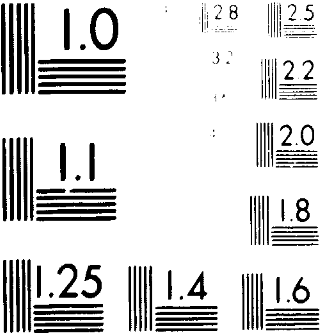
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org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ASSISTANCE TO THE

CEYLON MINERAL SANDS CORPORATION

– PROCESSING OF ILMENITE SANDS .

DP/SRL/78/031

SRI LANKA

Terminal Report

Prepared for the Government of Sri Lanka
by the United Nations Industrial Development Organisation
acting as executing agency for the United Nations Development Programme

Based on the work of

K.L. Little

Team Leader, Expert in Mineral Sands Processing.

United Nations Industrial Development Organisation

Vienna.

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ABSTRACT

Assistance to Ceylon Mineral Sands Corporation DP/SRL/78/031

CMSC has been producing ilmenite since 1960 and of recent years, rutile and Zircon at Pulmoddai, Sri Lanka. Assistance was given as an institution building project in maintenance, laboratory procedures, ilmenite upgrading, upgrading of existing operations, materials handling and future planning. Improvements were achieved in many fields.

CMSC has a rich deposit, utilized mainly in the manufacture of ti-oxide pigment. It is already an important industry but is nowhere near achieving its potential which involves better maintenance, operations, product handling, marketing, and proposed new plant, but mainly upgrading of the low value ilmenite product to more valuable intermediate products such as artificial rutile, titanium slag, or, the end product, ti-oxide pigment.

A number of future scenarios are examined and the one showing most promise involves pre-reduction of the iron content of the ilmenite, then electro smelting to produce raw iron and titanium slag. The latter is treated by the sulphate route process to make ti-oxide pigment. Phosphate fertilizer is made as a by-product using phosphate rock from Eppawela, sulphuric acid and waste acid from the sulphate plant.

Trincomalee has special advantages as a site for such a plant in waste disposal, and good harbour, water and power facilities.

Work remains mainly in establishing the technical feasibility of the process, however certain conditions should be met before committing further funds.

CONCLUSIONS AND RECOMMENDATIONS

(1) Sri Lanka has one of the worlds richest deposits of mineral sands utilised mainly in the manufacture of titanium oxide white pigment which, in turn, finds its way into paints, enamels, plastics, paper, artificial fibre, ceramics and numerous other products.

Indicated reserves are in excess of

12 million tonnes ilmenite $(FeO \cdot TiO_2)$

1.3 million tonnes rutile (TiO_2)

1.3 million tonnes zircon $(ZrSiO_4)$

(2) Mineral sands exports are already an important industry by developing country standards but the full potential is nowhere near being realized. Realizing this potential involves

(a) Upgrading maintenance

(b) Better shipping arrangements.

(c) establishing a wet gravity upgrading and wet magnetic separation plant (WGU & WMS plant)

(d) tidying up management procedures

(e) a rise in morale at Pulmoddai, and better worker participation

(f) marketing

(g) converting the ilmenite into more valuable products such as artificial rutile, titanium slag or, ultimately, ti-oxide pigment.

(3) The process of commissioning the plant was completed. Serious rutile losses were eliminated and zircon was made to standard grade. Premium grade is possible. The Wet Gravity Separation Plant and Dry Mill, first commissioned in 1977, now work to design specifications although there are still problems with the former. A higher grade feed, anticipated from the WGU & WMS Plant, will largely solve these and allow higher zircon recovery.

(4) Marketing of the products isn't satisfactory either in terms of tonnage disposed of or unit prices.

(5) There are immediate and long term problems with product handling. The shipping jetty is in danger of collapse. The short term solution appears to be a bridge for the Yan Oya crossing so that the product can be road carted to Trincomalee and loaded there. A further report from Mr. G.K. Jones, Expert in Materials Handling is to be made.

(6) There is a lean period ahead as production must fall due to the exhaustion of "non-magnetic tailings" stockpiles. The WGU & WMS plant must be commissioned before production will pick up again.

(7) CMSC is jeopardising its current ilmenite market by mixing together the ilmenites emanating from the dry magnetic separation plant and the dry mill. These products are suitable for two different purposes.

(8) The WGU & WMS Plant should be mobile and follow the mining operations if the building of a new power line is to be avoided,and power costs are to be reduced. Even so, power factor correction will be necessary.

(9) CMSC needs to establish its reserves through an internal exploration division and investigate future mining areas for potential separation and other problems.

(10) Mr. Kings preventative maintenance programme should be completely adopted.

(11) Changes are necessary to the combustion system of the main dryer DR401 or it may become unworkable.

(12) A number of possible future development scenarios were examined and the

one showing most promise involved pre reduction of the ilmenite, then electro smelting, then sulphate route pigment production. Raw iron and phosphate fertilizers are by-products, the latter emanating from phosphate rocks at Eppawela. Capital involved is of the order of $300 million. The products are

85000 tpa ti-oxide white pigment

52000 tpa raw iron

260000 tpa super-phosphate fertilizer

worth about $200 million.

