

MINERAL RESOURCES OF SRI LANKA

Introduction:

There are thousands of mineral species in the earth but only a few are of any use to man. These are known as economic minerals and they can be classified as energy minerals, metals and industrial minerals and rocks (see Table 1).

Table 1: Classification of Economic Minerals

<u>Class</u>	<u>Minerals</u>
Energy Minerals	Peat, Coal, Oil, Radioactive Minerals
<u>Minerals:</u> Ferrous	Iron
Non-Ferrous	Copper, Lead, Zinc, Aluminium, Tin
Industrial Minerals	Mineral Sands Ceramic Materials Fertilizer Minerals Construction Materials Graphite, Mica, Gemstones

Although Sri Lanka is a comparatively small country, it possesses a large variety of minerals, chiefly of the class known as the 'industrial minerals'. They include the mineral sands (e.g. ilmenite, rutile, zircon), graphite, mica and gemstones, which form the bulk of the exports; and ceramic and refractory raw materials (e.g., kaolin and other clays), constructional materials (limestone and clay for cement), and fertilizer minerals (dolomitic marble and apatite). These latter minerals are the raw materials for growing industries such as the manufacture of ceramic ware, pottery, bricks, tiles, glassware, cement, fertilizers, insecticides, agrochemicals and other products.

Unfortunately, the island is lacking in locally utilizable energy minerals like coal and oil, though exploration for the latter is proceeding. The only metal known to occur in the island in commercially exploitable quantities is iron (magnetite and hematite), and the presence of copper has recently been proved.

Mineral production is an important sector of the economy not only as an earner of foreign exchange through exports and a source of raw materials for industry but also as a major employer of skilled and semi-skilled labour.

Table 2 shows the amount and value of mineral production in 1982, and Table 3 shows mineral production in 1988.

Table 2: Mineral Production in 1982

<u>Commodity</u>	<u>Quantity</u> (Long tons)	<u>Value</u> (SL Rupees)	<u>Producer</u>
Ilmenite	68,262	27,224,000	Mineral Sands Corporation
Rutile	7,212	41,610,000	- do -
Zircon	5,789	11,578,000	- do -
Monazite	304	409,000	- do -
*Garnet	2	4,000	Geological Survey Dept
*Silica Sand	500	125,000	Private-Public Sector
*Quartz	2,000	500,000	Ceramics, LWL, LPL, Private
Apatite	13,993	10,627,972	SMDDC
Limestone	1,615,901	59,580,514	Cement Corp.
*Dolomite	15,000	2,250,000	Private-Public
Salt (common)	176,437	74,103,540	Salt Corp.
Mica	291	1,435,524	SMMDC
Graphite	8,803	61,843,998	SMMDC
Felspar	2,923	906,000	Ceramics Corp.
Clay (cement)	62,591	1,741,202	Cement Corp.
Kaolin	8,206	13,000,000	Ceramics Corp.
Ball Clay (raw)	8,554	1,539,000	- do -
Ball Clay (refined)	737	734,000	- do -
*Brick-Tile Clay	1,820,000	54,600,000	Cottage Indus.
*Brick-Tile Clay	378,000	12,040,000	Public-Private
Gems	-----	400,000,000	State Gem Corp
*Stone	2,000,000	200,000,000	Private-Public
*Sand(river)	3,000,000	120,000,000	- do -

* Accurate figures not available (estimated)

Total value of mineral commodities Rs.1,102,577,750 (comparative figures for 1978 and 1973 are Rs.700 million and Rs. 250 million respectively).

Table 3: Mineral Production in Sri Lanka 1987, 1988

		<u>1988 Metric</u> <u>Tons</u>	<u>1987</u>
Mineral Sands	Ilmenite	97085	175000
	Rutile	13759	9000
	Zircon	n.a	2500
	Monazite	n.a	100
Ceramic Materials	Kaolin	7097	6769
	Ball Clay	17200	n.a.
	*Building Clay	n.a	n.a.
	Feldspar	7278	7442
	Quartz	12578	5813
	Quartz Sand	n.a	n.a.
Construction Material	Limestone	735818	564625
	Shell & Coral	3325	7116
	Clay	n.a	23225
	Granite	76	334
Fertilizer Materials	Dolomite	n.a	n.a
	Apatite	23104	31305
Other	Graphite	6394	6718
	Mica	1981	1228
	Gemstones		

n.a. not available *brick-and-tile clay

ENERGY MINERALS :

Peat :

Nearly 50 million tons of peat are known to occur at Muthurajawela in an area of about 13 square miles, just north of Colombo. The peat forms a bed with an average thickness of 12 to 15 feet and a maximum thickness of 20 feet. The deposit is badly drained, the normal water level in the greater part of the swamp being about 6 inches to one foot above the surface, except during the dry season when it is about surface level. The exploitation of this peat deposit as a source of fuel and as a basis for nitrogenous fertilizer industry will first require a scheme of mining, de-watering and drying.

Geology of the area around Muthurajawela

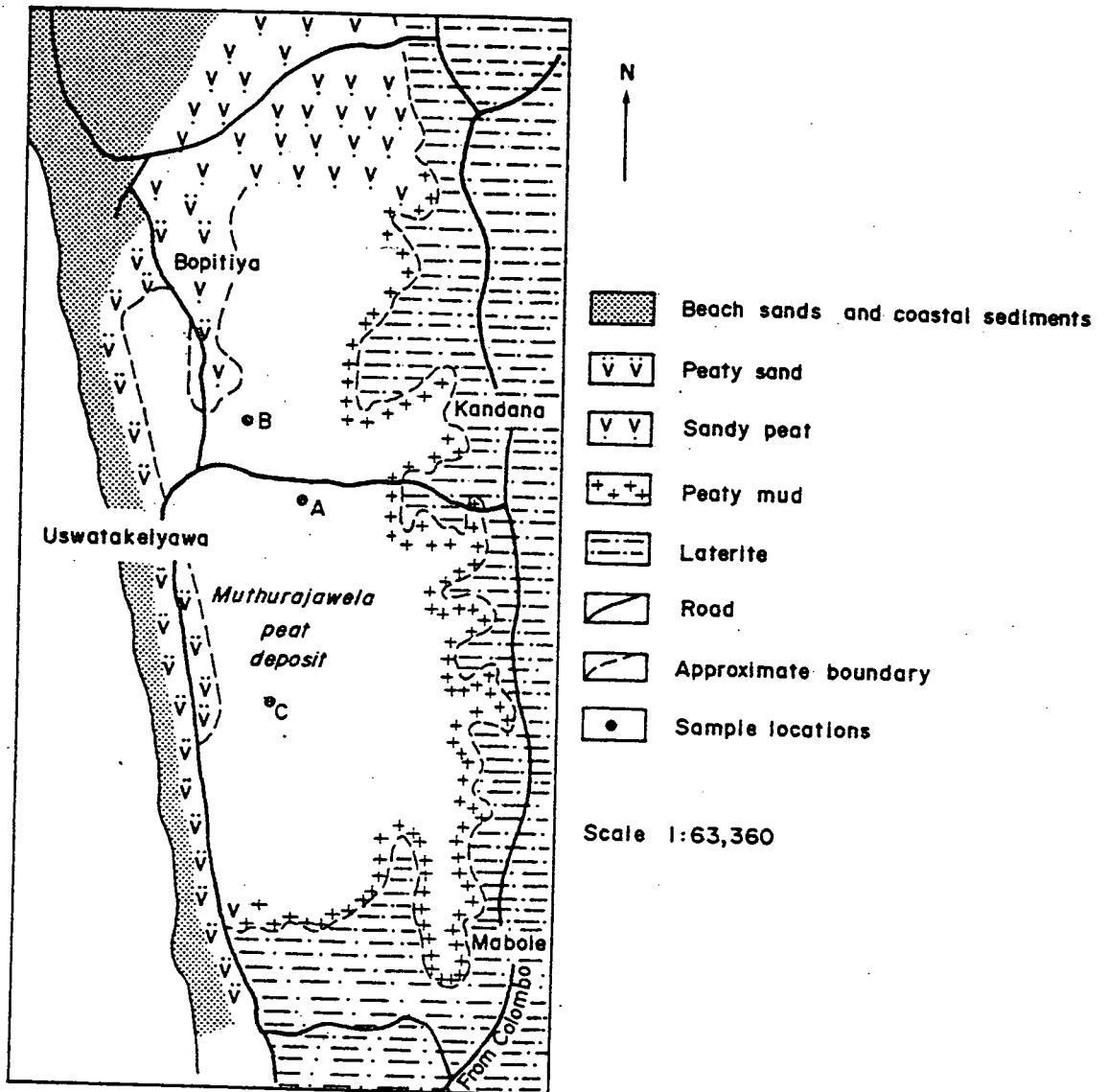


Fig. 1. Location and geology of the Muthurajawela peat deposit of Sri Lanka. A, B and C denote the locations of the bore-holes.

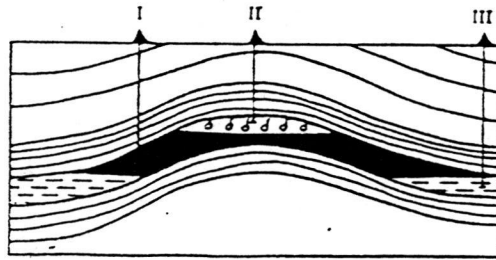
Oil

Exploration for oil in the north-west of Sri Lanka has been going on since 1973. Based on their geophysical work in Palk Bay and the Gulf of Mannar, the Soviet firm Techno-import drilled three stratigraphic wells on Mannar island. Though the wells were abandoned, they yielded significant and encouraging results.

