulk of zircon production is exported to Europe

Table 16. Production and export of mineral sands, Sri Lanka

(Tons)

	Ilmenite		*Rutile*		*Zircon*	
	Production	*Export*	*Production*	*Export*	*Production*	*Export*
1971	91 425	–	2 545	–	137	–
1972	81 200	–	2 117	–	30	–
1973	92 005	–	2 216	–	28	–
1974	79 817	85 627	4 200	2 335	–	30
1975	62 999	53 740	3 111	3 272	–	30
1976	59 932	54 592	1 039	2 177	–	–
1977	33 092	41 125	954	191	375	–
1978	33 041	37 145	11 497	9 246	3 194	2
1979	55 370	30 478	14 675	14 148	1 326	1 329
1980	29 340	36 680	12 789	12 148	3 032	2 025
1981	80 011	41 465	15 300	5 136	3 266	4 617
1982	68 282	48 895	7 212	15 301	5 789	–
1983	80 486	27 863	7 803	5 612	5 335	9 206
1984[a]	97 040	130 957	6 467	4 761	3 708	3 808
1985[a]	114 954	147 666	8 605	8 374	4 061	4 548
1986[a, b]	96 509	–	6 927	–	910	–

Source: Mineral resources of Sri Lanka – An information survey.

[a] Ceylon Mineral Sands Corporation.

[b] January-September.

and Japan; about 1 per cent is used by local industry. Most rutile and monazite production is believed to be sold on the open world market. There appears to be no imports into Sri Lanka of any heavy mineral commodities, either in the raw or processed state. (Chin and others, 1986; British Geological Survey, 1986; Clark, 1983).

Graphite

The mining of graphite in Sri Lanka and exports have continued since 1821 and in the early days the country enjoyed virtually a monopoly in the world markets. The graphite mining industry is one of the oldest mineral industries of the Island.

Though graphite from Sri Lanka accounts for a mere 2 per cent of world production, in terms of purity and physical property, it ranks amongst the best in the world. Total estimated reserves are in excess of 100,000 tons of which 61,000 tons are proven reserves. Bogala with a proven reserve of 54,750 tons is the main source followed by Kahatagaha-Kolongaha and Rangala. Deposits at Rajadara are still to be assessed.

In 1983 this mineral ranked sixth among the Sri Lanka's items of export. For nearly 100 years, the production of graphite was in the hands of the private sector. In 1971 the graphite mining industry was handed over to the State Mining and Mineral Development Corporation (SMMDC). The actual production in subsequent years has been in the range of 8,000 to 10,000 tons per annum. Sri Lankan graphite is under severe competition from several graphite producing countries. The main competitors are the Republic of Korea, Austria, Germany (Federal Republic of), the USSR, China and Mexico. The greatest competition is from Malagasy where graphite can be obtained from easily worked graphite deposits. The resession in the industrial world too had a considerable effect on the graphite market. During the period 1973-1981, the output of graphite has been around 10,000 tons. In 1980, it went as low as 7,300 tons as the world economic recession worsened.

Consequently, graphite production in Sri Lanka is dependent on overseas markets. In 1983 the Graphite Corporation had to slow down on its production due mainly to marketing constraints and both production and sales were comparatively low.

By the end of 1982 the Sri Lanka government decided to mount a project to develop the country's graphite industry. The cost of the project has been assessed at Rs.660 million. The Asian Development Bank has agreed to fund part of the project. This project will commence once the government makes a final decision taking the local component of the expenses (Rs. 260-280 million) into consideration. Meanwhile, the State Mining and Mineral Development Corporation (SMMDC) is considering the establishment of a graphite based industry in Sri Lanka with foreign collaboration. The Ceylon Ceramics Corporation has established a factory for the production of graphite crucibles for the domestic market. The SMMDC is also planning to set up a high quality graphite crucibles unit with a foreign collaborator entirely for the export market.

The production today is centred on two underground operations at Bogala and Kahatagaha-Kolongaha. There are two experimental mines at Rangala. The State Mining and Mineral Development Corporation has also opened-up two more abandoned mines at Siyambalapitiya and Pussehena.

The highest exports of graphite have been recorded in 1916 and 1942 when 33,411 tons and 27,734 tons were exported respectively. Table 17 is presented to show the exports of graphite during 10 year periods from 1900 and the annual exports for period 1970-1978.

Table 17. Exports of Graphite from Sri Lanka, 1900-1978

Period	*Quantity* (tons)*	*Year*	*Quantity* (tons)*
1900-1909	273 538	1970	9 631
1910-1919	237 289	1971	7 072
1920-1929	111 740	1972	6 161
		1973	7 462
1930-1939	121 651	1974	9 623
1940-1949	162 268	1975	6 000
1950-1959	88 852	1976	7 900
1960-1969	84 423	1977	8 800
		1978	11 163

Source: Geological Survey Department, Colombo 2.

* Approximate.

Production and sales of graphite in Sri Lanka in 1978-1983 is shown in Table 18, while projected export targets are presented in Table 19.