(13) For such a scheme CMSC will need a foreign partner(s) for capital, expertise and marketing. A profit shareing arrangement should be possible with the partner(s) putting up most of the capital.

(14) Much work remains to be done, mostly in establishing the technical feasibility of the above scheme and establishing a proposal for a foreign partner. CMSC should enter negotiations well prepared and well advised.

(15) There is scope for more UN involvement and potential for a major export industry for Sri Lanka but the UN may want certain assurances on the utilisation of its outputs and other matters before committing more funds.

(16) Without an upgrading facility of its own the future market for Pulmoddai ilmenite may gradually diminish.

INTRODUCTION AND BACKGROUND INFORMATION

Location and Products

The Ceylon Mineral Sands Corporation (CMSC) operates at Pulmoddai 35 miles north of Trincomalee on the north east coast of Sri Lanka (Ceylon). Operations commenced in 1960 in the first instance extracting only ilmenite but in the late 70's considerable tonnages of rutile and zircon. Its present production capacity is :

75,000	tonnes	ilmenite
15,000	"	rutile
7,500	"	zircon

(per annum)

These rutile and zircon figures however cannot be maintained with existing equipment since current production draws on non magnetic "tailing" stockpiled over previous years from the ilmenite operations. Sustainable figures are about half the above.

Sales of ilmenite have declined and 30,000 - 35,000 tonnes has been the range in recent years. Previously an excess of 80,000 tonnes per year was sold. Recent sales prices realised are:

Rutile	$ A 256 (Australian) FOB
Zircon	$ A 30
Ilmenite	$ US 17.50

Current market prices are:

Rutile	$ 270 A	see appendix 7
Zircon	$ 75 A	
Ilmenite	$ 22 A	

These prices, however, vary with grade and time.

A major investment was the dry mill wet gravity separation plant for rutile and zircon production constructed in 1977 with technical assistance from the Australian Mineral Development Laboratories (AMDEL).

Operation

Mining is by means of tractor trailers collecting wind dried sand previously deposited in wind row-s by drag line excavators. These work only on the beach which assays about 85% heavy mineral. Most of the HM is ilmenite but there are valuable amounts of rutile, zircon and monazite.

Tractor trailers deposit in a large holding shed via a weigh bridge and from there the mineral is fed by front end loader to a dry magnetic separation plant, separating the magnetic ilmenite from non-magnetic rutile, zircon and partly magnetic monazite.

The ilmenite passes to a large go down (storage building) of 50,000 tonnes capacity. The "non magnetics" passes first to the wet gravity separation plant for removal of quartz and other light minerals then to a concentrate storage shed for intermediate storage and draining. Dry milling is the next stage. The mixed minerals are dried, then separated into the mineral constituents by means of their different electrical conductivities, magnetic susceptabilities and specific gravities. There is an intermediate stage of wet gravity separation in which remaining quartz and "others" are removed.

Rutile is conducting and non magnetic. Thus it is separated from remaining ilmenite, conducting and magnetic; and zircon, non conducting and non magnetic; monazite, non conducting and partially magnetic and so on.

Rutile and zircon products pass to separate go downs of approximately 12,000 tonnes capacity each. See appendix 1

Shipping

A single 20 inch conveyor system connects the go down to a 900 foot jetty with water deep enough to load flat bottom barges of 100 tonne and 200 tonne capacity. The Corporation has a "shipping fleet" consisting of 3 tugs and 6 of 100 tonne and 200 tonne capacity flat bottomed dumb barges with removable hatch covers.

During the shipping season, from April to September inclusive (but somewhat variable) medium sized ships call at Pulmoddai and anchor about a mile off shore. The barges are brought alongside and their bulk mineral contents transferred to the ships hold by mechanical grabs operated by ship derricks.

A minor amount of mineral is shipped in paper sacks of 50 kilo capacity. When this happens the bagging is done in the hold of the barge at jetty end since no facility exists for bag material handling. The bags are transferred to the ship by cargo nets filled by hand labour and then re stacked by hand labour.

Pulmoddai is an open coastline with no protection from wind or sea. So rain or sea conditions precludes shipping in the October - March period and sometimes interferes with shipping during the so-called shipping season.

Facilities

Also at Pulmoddai the Corporation has a laboratory for chemical and physical analyses; mechanical, electrical, carpenters and mobile equipment workshops; a necessarily well stocked store; an administration office; and two housing complexes, north and south for officers and workers respectively.

All of these facilities are connected to power and running water, although the latter is not potable. The water comes from wells and from a water treatment facility fed from a 4 mile canal system from an anicut (small dam) on the Yan Oya river.