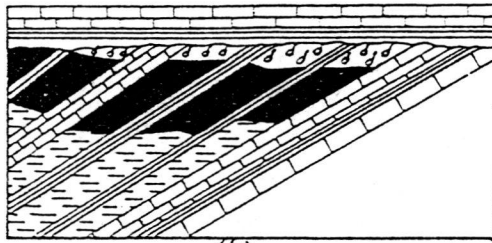
Fig.2. Oil Well

Structures favouring the accumulation of petroleum (oil) and natural gas:

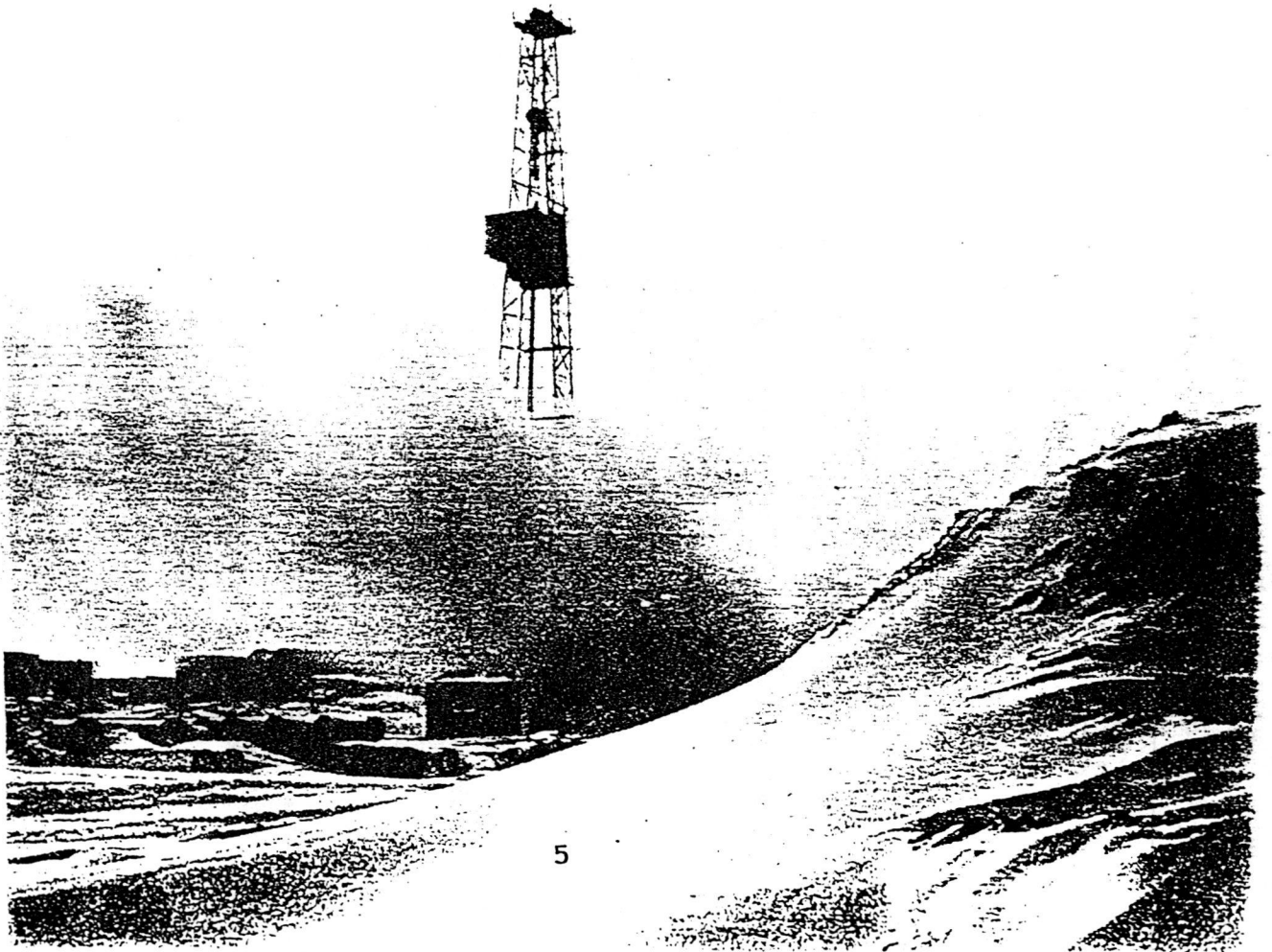
a — anticline; *b* — monocline; 1 — limestones; 2 — clays; 3 — oil; 4 — gas; 5 — water; I, II, III — boreholes



(a)



(b)



An offshore exploration licence was granted to Ceyoil Corporation in 1974, and further geophysical work was carried out, on the basis of which two offshore wells were drilled in the Palk Bay region in 1976 (Delft 1 and Palk Bay 1). Both wells were abandoned as dry. These wells showed the presence of a thick succession of clays, siltstones, sandstones and limestones the most favourable source rocks for hydrocarbons being in the Lower Cretaceous. In addition, seismic data suggested the presence of a structural favourable to the accumulation of oil and gas. The evidence so far available suggests that the hydrocarbons to be expected are likely to be gas rather than oil. This is because the source material is 'immature', it is also of the woody type, derived from terrestrial sources, which is more likely to yield gas on thermal maturation.

Radioactive and Rare-Earth Minerals :

The raw materials for nuclear energy are the radioactive minerals containing uranium and thorium. The chief of these are uraninite (U_3O_8) and thorianite (ThO_2), and a series of minerals containing mixtures of the two; the mineral uranothorianite, with about 50% of each, is midway in the series. The hydrated oxides of uraninite and thorianite, namely, gummite and thorogummite are also radioactive. The main radioactive minerals found in Sri Lanka are thorianite, thorite, monazite and allanite.

Thorianite was first discovered in Sri Lanka in 1904 -05. Several tons of thorianite were exported between 1905 and 1906, when the saleable value was £ 1,700 per ton. At that time the thoria content of the mineral was used only for the manufacture of incandescent gas mantles; no other use was then known for thoria.

Thorianite occurs as heavy, black, cubic crystals with a density of 9; it is thus the heaviest known mineral in the island. Owing to this high density and hardness the crystals remain close to their source after being released from their parent rocks by weathering; they also largely retain their cubic shape.

Thorianite occurs widely as a heavy mineral in the stream beds of the Bambarabotuwa and Mitipola areas, and decomposed thorianite-bearing pegmatites have been found in the Bambarabotuwa and Maddegama areas. Thorianite from Sri Lanka generally has 70-80% ThO_2 and 12-30% U_3O_8 .

Thorite ($ThSiO_4$), the silicate of thorium, is a brown, flattish mineral, quite unlike thorianite, with about 50-70% ThO_2 . It is also present in river and gem gravels in the south-west of the island, and has been located in some pegmatites in the Avissawella, Ratnapura, Balangoda, Welimada and Matale areas. Thorite in these pegmatites is generally associated with smoky quartz. Uranothorianite, with 48-54% ThO and 36-40% U_3O_8 , has been found in the stream gravels of Mitipola.

Monazite, with 9-10% ThO_2 , is the other major radioactive mineral in Sri Lanka besides thorianite. Apart from occurring as a beach concentrate at Induruwa, it is present as an accessory mineral in many of the gneisses and granitic rocks of the south-western, north-western and central parts of the country, (e.g. Kamburupitiya, Matara District), and in weathered pegmatites (e.g. Nuwara Eliya, Nugatenne near Teldeniya, and Denegama in Balangoda).

Allanite, with about 2% ThO_2 and 15-20% rare-earth elements is a brownish, liver-coloured mineral with a sub-metallic lustre. It occurs in large charnockitic pegmatites (e.g. at Alutepola near Negombo, and at Godagala near Beruwela), in the zircon granite at Balangoda, in some graphite-bearing veins, and in many gneisses. The presence of allanite is generally indicated by a reddish stained reaction rim around the mineral, caused by the radioactive bombardment of the host rock.

METALS

Iron

The presence of slag heaps in many parts of the island such as the Kandyan districts, Balangoda, Rakwana and Bingiriya shows that a small-scale iron-smelting and steel making industry existed almost all over Sri Lanka in the time of the ancient Sinhalese kings, dying out completely only at the beginning of the present century. The ore was smelted in furnaces with bellows blown by foot, and the iron so produced was used largely for the manufacture of spear heads, swords and other implements. Examples of round clay tubes of moulds (kova) as well as their casts (ware karal) can still be picked up at these old sites of smelting in various parts of the country. The industry was clearly based on locally available ores which occur on the surface in several million tons.