Table 18. Production and sales of graphite in Sri Lanka, 1978-1983

	1978	*1979*	*1980*	*1981*	*1982*	*1983*
Production (Metric tons)	10 579	9 491	7 124	7 453	8 257	5 528
Sales – quantity (Metric tons)	11 427	10 933	6 759	4 670	3 197	–
Sales – value (Rs.Mn.)	67.7	89.5	94.0	114.8	73.8	–
Exports – value (Rs.Mn.)	59.3	74.6	85.2	100.9	59.1	–

Source: State Mining and Mineral Development Corporation.

Table 19. Projected export targets for graphite in Sri Lanka, 1983-1987

	1983	*1984*	*1985*	*1986*	*1987*
Volume	11.3	13.3	13.3	14.3	15.0
Value	134	157	157	171	180

Source: SMMDC.

Note: Volume in '000 tons/Value in Rs. million.

During the last ten years, Sri Lankan graphite exports have earned Rs. 819 million, contributing Rs. 179 million to the national treasury duties. The most important markets for Sri Lanka's graphite are Japan, followed by the United States, the United Kingdom, Australia, India, Pakistan and Europe.

Phosphate

In 1971 the Department of Geological Survey located a very large deposit of phosphate-bearing minerals, apatite, at Eppawala. It has been estimated that more than 50 million tons of proven and probable reserves averaging 33 per cent P_2O_5 occur in the Eppawala area. Initial studies have indicated that the deposit occupies an area of 3 square miles. Drilling reveals that the deposit extends to 400 feet or more from the surface.

Chemical analyses have shown that Eppawala apatite is richer in chlorine than fluorine and hence may consist mostly of chlor apatite (Cao 53.8 per cent, P_2O_5 41 per cent, and Cl 6.8 per cent).

In 1978, the development of the resource was undertaken by the State Mining and Mineral Development Corporation. The Corporation has chosen the Agrico Chemical Company of the United States as a collaborator. The project cost was initially estimated at about US$400 m. It has been agreed to establish a plant capable to producing US$535,000 tons per annum (tpa) of diamonium phosphate for export and 50,000 tpa of triple superphosphate for domestic use. But this project has been deferred because of a glut in phosphates worldwide and the high processing costs owing to the large acid content in Sri Lankan phosphate.

Meanwhile, the State Mining and Mineral Development Corporation has produced increasing quantities of apatite since 1978. Its annual production of apatite in subsequent years is shown in Table 20.

Table 20. Apatite production in Sri Lanka, 1978-1983

(Metric tons)

Year	*Quantity*
1978	3 660
1979	8 671
1980	14 076
1981	15 294
1982	13 993
1983	15 727

Source: Economic Review, April 1984.

Clay

There are four types of industrial clays in Sri Lanka. They are china clay, ball clay, fire clay and earthenware clay. China clay or kaolinite is the chief raw material used in the manufacture of porcelain and ceramic ware. Kaolinite deposits are found as a sedimentary formation at varying depths in Boralesgamuwa and Meetouagpda area. These deposits are associated with quartz, mica, feldspar and heavy minerals such as ilmenite and monazite. The mining and processing of kaolinite are being carried out by the Ceylon Ceramics Corporation at its clay refineries in Boralesgamuwa and Meetiyuagods. The Ceramics Corporation however, finds its Boralesgamuwa deposit virtually exhaused and only low-grade tainted kaolin remains in the mine. The Geological Survey has discovered for the corporation a massive deposit of high grade kaolin at Metiyagoda in the south-western district of Sri Lanka. Spread over 110 ha, the deposits are estimated at 440,000 tons of kaolinite with 70 per cent kaolin content. Besides, plentiful availability of sea-shells, which provide high grade lime, calcium carbonate and whiting, and deposits of ball clay in the south-west coastal belt have also supported the growth of the ceramic industry. Miocene limestone and clay deposits in the north of Puttalam area supply the raw material for the cement plants at Puttalam, Kanakesanthurai and Ruhunu (Mining Annual Review, 1988). Kaolinite is also used as a filler and coating in the paper industry and also in the manufacture of numerous products such as paints and tooth pastes. It is also used in the rubber industry and in the manufacture of fiberglass. Chemically ball clay is very much similar to china clay. The difference lies in particle size and in the amount of impurities. Ball clay is noted for its toughness, plasticity, better binding power and low refractoriness. It is used along with china clay as a raw material in the ceramic industry. Deposits of ball clay are found in Bolgoda and Dediyawala areas. Fire clay possesses a remarkable resistance to heat and is termed refractory clay. It is used to manufacture refractory parts for kilns and furnaces. Earthenware clay in raw state is red, brown or grey as a result of the presence of iron oxide. When fired, the colour may vary from pink to red brown. It is mainly used for manufacture of pottery.