Water Supply

A 10 inch asbestos cement pipe line, 6 miles long, conveys the water to a 200,000 gallon (imp) elevated storage tank at Pulmoddai. The water is hard during the dry season from February to September, most of the 60 inch rainfall occurring during the October to December period during the north east monsoon. See appendix. 9 - 11

Power supply

Power is supplied by the Ceylon Electricity Board from hydro schemes. A 33 KV, 50 hertz power line was constructed in 1976, predominantly for the Corporations needs, and takes a round-about 46 mile route from the 132 KV supply at Trincomalee to the Corporations 3 MVA substation at Pulmoddai which incorporates automatic tap changing transformers capable of accommodating a 15% supply voltage drop. The line however could not supply 3 MVA without excessive line losses and a voltage drop beyond the 15% capacity. The CEB has recommended that to obtain 3 MVA, another 33 KV line must be run in parallel (by a more direct route) to the existing line at a cost to the Corporation of approximately 12 million rupees. There are however, means by which this can be avoided at less cost especially if power drafts are kept low.(Appendix. 8a)

The currect peak power draft is about 1100 KVA, 720 K.W., but will grow dramatically with proposed new plant. Until a few years ago unit power costs were low by world standards at 0.12 Rs./unit, but have escalated since due to the cost of imported fuel for emergency gas turbine generators and the capital costs of new hydro schemes which will greatly expand the countries' generating capacity, currently a low 440 MW.

Due to poor rainfall seasons and rapidly rising electricity demand there have been power cuts which are likely to extend to 1984 when the large hydro schemes are due to come on stream. At that time unit costs will remain high because of the large capital cost of the schemes. An estimate of Rs.1.40 /unit has been given. (see appendix 8b)

The Corporation has its own emergency power generators, twin 750 KVA Diesel sets, but fuel costs are high and the sets have not been properly commissioned by the suppliers.

Communications

Pulmoddai is linked by sealed road to Trincomalee and via Medawachchiya, to Colombo. The Road to Trincomalee however, has two ferry crossings, the second of which can be avoided by a short detour containing some 2 miles of gravel road, The first is a low capacity hand drawn ferry.

Trincomalee has an excellent natural harbour and was previously a major British naval base. Many storage and handling facilities remain from those days.

Administration

The Corporation has a head office in Colombo for administration, purchasing and, prev iously, sales. Sales are now handled by the Tenders Board which advertises the products for sale by tender.

The Corporation is wholly state owned, one of 22 in the country including such corporations as the Cement Corporation, Steel Corporation, Plantation Corporation, Hardware Corporation etc.

CMSC has some 650 employees and is administered by a Board of Directors, a Chairman/Managing Director and a General Manager. There has been a long standing association with the Ishibara Corporation of Japan which remains the major customer.

Immediate Plans

In 1979 the Corporation called tenders for a wet gravity upgrading plant and wet magnetic separation plan (WGU & WMS) and, separately, for a pipe line transportation system to supply material to same. This was on the basis of a tender document drawn up by previous consultants. The purpose of this plant is to allow the lower grade 'back' deposits to be mined as the beach deposits will eventually be worked out. Also this plant can supply the existing dry mill /wet gravity separation plant to capacity (and more) and will replace the dry magnetic plant in this function.

Current Problems

The dry magnetic plants' machinery is largely worn out and spares are not available. These are the only machines of their type operating in the world. No tender has been awarded to date and old stocks of non magnetic tailings from the early ilmenite operations are nearly gone.

When these are exhausted rutile production must be cut by half until the new plant comes on stream, an estimated 18 months from award of contract. Zircon production can proceed from an approximate 60,000 tonnes of stockpiled material. Zircon however is a lower value product, so cash flow will suffer.

Brief description of Products and Uses

Rutile:- is a granular mineral, predominantly titanium dioxide TiO_2. It is used for making titanium dioxide pigment (ti oxide pigment) by the 'chloride' process and is the major component of most welding rod coatings. It is also the main source of titanium metal via the Kroll process. For pigment and metal manufacture rutile is first converted to titanium tetrachloride, $TiCl_4$ (nick-named "tickle") by chlorinating with coke in a fluidized bed reactor. World production of rutile is some 360,000 tonnes.

Zircon:- is granular zirconium silicate $ZrSiO_4$, a smaller grained version of the gemstone zircon. It is used for steel castings, for replacing silica sand in mechanized foundrys, for ceramics and refractories. A small tonnage is used in the manufacture of zirconium metal and zirconium alloys. World production is around 500,000 tonnes.

Ilmenite:- a granular mixed oxide of iron and titanium, nominally $FeO.TiO_2$ but of varied composition due to solid solution and partial oxidization of the iron content from ferrous to ferric iron. Most ilmenite is converted to titanium oxide pigment by the "sulphate route" process either directly, or after conversion to a high titanium slag with pig iron as a by product. Recently increasing amounts have been converted to ti-oxide pigment directly by the chloride process.

Another type of high titanium slag made from ilmenite is converted to ti-oxide pigment by the chloride process and to titanium metal by the Kroll process.

Minor uses are for adding to the iron oxide charge of iron blast furnaces for slag forming and protection of the linings; for ceramics, and for welding rod coatings.