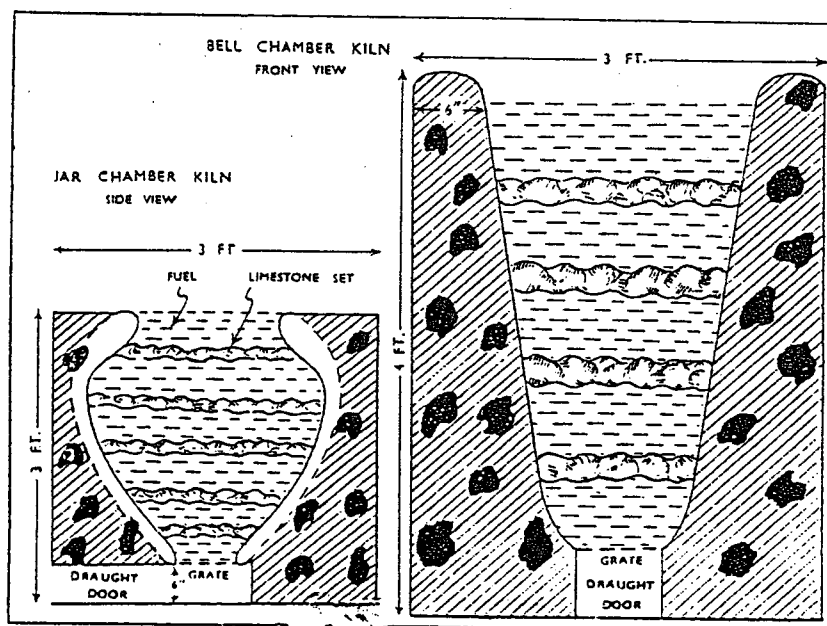


Fig 3. Diagrammatic Vertical Sections of
Typical Lime Kins

The island's iron ore resources fall into two broad categories, namely :

- (i) Deposits of hydrated iron oxides occurring at or near the surface, and
- (ii) Deposits of magnetite in iron-bearing formations within the crystalline complex.

Surface deposits consist of either a massive ore of hematite or a spongy aggregate of hydrate ores such as limonite and goethite; the latter, which resemble laterite in appearance, are porous, non-crystalline, and comparatively soft. These iron ores occur as surface cappings or as lenses, pockets and irregular masses extending a few feet below the surface, generally occurring as large blocks and boulders on the crests of hills or on hill slopes. They appear to be the residual products of the weathering of the underlying rocks, particularly those with an abundance of iron-rich minerals like garnet. The higher grade, massive, hematitic ores have an average metallic content of 50 per cent Fe and the lower grade lateritic ores have from 30 to 40 per cent Fe.

The most important areas in which the hydrate iron ores are found are mainly in the south-western portion of the island, in belts running practically parallel with the regional strike of the rocks. They are found chiefly in the Ratnapura, Balangoda and Kalawana areas of the Sabaragamuwa Province. The most important deposits occur at Dela, Noragalla, Oyata, Poronuwa and Wilpita. A total of 2 to 3 million tons of surface ore are easily accessible both by road and railway in these localities, and they can be mined with ease by open-cast methods not involving underground mining.

The Panirendawa deposit consisting of four closely related deposits is situated 5 miles north-east of Madampe in the North-Western Province of Sri Lanka. The deposits are directly accessible from the Madampe - Bingiriya road. Except for a few bands of quartzites, the bedrock is everywhere concealed by a mantle of lateritic over-burden. Rock types in the surrounding areas quartzites, biotite gneisses, migmatites and granite gneisses. The first systematic exploration of the area (geophysical work) commenced in 1962 as part of the general ground follow-up work of aeromagnetic anomalies of the south-west sector of the Island. Twenty five drill holes were also bored with a total footage of 2939 meters.

The occurrence of a copper-magnetite ore at Seruwila, near Trincomalee, was discovered in 1971. Preliminary investigations show that magnetite and the copper minerals chalcocopyrite, bornite, malachite and azurite occur in a zone of basic rocks at the junction between charnockitic gneisses. The ore is in the form of lenticular pods arranged along the regional strike (NE-SW) and is spread over an area of 10.4 sq km. Detailed investigation of this ore was completed in 1981. Drill-core samples showed copper values of 0.1 to 3.0%.

Gold

Extremely minute quantities of gold are widely distributed in the rocks of Sri Lanka, but nowhere does this precious metal occur in sufficient concentrations to be worked profitably. Small amounts of gold dust have been found in the alluvium and gravels of several rivers, as for example the Maha Oya near Ambepussa, the Kelani Ganga at Malwana, the Katugasella near Ratnapura, the We Ganga and the Weralupe Dola. Gold in bright yellow flakes up to 0.5g in weight occurs in the gem beds of the south-eastern part of the Ratnapura sheet. It is often associated with pyrite crystals. It is also sometimes found in decomposed bed-rock below the alluvium but is here even less concentrated than in the alluvium. In spite of systematic surveys for gold from time to time, such as those in 1092-03, 1909 and 1943-46, no workable placer deposit have yet been found in the island.

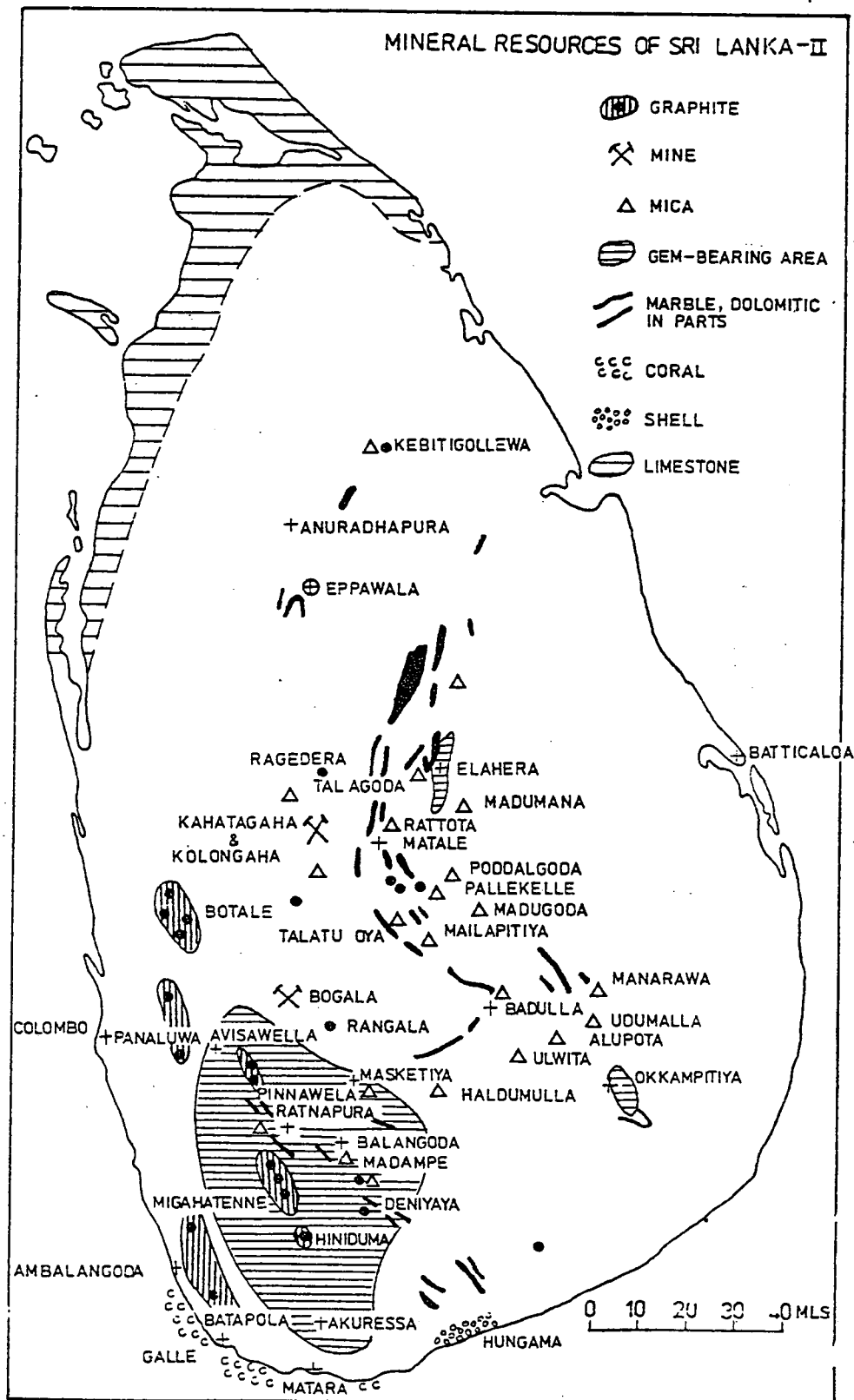


Fig. 4. Map of Mineral Resources of Sri Lanka:
 II — Construction Materials, Fertilizer Minerals, Graphite, Mica, Gemstones.