The two china clay refineries of the Ceylon Ceramics Corporation produce 700 tpa. The Corporation's main factories are situated at Negombo and Piliyandala. It also has nearly 10 factories producing tiles and another 10 factories producing wall tiles. A total of 7,000 tpa of ceramic ware, which includes domestic crockery, wall tiles, sanitary ware, mosaic tiles, electro – ceramics, ornamental and fancy ware are produced by the Corporation. Lanka Porcelain Ltd. at its factory at Rattota manufactures porcelain mainly for export. Products of Lanka Wall Tiles Ltd., in Balangoda too are meant for export.

In March 1983, the Dankotuwa Porcelain (Pvt) Ltd. a subsidiary of the Ceylon Ceramics Corporation was commissioned. This factory, one of the largest in Asia for porcelain manufacture, is export-oriented. According to the Corporation, export orders have been received from several countries including the United States and Canada (B. Marasinghe, 1984). Production and sales of ceramic ware is presented in Table 21.

Table 21. Production and sales of ceramic ware, 1979-1983 (Ceylon ceramics corporation)

(Tons)

Production	*1979*	*1980*	*1981*	*1982*	*1983*
Crockery	3 572	3 281	2 967	3 461	3 769
Sanitary Ware	804	1 075	1 045	1 030	1 126
Ball Clay – Raw	1 196	9 821	8 095	8 554	10 725
– Refined	–	1 636	1 139	737	1 255
Kaolin	5 870	6 614	7 315	8 206	7 976
Insulators	280	361	287	267	291
Mosaic Tiles	1 734	1 879	1 733	901	67
Tiles and Bricks ('000)	25 316	25 793	24 903	19 715	19 289
Quartz (upto Aug'83)	–	–	–	–	512
Feldspar (upto Aug'83)	–	–	–	–	1 547
Hydrated Lime (upto Aug'83)	–	–	–	–	1 012
Value of Production (Rs. 000)	132 718	190 517	199 079	200 776	–
Value of Sales (Rs. 000)	142 816	207 106	219 085	375 312	–
Foreign Exchange Savings (Rs. 000)	139 979	212 170	59 393	94 055	–
Foreign Exchange Earnings (Rs. 000)	11 087	14 630	9 394	2 732	–

Source: Ceylon Ceramics Corporation.

The main markets for ceramic products continue to be the United States, Canada, the United Kingdom, Germany (Federal Republic of), South Africa, Australia and New Zealand. The use of an internationally known brand name, available under a joint venture agreement, has been very effective in promoting exports of porcelain grade tableware manufactured by the Ceylon Ceramics Corporation. In the manufacture of ceramics and porcelain ware Sri Lanka has the comparative advantage on several counts: availability of clays, silica, quartz, feldspar and other minerals and also a relatively inexpensive workforce traditionally skilled in pottery and ceramics. The constraints are the inadequacy of technology and equipment to turn out high quality products and the absence of an effective marketing strategy. The export potential in this area is high and production capacity needs expansion and refinement. Some action is also needed to afford better freight rates to exporters.

Based on a better marketing effort, the following export targets, as shown in Table 22, appear reasonable.

Dolomite

Dolomite is a double carbonate of calcium and magnesium. These deposits are found mainly in the hill country in areas such as Kandy and Matale; and also in the Badulla and Ratnapura areas. Although this mineral has a value as a fertilizer, its use is rather limited because of its low solubility. However, dolomite can be used for several other purposes such as manufacture of scouring powder, floor polish and water colours, foundry bricks, manufacture of magnesia, and as fillers in the rubber industry. It is also used in mechanized glass factories and the ceramics, enamel and porcelain industries. About 15,000 tpa of dolomite is extracted from deposits in the Central Province. However, its use has been limited due to the preference for imported Kieserite and commercial Epson salt. The mode of production of dolomite in the country needs further development. The Industrial Development Board has come up with suggestion to establish small scale plants to manufacture about 25,000 tpa of 250 mesh dolomite with comparatively low investment and reasonably low running costs.

Table 22. Projected export targets for ceramic industry in Sri Lanka, 1983-1987

(Rs. million)

	Value				
Items	*1983*	*1984*	*1985*	*1986*	*1987*
Wall Tiles	85.0	108.8	139.0	178.0	228.0
Others (Mosaic Tiles)	12.0	13.2	14.5	16.0	17.5
Porcelain	76.0	80.0	83.0	90.0	100.0
New Projects	20.0	50.7	66.5	83.0	112.5
Ornamehtal & Souvehir Items	7.0	10.0	12.0	15.0	15.0
	200.0	262.7	315.0	382.0	473.0

Source: Economic Review, April 1984.

Feldspar

Mining of feldspar is carried out in the Matale area. The largest deposits are located at Kaikawala and these are exploited by the Ceylon Ceramics Corporation. Reserves at Kaikawala which persist to a depth of 600 feet are estimated at 3 million tons. The Corporation has also mined large deposits in the Talagoda and Rattota areas. There is potential for export of feldspar in crushed and fine ground form.

In the ceramic industry, feldspar is used as a bonding or coating material. The glass industry is another important consumer of this mineral. Feldspar is also used in the enamel, abrasive and scouring soap industries.