Some ilmenite is now converted to artificial rutile (ilmenite upgrading) by removing the iron oxide content.. World production is around 4.5 million tonnes some of which is, strictly speaking, titaniferous magnetite.

Monazite:- is the phosphate of the rare earth elements plus thoria, ThO_2. Its uses are too diverse and numerous to list except to state that thorium is a nuclear fuel used in certain reactors which breed uranium 233 from thorium. World production is around 20,000 tonnes.

Ti-oxide pigment:- the end product is arguably the most ubiquitous man made substance. It has only been produced since the early 20s but, having shed some early undesirable properties, is now found in a wide variety of products;

paints, enamels, ducos, varnishes, opaqued plastics, ceramics, paper, rubber goods, artificial fibres, wall and floor coverings, printing ink and cardboard facing etc.

It is chemically inert, non poisonous and has five times the covering power of its nearest rival in the white pigment field. It has replaced its lead and zinc based rivals in all but a few specialised fields. World production is around 2½ million tonnes.

It should be noted that rutile, ilmenite and monazite are strategic minerals. Titanium metal production emanating from rutile and ilmenite is small (90,000 tonnes) compared with pigment production and only dates back to 1949, but it is of vast military significance. In practice this strategic significance is more of a nuisance than a blessing as it leads to interference.

UNITED NATIONS ASSISTANCE AND INPUTS

Introduction

The scope of the programme is set out in project document, the budget and in the various position descriptions. Summarising :-

Scope of Project

A number of areas in the on going operations were seen as deficient. These included mechanical maintenance, laboratory operations and separation.

In addition a need was seen to determine long term strategy, meaning either better marketing for existing products or further processing of ilmenite to produce higher value products such as high titanium slag, artificial rutile or, ultimately, titanium oxide pigment itself. The latter is the end product, the others intermediate in its production.

The production of titanium metal was not considered as this is a high technology and highly capitalized operation with sensitive overtones.

Whether the Corporation officials considered the UN teams functions as these is another matter. It was difficult to have a meaningful dialogue on long term strategy for a number of reasons, chiefly because the Corporation officials involved were in Colombo preoccupied with other matters and seemed to regard it as their business only.

Another major weakness identified was the material handling of the finished products i.e. ship loading.

History of Involvement

CMSC applied for assistance to the U.N. in 1978 to assist them with their on going operations. This was largely at the instigation of a consultant who was instrumental in writing the job descriptions. The project was approved in 1978 and the first expert arrived in the field in late December 1979. This was Mr. King, Expert in Engineering Services.

The Team Leader, myself, arrived in April 1980. Mr.Walter Harrach, (Hungarian), Consultant, Electro Metallurgical Titanium Slag Production arrived in April 1980, for 2 months and wrote a report. Professor Seppo Wilska, Consultant, Titanium Dioxide and Synthetic Rutile Production arrived in August 1980 for four months and also wrote a report on his findings. Mr. Arno Leskinen (Finnish), Expert in Mineral Processing Laboratory Design and Management arrived in October 1980 and is due to finish his appointment in February 1982. Leave allowances will bring this back to December 1981.

My own term ends on December 8, 1981, but leave entitlements will bring this forward to late November. Total man month input will be

King	6 months
Little	20 months
Harach	2 months
Wilska	4 months
Leskinen	16 months
Total	48 months

A materials handling consultant Mr Jones is also approved. (2 months)

UN inputs are scheduled to end in December 1981 unless there are further developments.

INPUTS

Mechanical Maintenance

Mr. King drew up a scheduled maintenance programme which has been partly implemented. He concentrated on mobile equipment maintenance which is his particular field of expertise. He was not told to do otherwise. I feel however, the main problem is in the maintenance of the separation equipment where breakdowns and unscheduled downtime were affecting production. This situation has improved somewhat due to the maintenance programme and due to training the maintenance personnel. There is a severe shortage of trade skills due to poor training and lack of a mechanical background in the maintenance personnel. Many problems arise from initial poor trade work and snow-ball into major ones.

With the proposed new wet gravity upgrading and wet magnetic separation plant the need for mobile equipment maintenance is greatly reduced. This will remove a major problem as the foreman in the mobile equipment workshop does not have the respect of the men who spend their time talking, sleeping etc., only coming alive for overtime. The problem has been pointed out many times without results by Mr. King.

It is recommended that Mr. King's scheduled maintenance programme be fully implemented.

Ilmenite Upgrading

Electro metallurgical Smelting - SLAG

Mr. Herrach's report is on electro smelting of ilmenite in electro furnaces using locally produced char as reductant to produce titanium slag suitable for either the sulphate route process or the chloride process for making ti-oxide pigment. He drew upon the results at a large scale trial smelting of CMSC ilmenite with Sri Lankan char at the All-Union Research and Design Titanium Institute, Zaporozhie, in the Soviet Union, performed in 1976 and on the results of a feasibility study carried out by a Hungarian organisation drawing upon the Soviet technology.