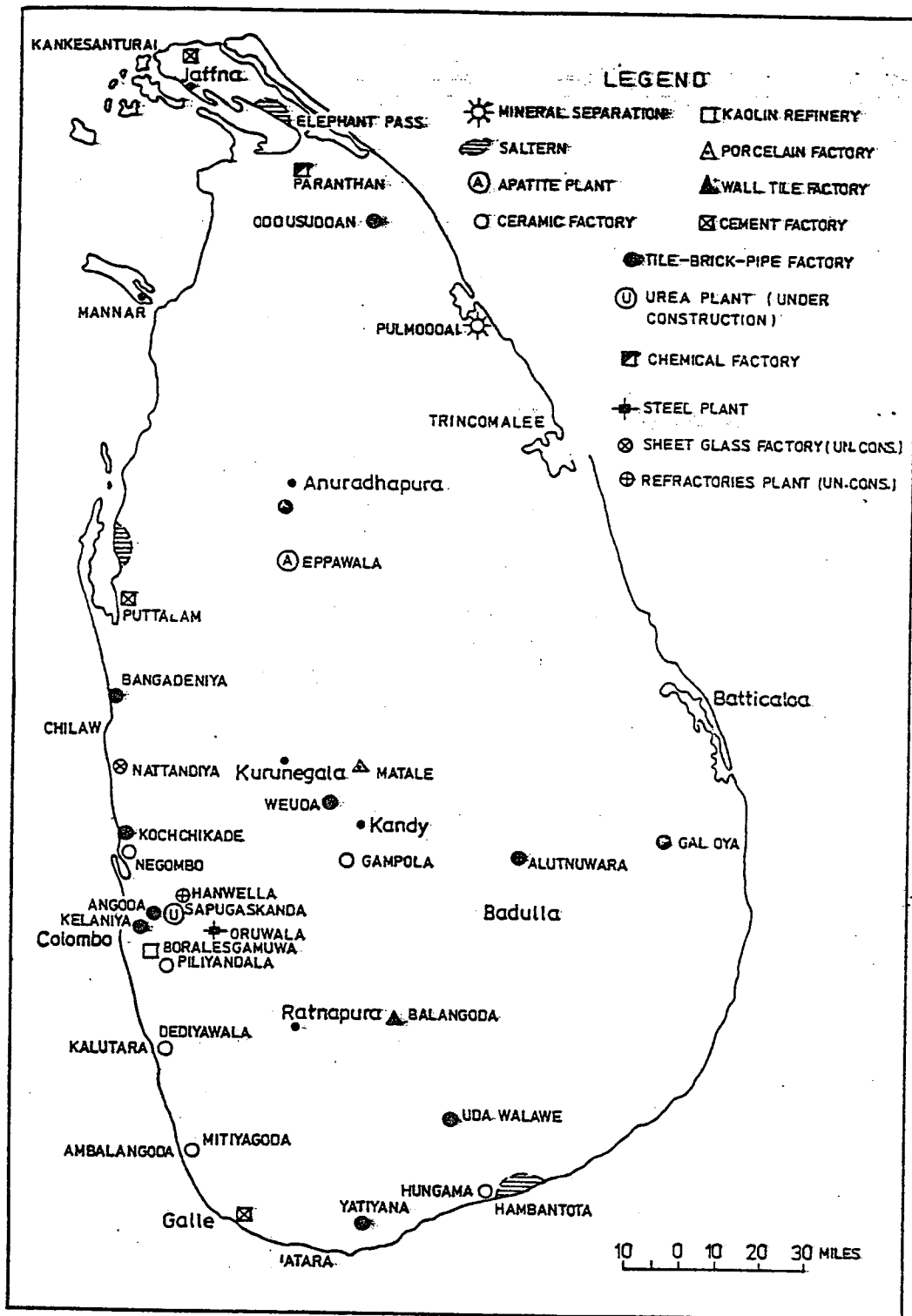


Fig. 5.- 1), Locations of factories using local mineral raw materials. (After Herath, 1977).

INDUSTRIAL MINERALS :

Mineral Sands

Scattered around the coastline of Sri Lanka, near the mouths of rivers, in isolated bays and on raised beaches are large placer deposits of heavy mineral sands totalling several million tons and containing a high proportion of ilmenite, rutile, zircon, monazite and garnet. These heavy minerals (with densities over 4.0 and a high degree of hardness) are constituents of the crystalline rocks of the island; they have been released by weathering and carried down to the sea by rivers and streams where they were probably deposited in old lagoons and beaches which existed when the shoreline was further inland than at present (and possibly in existing off-shore regions). Such appears to be the process of concentration of monazite sands along the west coast, at Kaikawala and Polkotowa, near Induruwa.

At Pulmoddai on the north-east coast, the heavy minerals are scoured out from Kokkilai lagoon during heavy rains and subsequently concentrated on the beach during wave action. Mineral sand concentrations also occur at Tirukkivil (south-east coast) and at Kudremalai Point (on the north-western coast).

Ilmenite, Rutile and Zircon

Ilmenite, a black oxide of iron and titanium (2FeTiO_3), is a very common accessory mineral in the crystalline rocks of the island, and is the predominant mineral in the 'black sands' so common around the coast. It can be seen almost anywhere, as for example on the beach at Galle Face, Colombo, where it occurs in streaks and pockets as a result of wave action, and on many footpaths and tracks in the interior of the country, where it is concentrated by rain water.

The most important deposit of ilmenite is found at Pulmoddai on the north-east coast, 34 miles north of Trincomalee. Where it forms the present beach down to low-water mark for a stretch of about 4 miles, between Arisimalai headland and the mouth of Kokkilai lagoon. The amount of raw sand present at Pulmoddai is estimated at 4 million tons. The beach sand is made up of 75-80 per cent ilmenite, 8-12 per cent rutile, 8-10 per cent zircon, 2-3 per cent magnetite, and significant amounts of monazite, together with small proportions of garnet, hypersthene and quartz.

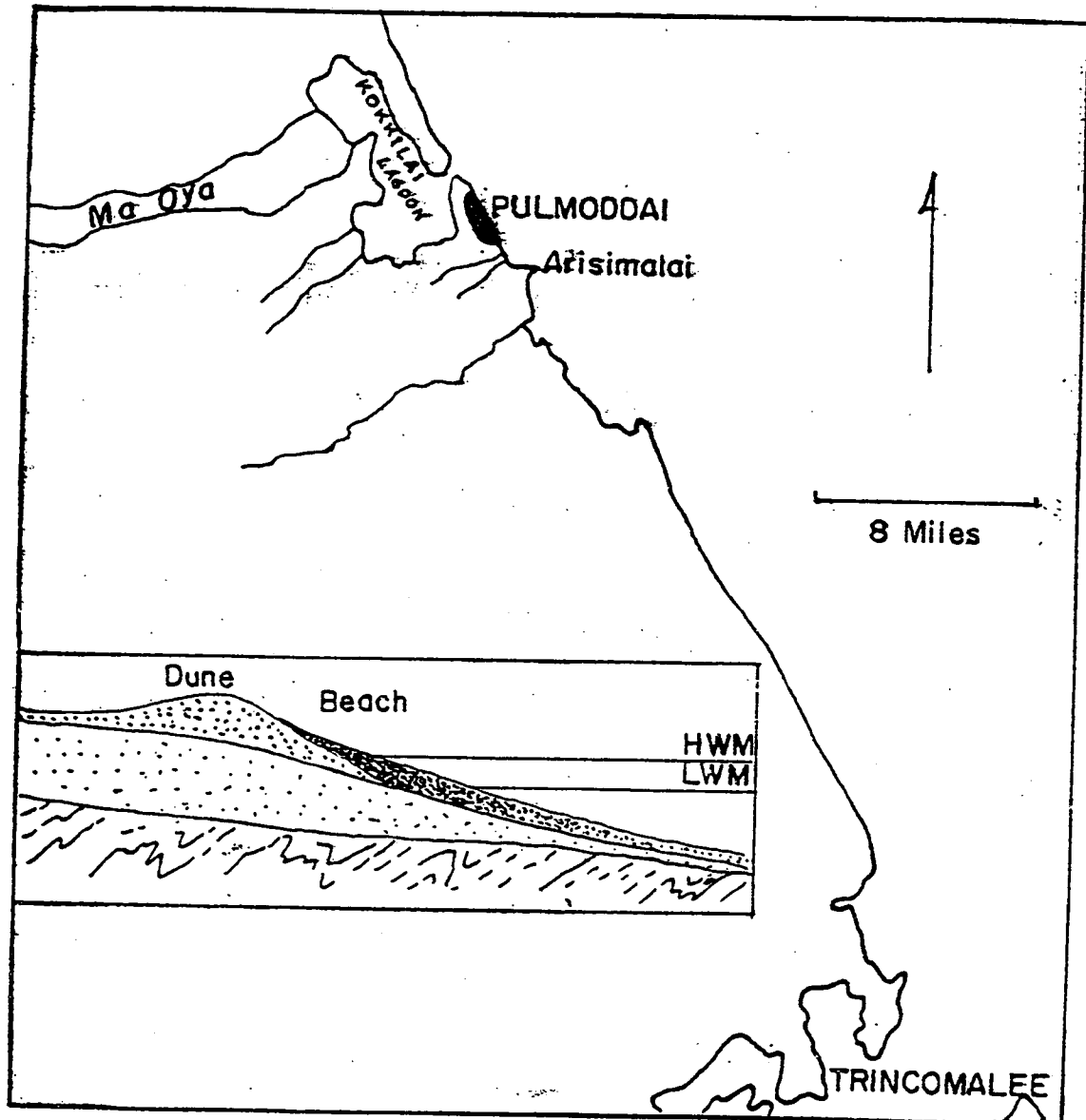


Fig. 6. Sketch map of ilmenite deposits at Pulmoddai. Inset: Diagrammatic section showing occurrence of ilmenite in beach and dune sands.

Ilmenite is the main source of titanium dioxide (TiO_2) which is used in the manufacture of high-grade white paint, but in recent years the metal titanium has increased in importance, particularly in the aircraft industry, owing to its lightness and resistance to corrosion. Rutile is in increasing demand as a source of titanium. Zircon ($ZrSiO_4$) with about 65 per cent zirconium oxide occurs as an accessory mineral in most of the crystalline rocks of the island, as a major mineral in some granites and pegmatites (for example the Balangoda Granite on Massena Estate), in many river gravels and gem gravels, and as a constituent of beach sands on both sides of the island. Its chief use is as a source of metal zirconium; other uses are for foundry bricks and in the ceramic industry as pigment and glazes.

Monazite

Golden yellow monazite is a phosphate of the rare earths cerium, yttrium and lanthanum, (about 60 per cent) and it also contains a fair proportion of radioactive thorium oxide. For this reason it is now a potential nuclear raw material and has strategic importance; its main use earlier was for the manufacture of incandescent gas mantles.