Limestone

Limestone is a valuable raw material as it is used in many major industries such as cement, fertilizer, ceramics, sugar and bleaching powder. As the activities in agriculture and construction have been greatly encouraged by the present government, there has been a sharp increase in the demand for limestone. It has been estimated that at least 15,000 tons of lime will be needed annually for government housing development alone. Limestone deposits are found in the central hills and in the northern region. The sources of limestone are available in abundance.

However, they are hard to mine and also contain impurities; as a result there is a higher demand for coral lime which is easy to mine and comparatively purer. The range of coral mining and processing is generally confined to a 50 mile stretch from Ambalangoda to Dondra head. Coral mining activities while providing a good income to the people involved has also created many problems. A unique and valuable coral reef ecosystem has been threatned with near extinction. More alarming is the fact that the coral mining leads to coastal erosion, with the removal of the natural barriers of the sea beach which curb a direct attack by waves on the beaches.

Cement

Massive development programmes started in recent years have led to a boom in cement production. The Ceylon Cement Corporation finds it hard to meet the demand. The Corporation's major cement works are located at Kankesanthurai and at Puttlam. The Corporation also has a grinding plant in Galle which uses limestone derived from Kankesanthurai. The Ceylon Cement Corporation produces about 2.5 million tons annually. In 1983 a public company called Lanka Cement Ltd., was commissioned. It is expected that the company will be initially producing 0.6 million tons of cement annually.

Also in 1983, a local private firm went into collaboration with Japanese firm to set up a Rs. 400 million cement complex in China Bay, where the clinker will be imported for this project, which has a production capacity of 200,000 tons of cement per annum. From September 1984 it hopes to produce 17,000 to 20,000 tons of cement per month, when the new plant at KKS is also at capacity production about 225,000 tons is expected to be available for export. In view of this situation there are possibilities that the country will be self-sufficient in cement and even have a surplus in the near future. This surplus would have to be exported to bring in foreign exchange. Production of cement in Sri Lanka is shown in Table 23.

Table 23. Production of cement in Sri Lanka

(Metric tons)

Year	*Portland cement*	*Masonary cement*
1977	362 860	–
1978	575 061	–
1979	591 797	68 800
1980	551 076	71 723
1981	630 944	74 731
1982	468 840	68 789
1983	446 469	33 099

Source: Ceylon Cement Corporation.

Mica

Mica deposits are found in the Badulla and Haputale districts. Although the quality of mica mined from shallow surface pits is rather low, it is believed that good quality sheet is available at depth. The State Mining and Mineral Development Corporation has been examining the potential for mica. In 1982 about 300 tons of mica was exported to Japan.

The Corporation was engaged in manufacturing vermiculite mica as there was a greater demand for this variety. Available data on production, exports and total income mica are presented in Table 24.

Table 24. Production, exports and total income from mica in Sri Lanka, 1978-1983

Year	*Production (Mt. tons)*	*Exports (Mt. tons)*	*Total earnings (Rs.Mn)*
1978	240	140	.4
1979	308	275	1.0
1980	145	88	.4
1981	182	168	1.0
1982	291	292	1.8
1983	171	111	.7

Source: State Mining and Mineral Development Corporation.

Recently mica is mined at Madugalla and promising occurrences of both phlogopite and muscovite varieties have been reported in the Central Province. Mica exploitation is confined to shallow workings and exports are mainly in the form of lower grades of sheet and scrap. The government has plans to set up a mica purification project at Ambana in the Laggala area. Mica and gypsum also occur at Pallama, Henyaya and Kirindigala in the Ibbagamuwa area. (Mining Annual Review, 1988).

Silica sand and stone

Quartz and silica sand are two abrasive materials that are abundant in Sri Lanka. Silica (SiO_2) is also used to manufacture glass. Most important deposits of silica are found at Marawila and in the Ampanavallipurum area near Point Pedro. In Nattandiya, the deposits spread over an area of 1,500 acres with an average thickness of about 4 ft. It has been estimated that in Nattandiya alone there is about 6 million tons of silica which contains 98 per cent silica, less than 1 per cent iron oxide (Fe_2O_3) and titanium dioxide (TiO_2). This is an ideal raw material for glass manufacture. Rayo Glass Ltd. produces 2,500 tpa of glass melt from which white and amber bottles are made. The company has plans to produce 30,000 bottles per day. The abrasive properties of quartz and silica make them useful in the manufacture of sand papers and other abrasive products. Sri Lanka also has high quality natural abrasive materials such as corundum and garnet. Garnet sand is available on the southern coast of the island.

Gems

Sri Lanka has earned a high reputation for its gems Although there are four other gem bearing areas in the world in South Africa, South America, Burma and Thailand no other country, with the possible exception of Brazil, produces such a variety of gemstones as Sri Lanka does. The country's economy has been greatly boosted by the gem industry. In recent years the export of gems has brought in about Rs. 500 million annually in foreign exchange to the country. In 1982 the figure reached Rs 695 million and in 1983 Rs. 940 million. This figure does not include the earnings through sales to tourists. The acual values could have been much higher if not for the illicit trade in gems.