He estimates the amount of pig iron produced as a by product and compares this with the country's raw steel needs and gives an estimate of its composition. He states that the iron material could be converted easily to the Steel Corporations' needs which are about 50,000 - 60,000 t.p.a.

Mr. Harrach concludes that the project is "feasible and competitive" but gives no cost estimates so that this project can be compared with the other possible scenarios in terms of capital costs, operating costs, balance of payments (Exports or Imports), return on investment and so on. Nor does he indicate how the problem of marketing is to be handled.

I have doubts about the feasibility of using char as a reductant. Sri Lanka is short of timber and coconut char sells at a high price, according to a report listed by Mr. Harrach. My feeling is that anthracite coal of specified and known quality would have to be imported. Relying on a cottage industry for char would yield varying quality and there would be attempts to dilute the char with worthless material to increase its weight. Dilution with calcium and magnesium is serious for slag destined for the chloride process and the country has many limestone reefs and lime soils. For the sulphate route process the presence of chromium and niobium is a problem.

Pigment & Synthetic Rutile

Professor Wilska produced a report on manufacturing ti-oxide pigment directly from ilmenite by the sulphate process and on making artificial rutile (upgraded ilmenite) from CMSC ilmenite. He examined a number of processes for the latter and gives details of them but favours the Benelite process, mostly on the basis that it is an industrially tried process. Others have never been tried beyond the experimental or pilot stage.

He goes further and proposes a scheme for integrating the ti-oxide pigment plant with a sulphuric acid producing plant and with a proposed oil refinery at Trincomalee. He points out that waste acid from the sulphate process could be utilized in making super-phosphate fertilizer from phosphate deposits at Eppawela. These deposits are currently exploited in a small way by mining and crushing the rock and selling it as a fertilizer. Without treatment by acid, however, phosphorous release to the soil must be very slow. (App.3

The oil refinery would provide sulphur if treating a high sulphur crude and could produce ammonium for mixing with the super phosphate fertilizer for the manufacture of the more usual mixed NPK fertilizers incorporating the three main plant nutrients, nitrogen, phosphorous and potassium.

Professor Wilska's report is through and gives the theoretical background. Some comments:-

1) It is difficult to foresee both a titanium dioxide pigment plant <u>and</u> a synthetic rutile plant. The latter is an intermediate product in producing pigment and is of much lower value, \$ 200/tonne against \$ 1600/tonne for pigment. Up to a point the economics of producing any commodity improve with the volume of output. Conversely there is a minimum break-even size of plant below which the operation would lose money. It is a matter of

examining the various alternatives to determine which is the best in this particular instance.

(2) Professor Wilska has dealt with the environmental aspects of the sulphate route pigment production and has suggested that much of the waste acid, normally one of the effluent problems, be utilized in making a necessary product, fertilizer.

The government of Sri Lanka should be clear about the environmental problem which has plagued sulphate plants overseas. The U.S.A. has not built a new sulphate plant since the early 1950's and many of the original plants have been closed down, many due to stringent pollution control requirements. Du Pont de Nemours, the worlds leading producer of pigment had moved entirely out of sulphate route production into chloride route, partly using ilmenite as feed. The normal feed for chloride route production is rutile and Du Pont is one of only two companies which can handle the technological complexities of the ilmenite feed, and has the necessary integrated and wide chemical industry base.

Sulphate route plants have been closed down by environmental agencies (at least temporarily) in Germany, Italy, Japan and France. In 1975 the EEC called for the phasing out of the process by member countries by 1985. This will not be done since the EEC has no powers to enforce its call and many countries question that they have a genuine problem; but it shows how seriously the problem is taken in a world increasingly environment conscious.

Also the product (pigment) is very nearly indispensible so environmental agencies usually content themselves with limiting outflow of pollutants. A

Thann et Mulhouse plant in France has had an artificial ceiling placed on its output for this reason.

The problem, briefly, is that for each tonne of pigment made from ilmenite (by the sulphate process) 2 tonnes of sulphuric acid (H_2SO_4) diluted with water; and 5 tonnes of hydrated ferrous sulphate, $FeSO_4 . 7H_2O$ known as "Copperas" must be disposed of. When dumped at sea, the sulphuric acid is not the main problem. As Wilska points out, sea water is mildly alkaline from bi-carbonate ions and the acid is neutralized. The main problem is the copperas which oxidizes, when close to the sea surface, into hydrated ferric oxide, a fine red rust, forming a suspension which can affect marine life. When deposited into shallow water it stains the sea red and is washed up on the shore line as a red scum, particularly after heavy weather.

A way of minimizing this problem now adopted is to convert the ilmenite first to slag by the electro metallurgical smelting operation. The iron content of the ilmenite is largely removed as a useful product and it is not necessary to add scrap iron to reduce the ferric iron to ferrous. Hence copperas effluent is reduced some 85 to 95% with the better slags. Also slag is more acid soluble than ilmenite so less acid is used and disposed of.