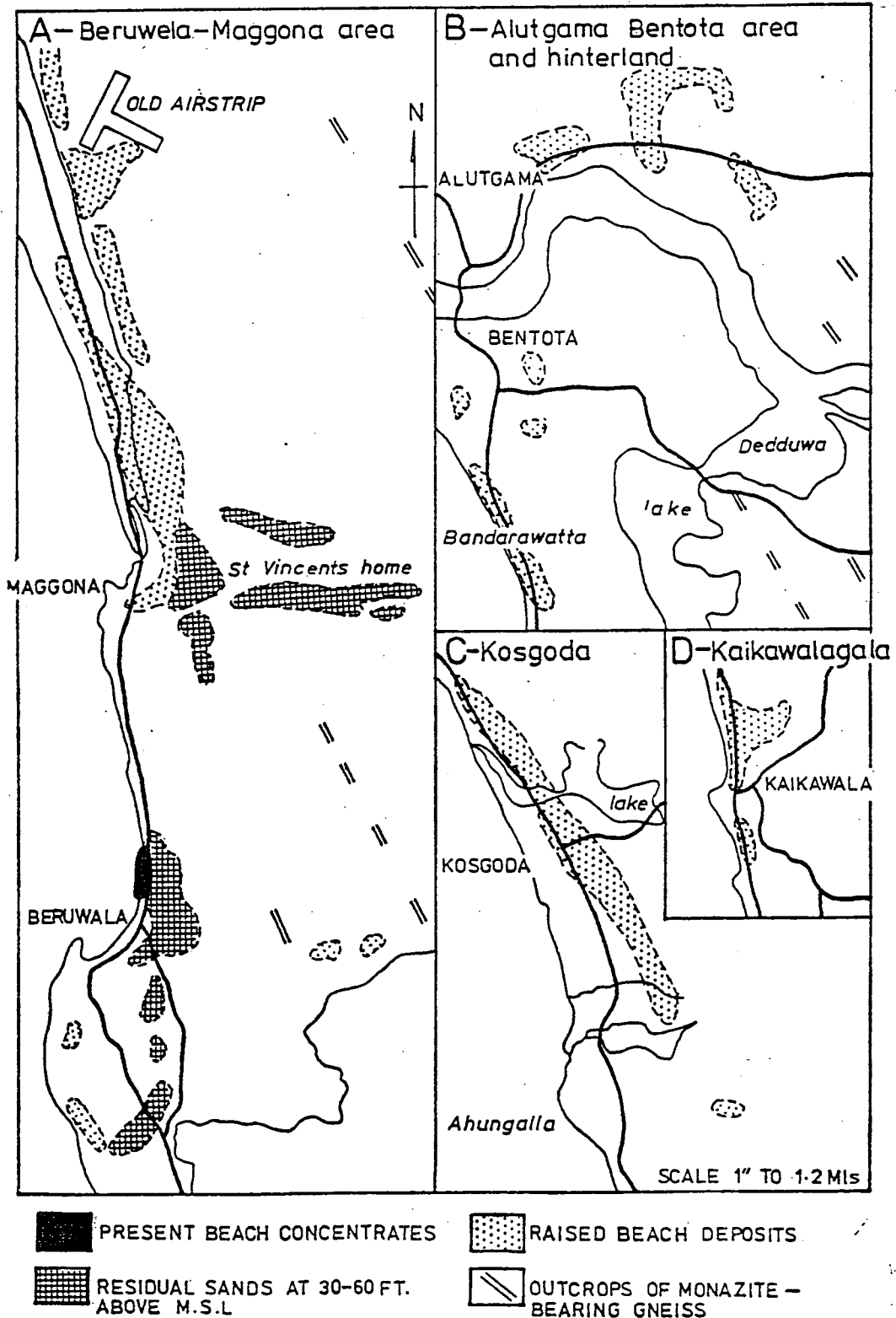


Fig. 7. Types of occurrence and distribution of monazite in the Alutgama area (After Searle, 1962).

The main concentrates of monazite are located at Beruwela, Kaikawala and Kudremalai on the west coast and it has also been proved to be a recoverable constituent of the Pulmoddai beach sand deposit. The monazite content of these sands varies considerably from one point to another and from day to day, rich localized patches with about 15 per cent or more monazite lying next to patches with only 3 per cent of the mineral. Like ilmenite on the west coast, monazite is concentrated in lenses, streaks, and pockets during the months of the south-west monsoon. In the Alutgama area in the south-west of the island monazite concentrates are also seen in stream and river gravels, in high-level river-terraces up to 60 ft. above MSL, and in raised beaches and barrier bars.

Monazite from Sri Lanka has an average thoria (ThO_2) content of about 10 per cent. The monazite-rich deposits of the south-west also contain ilmenite, zircon (4 to 5 per cent), rutile, garnet, tourmaline, and thorianite.

Garnet

Garnet is a pink to reddish mineral which occurs widely in the crystalline rocks of the island. It is concentrated in varying proportions in the beach and dune sands around the coast, and increases in proportion towards the south, reaching its greatest concentrations in the beach sands of Dondra (9 to 24%) and the dune sands of Hambantota (20%). Garnet is valued as a gemstone and as an abrasive material. Commercial production of garnet began in 1978.

Ceramic and Refractory Raw Materials

The term ceramic, originally meaning 'earthen', now embraces a wide variety of products made from clay, the main ceramic raw material, as well as from materials containing little or no clay, such as silica, which require high temperatures for their manufacture. Refractory materials are those possessing a remarkable resistance to heat.

Industrial Clays

Sri Lanka is comparatively rich in industrial clays of various kinds. The clay deposits are extensive and occur either as residual clays (by deep weathering of crystalline rocks) or as transported sedimentary clays in the flood plains of the major river valleys, in old river channels (owitas), and in the beds of lakes or artificial irrigation tanks.

Clays are extremely variable in their properties, depending on their mineral composition, the chief clay minerals being kaolinite, montmorillonite and gibbsite. Kaolinitic clays are

the least plastic and most refractory; montmorillonite clays are the most plastic and least refractory; the hydrous mica clays are of intermediate plasticity and low refractoriness.

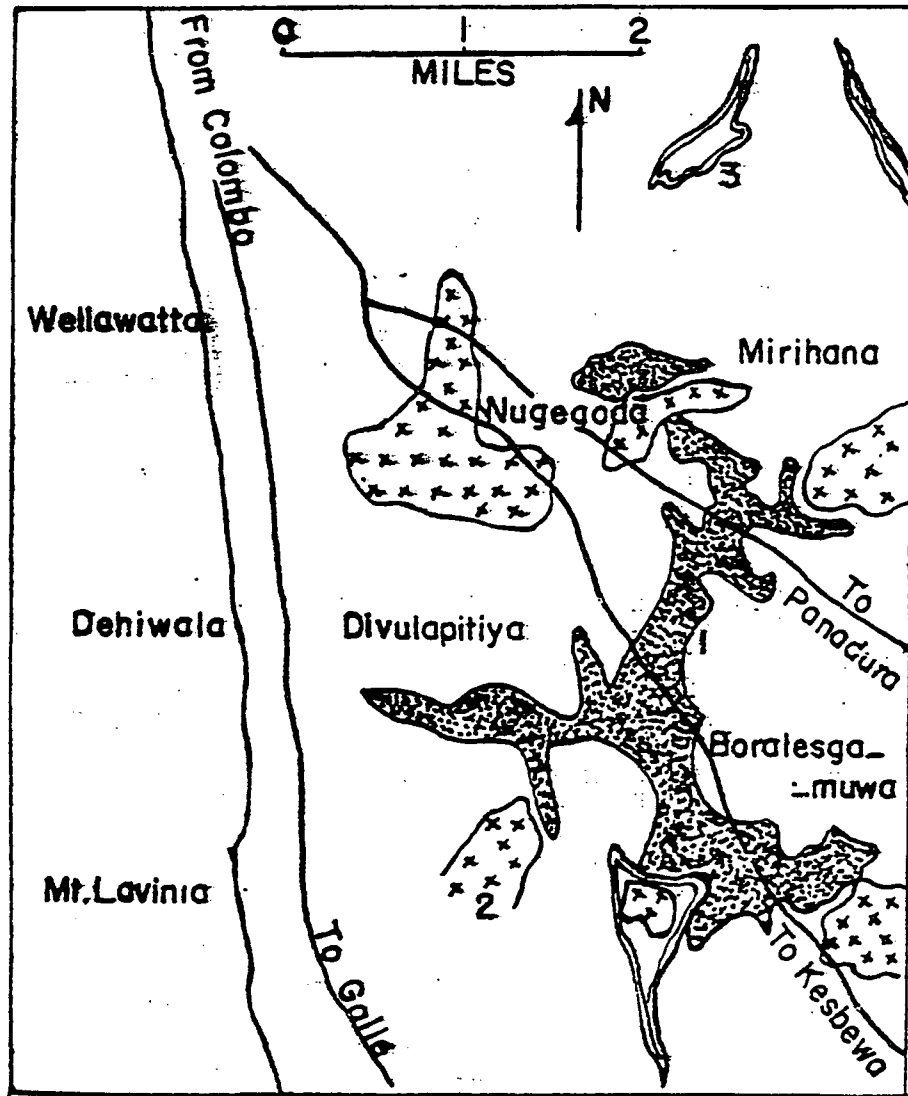


Fig. 8. Sketch map of the kaolin deposit at Boralessgamuwa.
(After J. W. Herath, 1963)

The most important types of industrial clay, all of which are found in Sri Lanka, are china clay or kaolin, building clay (or brick-and-tile clay), ball clay, and fireclay.