All types of gemstones with the exception of diamond, opal and turquoise are found here. Most common Sri Lankan gems are sapphire, ruby, aquamarine, topaz, tourmaline, garnet, spinel and zircon. Among the gemstones unique to this country are sinhalite, a magnesium aluminium borate, taaffeite, a magnesium berryllium aluminate and ekanite, a complex silicate of uranium, thorium, calcium iron and lead. The best known gem-bearing area is in the Sabaragamuwa Province. Nearly 80 per cent of the chief gem mines are found in this area It covers an area of about 1,800 square miles between Avissawella, Kamburupitiya and Moneragala. Among the villages famous for gems are Balangoda, Ehiliyagoda, Pelmadulla, Rakwana and Ratnapura. Other locations in the Okkampitiya – Elahera area as well as in Nuwara Eliya Horton-Plains Maskeliya and Kandy also yield some gemstones. Approximately 7,000 gem pits are scattered throughout the country.

Gemstones are found embedded in layers of gravel and sand in river beds, swamps and buried in river valleys The precious and semi-precious stones are found among the layers of older alluvium and river gravels of Quaternary age in the valleys of Ratnapura district in the south-west. Moonstones, tourmaline, garnet, and amethyst are exceptions as they are generally mined from weathered parent rocks. The extent of the gem gravels generally varies but usually has been between a few metres in breadth and about 30 metres in depth. When the depth is not more than 15 metres, exploiting the deposits is a relatively simple affair. When the gem-bearing gravels are located deeper, mining becomes difficult owing to the unconsolidated nature of the surrounding gravels which require support. The only form of mechanization is the use of water pumps to empty the water that collects at the bottom of the pit. A simple washing process is used to separate heavier gems from the lighter gravels. Although mechanically operated cutting and polishing machines are available, the lapidary work of the bulk of the Sri Lankan gemstones is done using hand machines of primitive construction.

A rich deposit of topaz found at Polwatta near Matale in Central Sri Lanka has been taken over by the State Gem Corp. The corporation will set up a topaz marketing centre to supply lapidaries with rough topaz from the deposit. The Geological Survey had an exploration programme to locate diamond occurrences in Koslanda, Ratnapura, the Sinharaja Forest, Embilipitiya, Welipatanwila, Elahera and Eppawala. The government had plans to develop the lapidary industry in a big way. At Ratnapura and Matale the State Gem Corp. has established lapidaries. The privately-owned Blue Peacock Lapidary on the west coast specializes in diamonds, which are cut and polished for export markets. Regular gem auctions have been held in the country since1980 (Mining Annual Review, 1988).

The value of exports of gems from Sri Lanka, on an official basis, has kept fluctuating over the years, despite the very generous concessions granted to gem exporters. The value of gems exported officially had dropped from Rs. 531 million in 1978 to Rs. 302 million in 1981. This fall in earnings was attributed partly to the fact that some of the gem-bearing areas had been exhausted as a result of intensive mining. Value of exports of gems is shown in Table 25.

Table 25. Value of exports of gems from Sri Lanka

Year	*Value (Rs.Mn.)*
1971	3.9
1972	12.5
1973	140.8
1974	108.7
1975	180.2
1976	261.4
1977	297.9
1978	531.0
1979	490.1
1980	458.1
1981	301.6
1982	684.9
1983	940.4
1984	617.0
1985	561.0
1986	755.0

Source: Sri Lanka Customs.

However, it appears that some gem traders were exporting their gems through illegitimate channels.

Although there has been a significant improvement in the gem industry owing to the presence of the State Gem Corporation, there are some areas which need further improvement. The local gem business is still in the hands of few traders with miners getting only a fraction of the profits. Illicit gemming is still going on and according to Customs, gem smuggling has not stopped either. Modernization of gem mining and processing as well as cutting and polishing could also help the industry.

Salt and salt-based chemicals

Sri Lanka is one among few countries that produces solar salt (98 per cent NaCI) for human consumption. The National Salt Corporation has recorded a production level ranging from 120,000 tons to 150,000 tons per year affording a surplus available for export in the range of 20,000 to 30,000 tons per year.

The National Salt Corporation which is the sole organization engaged in the production of salt has 17 solar evaporation units which have a total combined production capacity of 250,000 tons per annum (tpa). However, the production is kept at a lower level as the local demand does not exceed 120,000 tpa. (See Table 26).

Table 26. Production and sales of common salt by the National Salt Corporation

Year	*Production*		*Sales*	
1977	46 360	(tons)	120 586	(tons)
1978	149 268	(tons)	113 059	(tons)
1979	121 443	(tons)	110 615	(tons)
1980	127 161	(tons)	120 924	(tons)
1981	104 344	(mt. tons)	116 094	(mt. tons)
1982	169 232	(mt. tons)	106 329	(mt. tons)
1983 Upto August	84 603	(mt. tons)	69 820	(mt. tons)

Source: National Salt Corporation.

The output of the National Salt Corporation (NSC) in 1985 was 78,085 tons, 29 per cent down on 1984. In the first ten months of 1986 the NSC produced 104,279 tons.