Slagging operations are carried out by Quebec Iron and Titanium Corporation (Q.I.T.), at Sorel in Canada, by Richards Bay Iron and Titanium (Pty) Ltd. in South Africa, using Q.I.T. technology and at Zaparozhie as already mentioned.

Another problem is the sulphur dioxide (SO_2), sulphur tri-oxide (SO_3) and small amount of sulphuric acid given off to the air in the final "calcining" operations.

The east coast of Sri Lanka has a special advantage for the sulphate route process. This is the proximity of the continental shelf allowing effluent to be piped into very deep water where the problems described are not likely to arise, and the single wind direction minimizing wind carry problems. Sri Lanka airports are built with only one runway.

3. It should be pointed out that chloride process producers claim that their pigment is of inherently higher quality. In their process titanium tetra chloride (tickle) is produced as an intermediate product. This is a liquid and is refined by fractional distillation to a high level of purity so that when it is reacted with pure oxygen there is virtually only titanium dioxide. By contrast, in the sulphate process, many impurities in the ilmenite are taken up along with it into sulphuric acid, and follow the titanium dioxide into the final product. Also the addition of scrap iron adds more contained impurities.

Harmful impurities are chromium, vanadium and niobium, since they colour the pigment. Nothing can be done about this except to put a limit on the maximum level of these impurities in the ilmenite used. The "Q" grade of ilmenite from Quilon in India lost most of its market when lower chrome ilmenite became available. Q ilmenite commonly assays 0.15% chromium oxide, Cr_2O_3.

Sulphate producers, however, counter that there is no real difference between the pigments produced by the two processes, given good ilmenite feed. They dismiss the claim as a sales gimmick.

Foreign Partner

Wilska has, I feel rightly, pointed out that a foreign partner would be almost a necessity. For the sulphate route plant package that Wilska proposed capital of the order of $150 - $200 million would be required. Also necessary are expertise and, above all, marketing.

Pigment is made in at least 20 different grades differing in crystal structure, rutile or anatase type; grain size(normally 0.3 to 0.5 microns); and after treatment. The after-treatments protect the pigment from photochemical reaction in sunlight which causes "chalking" and also from reactions with the various chemicals used in the different pigment applications.

Hence the customer needs high class technical advice and probably the assurance of buying a familiar brand name product. The producer needs research laboratories to investigate customer complaints and problems and to keep abreast of technical developments, partic ularly by rivals.

Neither the capital nor the expertise is likely to be available in Sri Lanka and the product is unlikely to be sold successfully by the tender board system.

Future Strategy Scenario

The Harrach & Wilska reports need tying together. Four future strategy scenarios emerge.

1) Complete the proposed WGU & WMS plant and then stop large capital input. Concentrate on marketing the ilmenite, rutile and zircon products as is.

Rutile and zircon have a market, if somewhat variable,and the ilmenite is a reasonable product close to the southern European and Japanese markets.

Its' sale should present no great difficulty. See App 13

This strategy probably represents the greatest percentage return on capital invested, but Sri Lanka needs hard currency for its balance of payments. Processing of ilmenite to higher value products serves this need better.

Or get a foreign partner(s) and:-

2) install a sulphate route plant for processing the ilmenite to titanium oxide pigment. Utilize the higher concentration waste acid to convert Eppawela phosphate rock to superphosphate. Construct a sulphuric acid plant with excess capacity for the acid needs. The remaining production can form the basis of a chemical industry.

3) Additionally install an electro smelter to convert the ilmenite to high titanium slag and iron. Use the iron for the countrys now imported steel needs (fairly simply arranged). App. 12 The sulphuric acid plant is again required and the same comments regarding waste acid apply.

4) Additionally to 3 install a pre-reducer to largely reduce the iron oxides content of the ilmenite to metallic iron. This requires imported coal but reduces the number of electro smelting units by 60%, reduces their coal requirements and reduces the electro smelting power draft by 60%.

These proposals are shown diagrammatically in the appendixs 4, 5, + 6

Each proposal has to be assessed for capital expenditure, operating costs and personnel requirements, the latter to include the various levels of skills. Also the environmental effects of each should be assessed.

Then the decision can be made as to which proposal best fits the circumstances and a flexible basis for negotiation drawn up for approaching foreign partners. I have attempted to do this as shown in the appendix but it needs more work. The figures are not intended to be final. One possible difficulty may be in obtaining Soviet technology but there is the Q.I.T. alternative available.

A number of scenarios have been rejected. These are listed with brief reasons.

1) Sit tight. Don't do anything. Don't go ahead with the wet gravity upgrading plant and wet magnetic separation unit.

Not advisable because current rutile and zircon production, the main cash flow producers must drop by half. This will make the operation marginal. The high grade beach reserves will eventually be worked out and the existing plant cannot handle the lower grade reserves. Ilmenite sales will continue to decline, unless markets are actively sought.

2) Install more dry magnetic separation capacity. This briefly solves the rutile and zircon production problem but not the high and low grade problem above. The present machinery is nearly worn out and is obsolete. It requires more power input than wet magnetic separators of the same capacity.