Kaolin

Kaolin is the name given to pure white clays composed mainly of kaolinite. It is the final product in the weathering of feldspars in granites, pegmatites and feldspar-rich gneisses. Apart from its high refractoriness, kaolin has the additional important property of turning pure white in colour when fired. The uses of kaolin are numerous, among them being for the

manufacture of high-quality domestic pottery, electrical insulators, sanitary ware, refractory bricks and as a filler in textiles, paper, paints and powder.

The largest deposit of kaolin in Sri Lanka is found in the swampy ground between laterite hillocks around Boralesgamuwa, 9 miles south-east of Colombo.

It has been estimated that over 1 million metric tons of kaolin are present in the Boralesgamuwa deposit. A second refinery has been established at Meetiyyagoda, near Ambalangoda, where there is another large deposit of kaolin.

Building Clay

These are mostly coloured clays with a high proportion of iron minerals and a low refractoriness. They are used mainly for the manufacture of structural clay products such as bricks, tiles, stoneware and pipes, and for cement.

The manufacture of bricks and tiles used to be predominantly a seasonal, cottage industry concentrated in a few of the major river valleys. Today, this cottage industry is much more widespread and more flourishing, producing about 320 to 400 million bricks per year in addition to this, about 50 modern private factories, together with 10 Ceramic Corporation factories produce about 65 million unglazed tiles as well as earthenware pipes and floor tiles.

Ball Clay

Ball clays are sedimentary plastic clays, usually dark in colour but burning to a white or cream body. They are tougher and more plastic than kaolin, have better bonding power and are less refractory. Ball clays are used mainly for china and fine earthenware, and as a bonding material for less plastic clays.

Feldspar

Potassium feldspar (microcline) occurs in pegmatites at various places in the island, as at Rattota, Talagoda, Kaikawela, Namaloya and Koslanda. The largest deposit is on Owella Estate (Kaikawela) where reserves of over 3 million metric tons have been estimated. The feldspar occurs to more than 600 feet below the surface. Feldspar deposits at Pussella (near Ratnapura) and in the Talagoda area have been worked for a number of years.

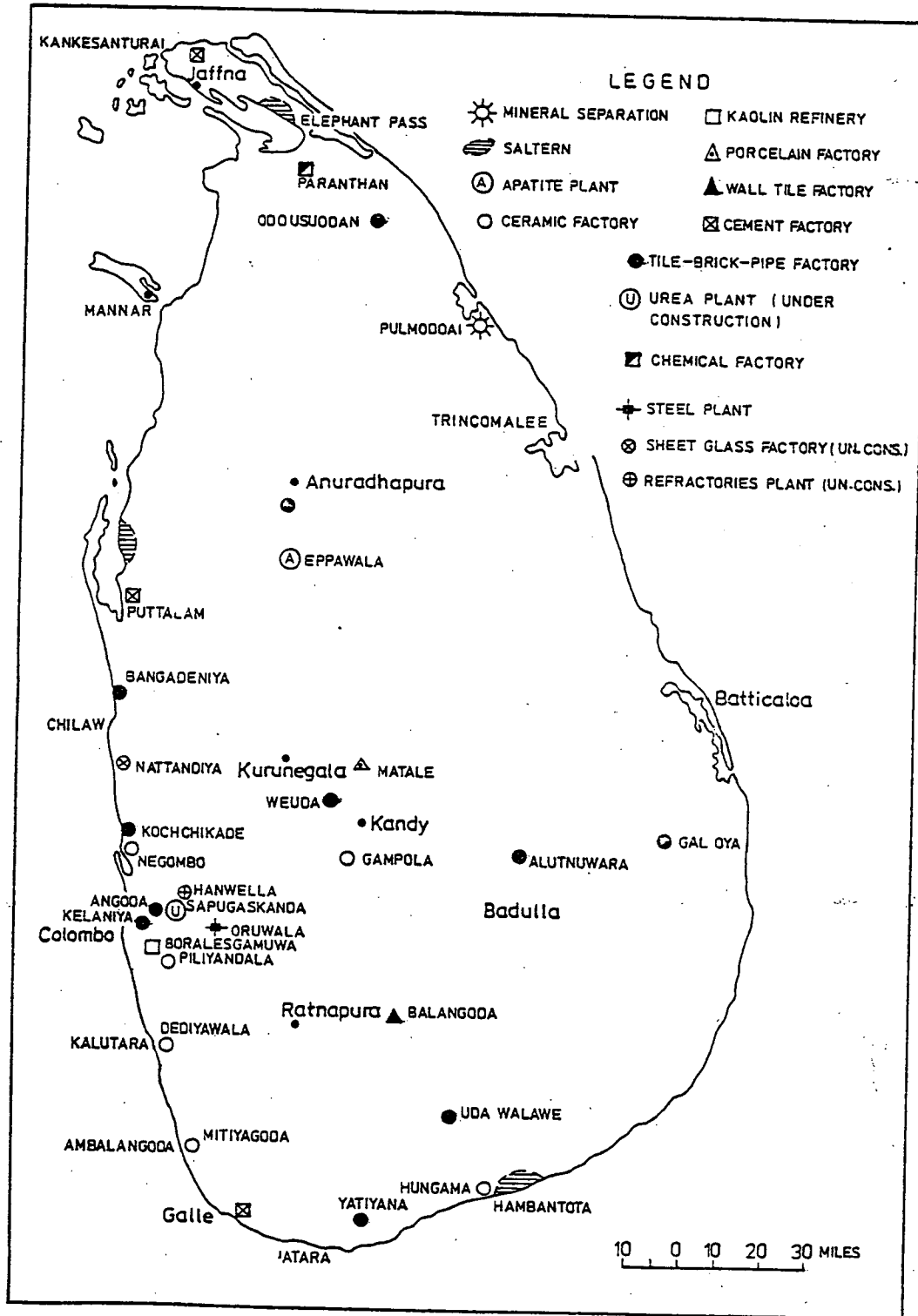


Fig. 9. Locations of factories using local mineral raw materials. (After Herath, 1977).

Quartz

Massive quartz of over 98.8% purity occurs in quartz veins in many localities, the best known being in the Opanaike, Pelmadulla, Pussella, Rattota and Ratnapura areas. The veins at Pussella have been worked for many years. The total reserves of vein quartz are not known.

Quartz sands

Deposits of pure quartz sand suitable for the manufacture of glassware are present in several parts of the island. The best known of these deposits are in the Nattandiya Marawila and Madampe areas north of Colombo, and in the Ampan-Vallipuram area in the Jaffna Peninsula.

The Nattandiya and Madampe deposits cover an area of about 1,500 acres with average thickness of 4 feet. The sands occur on the surface and there is no overburden.

The Ampan-Vallipuram deposits are very large and occur in the form of sand dunes on the east side of the Jaffna Peninsula.

The quartz sands at Nattandiya form the raw material for the manufacture of bottles and tumblers in the glass factory at Nattandiya. It is also proposed to establish a sheet glass factory at Dankotuwa, 10 miles along the Negombo, Nattandiya road.

Magnesite

A small deposit of crystalline magnesite (magnesium carbonate, $MgCO_3$) is associated with dolomitic marble at Randeniya, 4 miles north of Wellawaya. About 4,000 metric tons are known to occur here and this deposit is a potential source of raw material for the production of refractory bricks, cements and flooring.

Ceramic Industries

The most significant aspect of industrial development in Sri Lanka has probably been in the field of ceramic industries. The ceramic ware factories at Negombo and Piliyandala produce more

than 80,000 metric tons of ceramic ware a year (domestic crockery, sanitary ware, wall tiles, mosaic tiles, electroceramics and miscellaneous ornamental and fancy ware) and for many years have supplied the entire needs of the home market.

Fertilizer Materials

Apatite

A large deposit of apatite, a calcium phosphate mineral, was discovered at Eppawala in 1971. The ore body is a 'leached apatite-bearing zone' capping the carbonatite which extends from the surface to a depth of about 200 feet; fresh apatite-bearing rock extends downwards for a further 200 feet.

The average phosphate content of the leached zone is about 35% P_2O_5 .

The apatite, classes as a chlorine-rich fluorapatite, is present in a matrix of francolite (a white, secondary carbonate apatite), martite and goethite (Fe oxides), and rutile (TiO_2).

Phosphate rock, when finely ground, has only a limited use as a direct fertilizer, owing to its low solubility. It has, however, been found suitable for long-term crops like tea, rubber and coconut, and it is now being applied directly to the soil as a fertilizer. In order to be most effective, however, it should be converted to more soluble forms such as superphosphate, tricalcium phosphate, or fused magnesium phosphate.

Dolomite

Very large reserves of dolomite ($CaCO_3, MgCO_3$) occur in the island as dolomitic marbles, especially in the Ratnapura, Badulla, Kandy, Matale and Balangoda areas. Although dolomite is sometimes used for the manufacture of lime and in the ceramic and allied industries, its main use in Sri Lanka is as a fertilizer. For this purpose the rock is reduced to small aggregates and is mixed with other fertilizers, its function being to reduce magnesia deficiency in soils.

More dolomitic varieties of marble (i.e. those with a higher magnesia content) will be used for foundry bricks in the Iron-and-steel factory.

Constructional Materials

Limestone

The limestone resources of Sri Lanka are of three main types, namely, sedimentary limestone, coral and sea shells, and marble. The sedimentary limestone of the Jaffna Peninsula and the north-western coastal belt, owing to its accessibility, great extent and purity ($CaO-52\%$), is eminently suitable for the manufacture of cement.