The export of the product is hampered owing to the high cost of freight. There are many chemicals that can be manufactured starting from salt. They are caustic soda, washing soda, bleaching powder, hydrochloric acid and gaseous chlorine. Only 2 per cent of Sri Lanka's total production is used for the manufacture of chemicals. Production of these chemicals is presently done by the Paranthan Chemicals Corporation which operates the caustic soda plant. The government is considering the setting up of a second caustic soda/chlorine plant. There is a great demand for caustic soda which is an important raw material in the paper industry. The National Salt Corporation is collaborating on a Rs. 100 million project with the Paranthan Chemicals Corporation and the National Paper Corporation to establish a plant to manufacture 700 tpa caustic soda/chlorine at Embilipitiya. Unlike the traditional method which uses the diaphrag – cell technique, this project is to be based on the latest membrane cell production technology.

A chemicals industry is a fundamental requirement for the speedy industrialization of a country and with this as one of its objectives the Paranthan Chemicals Corporation commenced commercial production of chlorine, caustic soda and sulphuric acid at the beginning of the 1960s. Although the Corporation is mainly concerned with the production and disposal of caustic soda and liquid chlorine, limited quantities of table salt are also produced for sale locally.

Production of salt-related products in Sri Lanka is shown in Table 27.

Table 27. Production of salt-related products by the Paranthan Chemicals Corporation

Year	*Caustic Soda*	*Liquid Chlorine*	*Table Salt*	*Hydro-chloric Acid*	*Ferric Chloride*	*Zinc Chloride*
1977	1 515	662	559	550	108	110
1978	1 865	1 156	486	668	110	121
1979	1 723	1 274	519	1 041	78	63
1980	1 827	1 456	521	982	123	74
1981	1 729	1 339	498	979	108	59
1982	1 407	845	365	627	117	45
1983	1 420	903	520	563	90	32

Source: Paranthan Chemicals Corporation.

B. CONTRIBUTION OF MINING INDUSTRY TO THE NATIONAL ECONOMY: CURRENT STATE AND PROJECTIONS

The value of the contribution from the mineral sector, as shown in Table 28, has progressively moved up nearly over eight-fold between 1970 and 1983. The value of mineral and quarrying which was estimated at Rs. 95 million in 1970 had reached an estimated Rs. 800 million by 1983.

Table 28. Contribution of mining and quarrying to the Gross National Product at Constant (1970) factor cost prices

(Rs.Mn.)

Year	*Mining and quarrying value*	*GNP value*
1970	95	13 187
1975	395	14 987
1980	684	19 575
1981	713	20 706
1982	742	21 756
1983	800	22 824

Source: Central Bank of Sri Lanka.

Increase over the last 6 years was due to a heavier exploitation of these resources for the construction industry, new ventures in phosphate fertilizer, ceramic ware, mineral sands and continuing exports of graphite and gemstones. There are however views expressed that many existing minerals resources are yet under-utilized or not utilized at all and as a result the country is being deprived of the potential benefits. There are pressures for establishing industries from these resources on a more permanent and scientific foundation and ensuring that they are not sent out as raw materials in bulk or semi-finished state, but processed locally in order to get the most out of the value added.

The potential value of exports was expected to exceed Rs. 2,500 million by 1987 with the highest exports from gems and jewellery (Rs. 1,500 mn), ceramics (Rs. 473 million), cement (Rs. 300 mn), graphite (Rs. 180 mn), mineral sands (Rs. 110 mn) and salt and salt-based chemicals (Rs. 20 mn).

The actual value of mineral exports for recent years, however, indicates that the prans were too optimistic. In 1986, export earnings from mineral sector was Rs. 1,182 million, less than a half of expected value for 1987. The export earnings from gems and other minerals (graphite, iron pyrites and ilmenite) have been static in dollar terms and after an encouraging upsurge in 1983 fell sharply in 1984 and 1985. A strong recovery in 1986 restored the level of dollar receipts to nearly the 1980-83 average level, though as a proportion of total exports gems and minerals contribution was still only small at 3.5 per cent. Mineral exports in term of value in recent years are shown in Table 29.

Table 29. Mineral exports of Sri Lanka, 1981-1986

(SLRs Mn)

	1981	*1982*	*1983*	*1984*	*1985*	*1986*
Gems	633	685	940	617	561	755
Other	159	174	192	215	304	427
Total	792	859	1 132	832	865	1 182
$ Mn	41	41	48	33	32	42

Source: Central Bank of Sri Lanka.

In order to transform in an under-developed Sri Lankan economy into a developed one, the industrial sector will have to play a dominant role.

The Government has recently authorized private sector participation in the refractories project of the Ceylon Ceramics Corporation and projects initiated by several other state corporations including the State Mining and Mineral Development Corporation, the Hardware Corporation and the Ceylon Mineral Sands Corporation. Enterepreneurs should explore the possibilities of getting involved in similar mineral-based industries. For example, it may be possible for private miners to open some of the old abandoned graphite mines with technical advice from the SMMDC. The private sector should also consider setting up of graphite-based industries. Among such possible industries are the manufacture of cinema arc carbon, carbon arc electrodes, midget electrodes for dry cells, carbon brushes, colloidal graphite lubricants, greases, paints and crucibles. Small scale indigenous industries based on local minerals such as clay, glass-sand and limestone are comparatively easier to realize.