3) establish a synthetic rutile plant.

Wilska has examined many possibilities and rejected them. He proposed the Benelite process, but this has problems. The Kerr Mc Gee plant at Mobile, Alabama was closed down at least partly due to technical problems. A large benelite plant is being established in India and already, before commissioning, the outlook is poor..

The commercial process with the best track record, the Western Titanium process at Capel, Western Australia may not be available for licencing.

Synthetic rutile also is an intermediate product of moderate value requiring an expensive plant and a high level of technology, the latter more so than for a sulphate route pigment plant. After 60 years of operations most of the problems with sulphate route production are known. Any plant presents a problem in the comissioning stages, the sulphate plant probably less than for a synthetic rutile plant, all of which have given problems on commissioning.

4) Establish a chloride route plant to make ti-oxide pigment from rutile <u>and</u> ilmenite.

The capital requirements are high and the technology is known to only two companies to my knowledge. They are not likely to be partners. Also this ilmenite is not particularly suitable. A higher TiO_2 is preferred. (See appendix 13)

Although under US Law Du Pont de Nemours which developed the chloride process in the late 50s, has to licence its use by other companies, this applies only to the information available from patent applications. They do not reveal "tricks of the trade" knowhow and a number of companies have tried unsuccessfully to adopt the chloride process which is only superficially simple. Some have failed and some have been nearly broken in the effort.

Team Leader/Expert in Mineral Sand Processing

The team leaders function is outlined in the job description and two tripartite review reports have been submitted. This is the final report on his activities.

However a number of extra duties were required. First the process of commissioning the dry mill and wet gravity separation plant had not been completed. This was an immediate problem and needed attention. Second the tenders for new plant as described had to be evaluated and negotiations held with the suppliers. This took some time also.

Expert in laboratory Design and Management

Mr. Leskinen arrived early October 1980 and is due to complete his term in December 1981. One aspect is the non-arrival of laboratory equipment ordered in January. UNDP Colombo is understandably concerned at this equipment arriving without an expert in the field to supervise its installation. Some equipment has now arrived.

Mr. Leskinen will write a report on his activities.

Other inputs

The main UNIDO input was technical expertise and advice. Equipment and other inputs were minor by comparison. The equipment budget was $31,000 at the last revision dated May 1981. This is mostly in laboratory equipment necessary to upgrade laboratory services. A number of standard text and reference books were purchased for a plant library and formally taken into stock by the Corporation.

These are the types of books which normally form part of a professional's private library for constant reference. However pay scales in developing countries do not allow the purchase of such items which can represent a large portion of a years salary; so engineers, chemists etc. usually struggle on without them. They represent a good investment for aid agencies and for the Governments themselves, and it is recommended that the library be extended.

Budget

The revision of May 1981 shows a total budget of $ 282,583 divided accordingly.

	allocated
11. Experts 46 man months	237,483
13. Support personnel	2,000
15. Experts travel	5,000
16. Other personal costs	2,500
31. Fellowships	2,000
49. Total equipment	31,000
52. Reports	a 3,000
	282,583

This includes 2 man months for a Consultant in Materials Handling but does not include a n extension for the Laboratory expert, partly made necessary by the non arrival of equipment on schedule.

There have been some savings on the budget.

REVIEW OF OPERATIONS

EXPLORATION

The first question any prospective foreign partner will ask is "What are the reserves?". At present this cannot be satisfactorily answered.

Recently a team from the Netherlands was engaged to conduct an exploration programme. A team of three expatriates assisted by local labour spent some 3 months in the field. They brought with them a mechanical drilling rig mounted on a trailer capable of being towed on site by their "range rover" vehicle. They set up a section in the Pulmoddai laboratory and analysed the samples, with local labour, by sink float separation in bromoform, a liquid with 2.9 specific gravity. The heavy mineral "sink" was forwarded to the Netherlands for analysis by quantitative x-ray fluorescence spectroscopy, a fast instrumental technique capable of determining the heavy mineral breakdown i.e. what percentage ilmenite, rutile,zircon, monazite etc is in the sample.

10 million rupees was budgeted for the work, which was to delineate reserves identified in a scout type survey by the Geological Survey in 1979.

An interim report and a full report are awaited.

I have my doubts as to the worth of the results for two reasons. First the type of drill,and second the wide grid.

The mechanical auger drill had a long screw flite. The auger was lowered into the ground and the drillings scraped away as they emerged on the surface. When the maximum depth required had been reached, the drill was withdrawn and material adhering to the drill was removed and added to the sample. Samples were taken for different depth intervals but, in fact, it could not be said with certainty that material emerging at a given time was from a particular depth. Material emerged at the surface at varying rates and, in some instances, the drill advanced for considerable distances without any material emerging at all. There was also the possibility of material from different layers mixing on the way to the surface. A "Proline" drill of this type was tried and rejected in Australian mineral sand practice many years ago. It was found that the results did not correlate with those of a hand auger drilling, the normal method.