A further deposit of over 18 million metric tons of limestone has been proved at Aruakaru 18 miles north of Puttalam. In the manufacture of cement, proper proportions of limestones and clay

are burnt to produce a 'clinker', which is then cooled and stored. The finished cement is made by grinding the clinker with a small amount of gypsum.

Coral limestone, though of relatively pure calcium carbonate and easily obtainable, does not occur in large enough quantities for the manufacture of cement. It is, however, extensively burnt for 'chemical lime' (quicklime and slaked lime), especially along the south-western coast between Ambalangoda and Matara. The coral is also transported to lime-kilns many miles inland, where no other source of calcium carbonate is available.

The Precambrian marbles are not suitable for the manufacture of cement owing to their impure nature, and to the fact that many are dolomitic (or magnesia-rich) in composition. When pure, however, the marbles are used for the manufacture of lime, as in the Kandy and Badulla areas.

Building Stones

Any rock, to be suitable for use as a building stone, must be both strong and durable. Most of the crystalline rocks of Sri Lanka and some of the sedimentary types are eminently suitable as building stones. Some rock types have been used extensively in the past, and many local stones are once again being increasingly used for building purposes.

The marbles, owing to their attractive appearance and easy working, were popular with the early builders and sculptors in Sri Lanka, especially in the ancient capitals of Anuradhapura and Polonnaruwa.

One of the most beautiful stones in Sri Lanka is a green serpentinous marble, at present known to occur in small quantities at Rupaha, near Nuwara Eliya. The Rupaha marble, used by the local villagers for making small ornaments, is in a very inaccessible spot. These green marbles, when polished, make excellent ornamental stones such as monuments and wall facings, but they are too soft to be used for flooring.

Dark grey charnockitic gneiss is a favourite building stone in the Central Hill Country where great quantities of it occur, and several of the small churches in this part of the country, for example those at Lindula, Norwood, and Madulkele, are built of this rock.

By far the commonest crystalline rocks used for building purposes are the granites and gneisses. In most of the ancient ruined cities of Sri Lanka large monolithic pillars, blocks and slabs of gneisses lie about in great abundance as a testimony to their popularity as building material. The statues of the Buddha at Dambulla and the Gal Vihare at Polonnaruwa are a few of those

that come readily to the mind. Large quantities of granite are now being quarried and exported as ornamental stones.

Apart from the crystalline rocks, only laterite and sedimentary limestone are of any importance as building stones. In the Jaffna Peninsula, nearly 15 per cent of the houses are built of Jaffna Limestone; in the south-west of the island kabook or laterite is the commonest building material, being readily available and cheaper than clay bricks.

GRAPHITE

The mining of graphite is one of the oldest mineral industries in Sri Lanka. At one time the country even enjoyed a virtual monopoly of the world market. Exports reached their peaks during the two World Wars, namely, 34,000 m.t. in 1916, and 28,000 m.t. in 1942, but in recent years it has averaged about 8,500 m.t. per year.

Graphite (or plumbago as it is commonly called) is pure crystalline carbon which occurs as minute, disseminated flakes in many of the crystalline rocks of the island, especially in the Highland series. The graphite-bearing veins vary from a few inches to 3 or 4 feet in width, but sometimes reaching up to 12 feet wide. They are variable in length, attitude and extension at depth.

Very few other minerals are associated with the graphite, and where gangue minerals such as quartz, calcite, pyrite and chalcopryrite are present, they occur in very small amounts.

The major deposits of graphite in Sri Lanka are found mainly in the south-western sector of the island, the three major mines being the Kahatagaha and Kolongaha mines near Kurunegala and the Bogala mine near Ruanwella.

The extraction of graphite is relatively simple. In the large mines the veins are worked underground along horizontal adits by blasting and pneumatic drilling or by hand picks, the lumps of more or less pure graphite being brought to the surface by trolley and electrically operated lifts. The graphite is classified into a number of grades for export purposes, depending on particle size (lump, chip or dust), carbon content (commonly over 99%) and structure (bright large lump, hard large lump, and slaty).

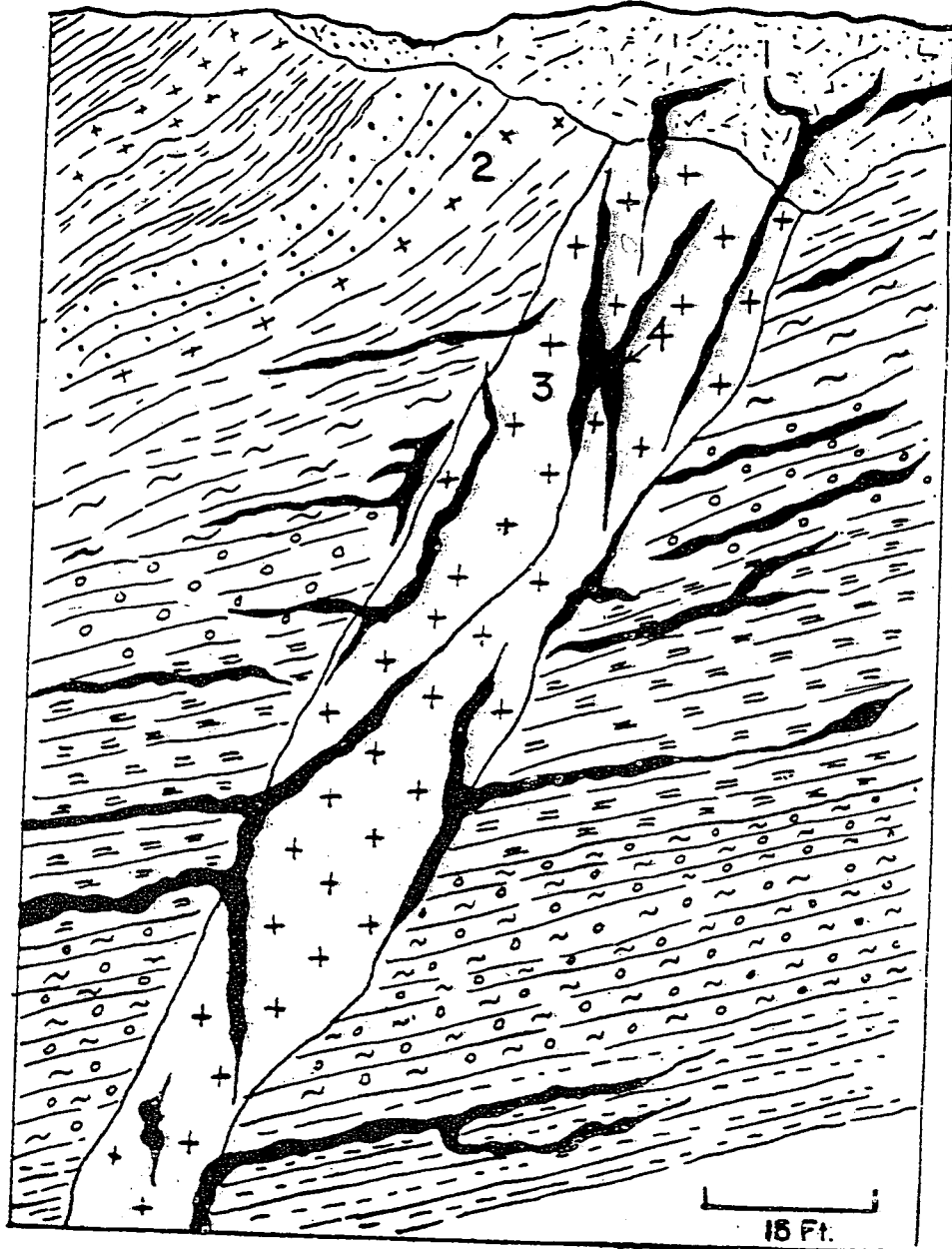


Fig10 Sketch section showing common types of graphite veins in Sri Lanka.
(D. N. Wadia, 1945)

(1) laterite, (2) country rock, (3) pegmatite dyke, (4) graphits veins.

MICA

The main types of mica found in the island are phlogopite, muscovite and biotite, phlogopite being associated with marbles, the other varieties with gneisses and schists of the Highland series. Workable deposits occur as pockets and veins or as concentrations in pegmatites. The principal known deposits are found in the Kurunegala, Kandy, Matale, Badulla and Ratnapura, areas well known localities being Talatu Oya, Madumana, Mailapitiya and Pinnawela.

The mica occurs as "books", some over a foot wide, but the deposits are sporadic and inconstant, the marketable mica which can be recovered from these deposits being small. One reason for this is that the mica crystals are usually so cracked and shattered that only relatively small pieces of unblemished mica can be obtained from the books by trimming.

Commercial mica is broadly classified as 'sheet mica' and 'scrap' and 'flake' mica. The mica from Sri Lanka has so far been classified as low-grade sheet mica, and exports have been mainly of mica scrap.

GEMSTONES

Sri Lanka in relation to its surface area, is the most dense gem-bearing country in the world. No other country in the World except perhaps Brazil has such a wide variety of gem-stones as Sri Lanka (Table 1 and Table 2). In spite of these unique circumstances, gem exploration and exploitation in Sri Lanka are still based on scientifically primitive methods.

Even though gem mining in Sri Lanka has been going on for centuries, the selection of target areas for gem mineral exploration is still based on mere "hearsay" information of villagers and gem miners. The research input into the gem industry of Sri Lanka has therefore been negligible. In view of the extremely large potential of gem minerals in Sri Lanka and the valuable foreign exchange earned from gems, location of new gem fields using modern "scientific" techniques is therefore a national need for Sri Lanka.