Kaolin which is a valuable raw material for ceramics, the paper and paint industries, can also be used as a refining agent in the sugar industry and also to make dielectric parts for electronic equipment. Garnet sands may be used to make sand papers. At present mica is exported in the raw state. Mica may be processed to produce sheets to be used in insulating materials for electrical appliances.

The mineral sands industry is heavily dependent on exports for its survival. There are possibilities of establishing domestic manufacturing industries based on these resources. In this way value-added mineral products could be available for the more diverse industrial markets.

Once the Eppawala phosphate project is completed, Sri Lanka would be a major producer of phosphate fertilizer, capable of producing 530,000 tpa of diammonium phosphate and 50,000 tpa of triple superphosphate.

As a source of minerals, the potential of the sea is enormous. Apart from salt, chemicals that can be extracted from sea water include magnesium sulphate, magnesium chloride, calcium sulphate, bromine and iodine. Sri Lanka's maritime boundaries cover an area of 4 times its size and therefore the amount of marine minerals available to the country is almost limitless. Ectraction of marine minerals and production of chemicals from them can no doubt be a profitable business. Demand for caustic soda, for instance, is growing annually by about 12 per cent. This growth in demand is mainly due to the increased demand for pulp and paper. In 1984 the Ceylon Petroleum Corporation has planned to commence off-shore oil exploration in collaboration with a Canadian firm. If, successful, this venture could make a tremendous impact on the nation's economy.

At present most of Sri Lanka's valuable minerals are exported almost in raw state. Processing of minerals increases their value by a great margin. In some cases, the increase may be twenty fold or more. It is time that this country considers the processing of minerals before exporting them.

There are several reasons why the potential of local minerals has not been fully exploited. Inability to find the capital, non-availability of technology in the past, low level of entrepreneurship and a hostile international climate may have been some of them. Political and social pressures too may have inhibited effective policy adaptation. The international market for some of the mineral commodities too has gone through a difficult period in recent years because of a slowing down in the rate of economic growth in some of the industrialized countries. The need for foreign investment to supplement local capital resources, technology and access to export markets has now been recognized. The recent tendency of international mining companies to strengthen their investment and exploration efforts in industrialized countries at the expense of their activities in developing countries has nothing to do with the natural potential for mineral resources in developing countries. It is largely based on political, fiscal and economic considerations. To counteract this tendency it is necessary to strengthen mutual trust and stability and to create conditions which attract foreign investment and investors who will bring in the technical expertise and technology.

Some of the Sri Lankan industries are faced with marketing difficulties because of the competition from imported products. A classic example of this situation is the closure of stage II of the Ceylon Steel Corporation project where an electric arc furnace worth over Rs. 180 million was left idling.

Stage II which was commissioned in mid 1982 had to be shut down in 1983 being unable to compete with imported products. Since early 1984 Stage II has been back in operation, however, and its future remains bleak unless remedial action is taken. Considering the advantages flowing from such enterprises through the use of indigenous raw materials, generating of employment and savings of foreign exchange, a re-examination of the present tariff structure so as to ascertain the degree of protection that needs to be afforded to the local industry merits some consideration.

Another state venture that had to face similar competition is the Paranthan Chemicals Corporation which manufactures and sells caustic soda and chlorine, hydrochloric acid, zinc oxide, ferric chloride and table salt. Its production and sales were affected in 1982 as a result of the lower prices of imported finished products and substitute products. Imported caustic soda and chlorine were cheaper than the locally manufactured products and hydrochloric acid sales were affected as several customers switched to the use of imported sulphuric acid.

Local manufacturers generally prefer to use imported raw materials of superior quality unless the quality of the locally available raw material is acceptable to them. For example, although china clay is available in Sri Lanka, the quality of the mineral is not quite acceptable for industries such as paper and paint, owing to its low brightness. It may be possible to improve the brightness of local china clay by chemical or electrolytic treatment. There are a number of similar cases. The domestic market may not be adequate for profitable running of some industries. The alternative is to look to the international market. The quality of the finished products must be improved to be able to compete with products of other countries. Therefore, it is of utmost importance to encourage research and development work on local mineral resources. Appropriate research projects may be carried out at the universities and research institutes where scientific personnel and laboratory facilities are available. State corporations and prospective manufacturers who would be the ultimate beneficiaries of such work could provide funds for research projects. Similar action by the business community can ensure not only economic progress but also an eventual return on investment (Economic Review, April 1984).

IV. SELECTED BIBLIOGRAPHY

1. Adams R., 1984. Titanium and titanium dioxide. Financial Times Information Ltd., London, 244 p.

2. Becker J., 1983. Investigations for uranium in Sri Lanka, RMRDP Report No. 187, Bandung, Indonesia.

3. British Geological Survey, 1986. World mineral statistics 1980-1984: production, exports, imports. (Keyworth, Norttinghamshire).

4. Chin E. and others, 1986. Sri Lanka. In Minerals yearbook, 1984, Vol. III, Area reports: international. United States Bureau of Mines, p. 1033-6.

5. Clark G., 1983. Sri Lanka's industrial minerals – much potential to be realized. Industrial minerals, No. 193, p. 61-71.

6. Dahanayake K. and Jayawardana S.K., 1979. Study of red and brown earth deposits of northwest Sri Lanka. Geological Society of India, Journal, Vol. 20, p. 433-440.

7. Fantel R.J., Buckingham D.A. and Sullivan D.E., 1986. Titanium mineral availability – market economy countries. A minerals availability appraisal, United States Bureau of Mines, Information circular 9061, 48 p.

8. Gunawardene R.P. and Tennekoon D.T.B. Production of Phosphate from Eppawala Apatite-chemical aspects. In: "Karmantha" Vol. 3, No. 1976, p. 12.

9. Herath J.W., Mineral Resources of Sri Lanka. Economic Bulletin No. 2, Geological Survey Department, 1980.

10. Herath, M.M.J.W., 1977. Mineral based industries of Sri Lanka. Commonwealth Committee on Mineral Resources and Geology liaison report CGLO LR 131, p. 24-26.

11. Kanapathipillai K.C., 1964. Ilmenite from the east coast of Ceylon. Mining magazine, April, p. 239-41.

12. Kim S.Y., 1981. Geological/geochemical assessment of iron-copper deposits and uranium resources in Sri Lanka. RMRDP Report No. 157, Bandung, Indonesia.

13. Lynd L.E. and Leford S.J., 1975. Titanium minerals. In Lefond S.J. (ed.), Industrial mineral and rocks, 4th edition. American Institute of Mining, Metallurgical and Petroleum Engineers, Inc. p. 1303-3362.

14. Marasinghe B. Economic minerals and related industries in Sri Lanka, Economic Review, April 1984.

15. Meyer K., 1983. Titanium and zircon placer prospection off Pulmoddai, Sri Lanka. Marine mining, Vol. 4 (2/3), p. 139-166.

16. Review of Activities, 1982. Ministry of Industries and Scientific Affairs.

17. Siddiquie H.N. and others, 1984. Superficial mineral resources of the Indian Ocean. In Martin, V. (ed.), Marine science of the northwest Indian Ocean and adjacent waters. Deep sea research.

18. Sri Lanka's Graphite Industry. In: Economic Review, Vol. 6, No. 6. July 1980, p. 3. A People's Bank Publication.

19. Sri Lanka's Gem Industry. In: Economic Review, Vol. 3, No. 6. September 1977, p. 3A. A People's Bank Publication.

20. Tillekeratne L.S.G. Manufacture of Dolomite Powder. In: "Karmantha" Vol. 1, No. 8. August 1975, p. 8.

21. Wickrema K.H.S. Minerals of Sri Lanka and related Industries. In: "Karmantha" Vol. 1, No. 8. August 1975, p. 19.

كيفية الحصول على منشورات الامم المتحدة

يمكن الحصول على منشورات الامم المتحدة من المكتبات ودور التوزيع في جميع انحاء العالم ٠ استعلم عنها من المكتبة التي تتعامل معها أو اكتب الى : الامم المتحدة ،قسم البيع في نيويورك او في جنيف ٠

如何购取联合国出版物

联合国出版物在全世界各地的书店和经售处均有发售。请向书店询问或写信到纽约或日内瓦的联合国销售组。

HOW TO OBTAIN UNITED NATIONS PUBLICATIONS

United Nations publications may be obtained from bookstores and distributors throughout the world. Consult your bookstore or write to: United Nations, Sales Section, New York or Geneva.

COMMENT SE PROCURER LES PUBLICATIONS DES NATIONS UNIES

Les publications des Nations Unies sont en vente dans les librairies et les agences dépositaires du monde entier. Informez-vous auprès de votre libraire ou adressez-vous à : Nations Unies, Section des ventes, New York ou Genève.

КАК ПОЛУЧИТЬ ИЗДАНИЯ ОРГАНИЗАЦИИ ОБЪЕДИНЕННЫХ НАЦИЙ

Издания Организации Объединенных Наций можно купить в книжных магазинах и агентствах во всех районах мира. Наводите справки об изданиях в вашем книжном магазине или пишите по адресу: Организация Объединенных Наций, Секция по продаже изданий, Нью-Йорк или Женева.

COMO CONSEGUIR PUBLICACIONES DE LAS NACIONES UNIDAS

Las publicaciones de las Naciones Unidas estan en venta en librerías y casas distribuidoras en todas partes del mundo. Consulte a su librero o diríjase a: Naciones Unidas, Sección de Ventas, Nueva York o Ginebra.

Printed in Bangkok
(2,750 copies)

01200

United Nations Publication
Sales No. E.89.II.F.14
ST/ESCAP/718
ISBN 92-1-119541-1
ISSN 1014-5451