In addition to the commonly found gemstones (Table 1 and Table 2), one also finds associated with the gem gravels, minerals such as taaffeite, sinhalite, olivine, ekanite, etc., which may be useful as index minerals. These and the potential of valuable

elements generally found in the gem gravels such as gold, thorium, uranium, tin, tungsten, platinum, niobium, tantalum have rarely been considered.

There are four types of gem mining that are being carried out in Sri Lanka :

- (1) Deep mining (Pathal) - Ratnapura, Balangoda
- (2) Tunnel mining (Dona) - Ratnapura, Balangoda, Meetiyagoda
- (3) River bed mining (Ganga Adeema) - Ratnapura
- (4) Open pit Shallow mining (Pathas)- Kataragama, Elahera

The present status of the Gem Industry in Sri Lanka :

The uncut gem market at present is divided into three segments. One segment is controlled by the Sri Lankan gem dealers, the second segment is the Gem Corporation and the other segment is controlled by foreigners, mainly Thai nationals. The growth of the latter segment has affected Sri Lankan gem dealers and sharply reduced the volume of legitimate transactions.

In addition to the above mentioned categories in the uncut gem stones market there are four types of markets operational in Sri Lanka.

- (1) The street market is the commoner type of rough stone market. Rough stone buyers and sellers gather at specific places in the morning and trade their rough stones.
- (2) Private gem auctions are also a common form of selling rough stones. Miners organize such auctions in private places. A commission of about half percent has to be given to the auctioneer and another half percent is distributed among the other assistants.
- (3) Gem dealers go to the miners and make purchases of rough stones directly from the miners.
- (4) Miners themselves go to the gem dealers and sell their stones.

Table 4 : Gemstones Found in Sri Lanka

Mineral	Chemical formula	Variety
<u>Silicates</u>		
Feldspar		Orthoclase Moonstone
Olivine	$(\text{Mg,Fe}_2) [\text{SiO}_4]$	
Garnet	$\text{Mg}_3\text{Al}_2 [\text{SiO}_4]_3$ $\text{Fe}_3\text{Al}_2 [\text{SiO}_4]_3$ $\text{Ca}_3\text{Al}_2 [\text{SiO}_4]_3$ $\text{Mn}_3\text{Al}_2 [\text{SiO}_4]_3$	Pyrope Almandine Grossularite Spessartite
Zircon	$\text{Zr} [\text{SiO}_4]$	
Titanite (sphene)	$\text{CaTi} [\text{O/SiO}_4]$	
Andalusite	$\text{Al}_2 [\text{O/SiO}_4]$	
Sillimanite (Fibrolite)	$\text{Al}_2 [\text{SiO}_5]$	
Topaz	$\text{Al}_2 [\text{F}_2/\text{SiO}_4]$	
Kornerupine	$\text{Mg}_4\text{Al}_6 [(\text{O,OH})_2/\text{BO}_4/(\text{SiO}_4)_4]$	
Danburite	$\text{CaB}_2(\text{SiO}_4)_2$	
Epidote	$\text{Ca}_2 (\text{Fe,Al}) \text{Al}_2 [\text{O/OH/SiO}_4 [\text{Si}_2\text{O}_7]$	
Ekanite	$\text{K} (\text{Ca,Na})_2 \text{Th} [\text{Si}_8\text{O}_{20}]$	
Beryl	$\text{Al}_2\text{Be}_3[\text{Si}_6\text{O}_{18}]$	Aquamarine
Cordierite (Iolite)	$\text{Mg}_2\text{Al}_3 [\text{Al Si}_5\text{O}_{18}]$	
Tourmaline	$(\text{Na,Ca}) (\text{Li,Mg,Fe,Al})_9 \text{B}_3\text{Si}_6(\text{O,OH})_{31}$	Schrol
Axinite	$\text{Ca}_2 (\text{Mn,Fe}) \text{Al Al} [\text{BO}_3\text{OH/Si}_4\text{O}_{12}]$	Uwait
Pyroxene	$\text{LiAl} [\text{Si}_2\text{O}_6]$ $\text{Mg}_2[\text{Si}_2\text{O}_6]$ $(\text{Fe,Mg})_2 [\text{Si}_2\text{O}_5]$ $\text{CaMg} (\text{SiO}_3)_2$	Spodumene Enstatite Hypersthene Diopside
Scapolite	$(\text{Na,Ca})_8 [(\text{Cl}_2,\text{SO}_4,\text{CO}_3)_{1-2} (\text{Al}_{1-2}\text{Si}_{3-2}\text{O}_8)_6]$	
<u>Haloids</u>		
Fluorite	CaF_2	

Contd.

(Table Contd.)

Mineral	Chemical Formula	Variety
<u>Sulphides</u>		
Chalcopyrite	Cu Fe S_2	
Marcasite	Fe S_2	
Pyrites	Fe S_2	
<u>Oxides</u>		
Quartz	SiO_2	Rock crystal, Amethyst Rose-quartz, Smoky- quartz, Brown-quartz, Citrine
Quartz with inclusions		Quartz - Cat's eye Quartz - Tiger's eye
Quartz (Cryptocrystalline)		Chalcedony, Jasper, Agate
Chrysoberyl	BeAl_2O_4	Chrysoberyl cat's eye
Spinel	MgAl_2O_4	Ceylonite
Taaffeite	$\text{Al}_4\text{MgBeO}_8$	
Corundum	Al_2O_3	Ruby, Star-ruby, Sapphire, Star sapphire, Yellow sapphire, Pink sapphire, Padmaraga
Rutile	TiO_2	
<u>Carbonates</u>		
Calcite	CaCO_3	
<u>Phosphates</u>		
Apatite	$\text{Ca}(\text{F,Cl}) \text{Ca}_4 (\text{PO}_4)_3$	
Monazite	$\text{Ce} (\text{PO}_4)$	
<u>Borates</u>		
Sinhalite	$\text{Mg Al}(\text{BO}_4)$	
<u>Tungsten</u>		
Scheelite	CaWO_4	

TABLE 5: PRIVATE GEM EXPORTS-VARIETY WISE (in carat) 1984, 1985 & 1986

	<u>1984</u>	<u>1985</u>	<u>1986</u>
Blue Sapphire	54,379.42	47,260.71	55,976.87
Star Sapphire	183,346.67	192,154.74	251,378.40
Ruby	2,287.49	1,834.75	1,563.55
Star Ruby	6,655.22	4,445.76	3,824.60
Cat's Eye	32,447.57	24,466.81	28,751.89
Alexandrite	895.93	832.12	645.68
Blue Star Sapphire	32,907.15	53,427.70	60,895.86
Yellow Star Sapphire	289.40	2,431.04	8,345.53
Pink Star Sapphire	5,323.62	3,573.44	15,858.28
Yellow Sapphire	30,577.36	47,608.56	137,875.18
Pink Sapphire	6,616.12	5,163.59	7,949.56
Fancy Sapphire	21,291.73	20,474.59	16,077.54
Orange Sapphire	629.17	448.73	586.70
Purple Sapphire	-	-	117.25
White Sapphire	13,944.95	565.61	1,254.29
Sapphire mixed	1,008.39	4,738.68	191,511.23
Golden Sapphire	337.53	51.52	119.02
Green Sapphire	-	10.22	89.53
Violet Sapphire	-	26.25	214.32
Quartz	-	16,874.26	56,280.77
Topaz	630,794.03	1,244,618.26	3,191,338.35
Padmaraja	1,247.33	1,472.33	1,548.06
Garnet	27,440.46	40,382.93	33,273.17
Moonstone	191,747.27	226,714.26	345,631.68
Spinel	7,718.00	9,675.74	9,743.50
Chryoberyl	2,092.63	1,546.67	1,877.33
Sinhalite	-	479.35	728.65
Zircon	10,753.07	8,999.14	7,594.26
Amethyst	3,257.94	4,750.27	8,348.83
Aquamarine	-	3,886.80	2,852.98
Tourmaline	16,475.37	12,974.05	6,075.38
Beryl	-	-	351.77
Others	322,372.18	77,715.30	47,795.02
Opal	-	-	7.19
Diamond	-	-	6.15
Sapphire	48,830.94	192,877.39	-

Figure Captions

- Fig. 1 - Location and Geology of the Muthurajawela Peat Deposit of Sri Lanka.
- Fig. 2 - Oil Well.
- Fig. 3 - Diagrammatic Vertical Sections of Typical Lime Kins.
- Fig. 4 - Map of Mineral Resources of Sri Lanka.
- Fig. 5 - Locations of Factories Using Local Mineral Raw Materials.
- Fig. 6 - Sketch of Ilmenite Deposits at Pulmoddai.
- Fig. 7 - Types of Occurrence and Distribution of Monazite in the Aluthgama Area.
- Fig. 8 - Sketch of the Kaolin Deposit at Boralesgamuwa.
- Fig. 9 - Locations of Factories Using Mineral Raw Materials.
- Fig. 10- Sketch Section Showing Common Types of Graphite Veins in Sri Lanka.
- Fig. 11- Simplified Geological Map of Sri Lanka.

Table Captions

- Table 1 - Classification of Economic Minerals.
- Table 2 - Mineral Production in 1982.
- Table 3 - Mineral Production in Sri Lanka 1987, 1988.
- Table 4 - Gemstones Found in Sri Lanka.
- Table 5 - Private Gem Exports-Variety Wise (in Carat) 1984, 1985 and 1986.