The hand auger takes a core sample, normally 2 feet at a time. After each two foot increment in depth the drill must be raised, the core removed and the bit re-lowered adding extra lengths of shaft as required. With high labour costs it can be imagined that this procedure is expensive and the faster mechanical method was not rejected lightly. With the core taken by the hand auger the sample can be positively identified with a depth interval and there is no cross contamination between different depth intervals unless sloppy procedure is adopted. Results correlate closely with results obtained when the area is mined.

There is now a mechanical type of drill in use but it too takes a core which is forced up a hollow stem with compressed air. It was not adopted until after extensive trials showed the same results as with hand drilling were obtained.

In Sri Lanka conditions the hand auger is quite suitable because of the lower labour costs and the need to employ un-skilled people.

Secondly the grid used was coarse. The closer the grid the more holes drilled and the more accurate the results. The object is to make the grid as coarse as is consistent with accurate results or the desired accuracy of results. Scout drilling is done on a coarse grid, but the results obtained are not claimed as "proven" reserves. "Proven", "Probable" and "possible", or the alternate classification "measured", "indicated" and "inferred" applied to reserves are terms with a legal meaning. It is, for instance, an offence to describe reserves as "proven" in a company prospectus if the term does not apply. To "prove" the deposit the grid is closed up, usually by drilling lines and rows of holes between the original lines and rows.

What constitutes a "coarse" or "fine" grid depends on the variability of the deposit. A large deposit of uniform grade can be proved with a relatively few holes on a coarse grid. Mineral sand deposits are wave laid and have lens concentrations parallel to the shore. A typical fine grid is 10 metres transverse by 40 metres along, and this is closed up to 5 metres by 20 metres if there is a large variation in grade.

Hence it is hard to describe a grid of 100 metres by 200 metres as a fine grid. In one case the grid completely straddled a low dune likely to contain mineral values and the previous survey showed that there is considerable grade variations in 100 metres in many cases as, for instance, holes AH108 to AH103 near the plant site which are approximately 100 metres apart.

The Corporation needs an internal exploration division to delineate reserves in the Pulmoddai area i.e. from Mullaitivu to Nilaveli and to investigate deposits elsewhere. Deposits are known to exist at Dondra at the extreme south of the island where 20% rutile in the beach makes it the richest known rutile deposit. It is, however, small. There are dune deposits in the south of some size indicated to contain 5% rutile mixed with much fine garnet, (information from Geological Survey) and this also makes them rich when it is considered that on the east coast of Australia dune deposits containing as little as 0.3% heavy mineral with 0.12% rutile are economically worked. There are also small areas of rich monazite deposits on the west of the island at Kalutara and to the south. These have useful amounts of rutile and zircon and ilmenite associated with the monazite.

There is even a thorianite deposit with contained uranium at Indurawa.

These deposits all need delineating for the Corporations information and that of prospective partners. In normal practice it is usual to take explorations only to the "probable" stage unless mining is due to take place within the next three years.

An exploration division would consist of a leader, probably a geologist, a surveyor for laying out the grid lines and plotting the results, a draftsman or tracer to assist him and a number of 3 man drilling crews, probably 4. The techniques are adequately dexcribed in Eion McDonalds "Manual of Mineral Sand Mining" available from the Australian High Commission published by the Foreign Affairs Department.

The laboratory would need to be able to process 200 samples a day by sink float separation in bromoform or TBE liquid and would need grain counting facilities (now developed) to analyse the sink fractions. A mineralogist would be very helpful in this regard and for mineral identifications generally.

One argument against having an internal exploration division is that overseas investors would have no confidence in its findings. They would suspect an attempt to inflate the reserves or that the drilling crews had spent the day in a trees' shade, presenting, at the end of the day, "samples" from holes that were never drilled. The latter, and sloppy procedures, can only be stopped by good supervision.

The confidence problem has arisen many times when companies seeking capital or changing from private to public companies present a prospectus or when one corporation "takes over" another. What then happens is that the internal exploration findings are checked by an independent consulting concern which presents a report. It is only necessary for the consultant to put down a relatively few holes alongside some original bore holes chosen at random. Discrepancies are soon apparent so the original results are easily checked.

Drilling results are presented as a bore plan showing heavy mineral values above and below water table and the type of bottom, silt, clay, rock etc; and also on cross sections with the HM assay of each 5 foot or 2 foot increment shown together with the water table and bottom. The vertical scale of cross sections is usually exaggerated and the value ranges are colour coded, 0-5% H.M., 5-10% H.M. etc. This greatly assists in mine planning.

Again, the technique is adequately described in the McDonald manual.

Other information required is grain sizing, both of the heavy mineral grains and of the quartz grains or any other light mineral grain, i.e. "floats".

Reserves

The Geological Survey exploration programme in 1979, while limited in scope as already stated, investigated some 45 miles of coastline centred on Pulmoddai and identified new areas of mineralization. The cut off grade was set at 5% heavy mineral (S.G.> 2.9) which is an economically realistic figure but, even with the new wet gravity upgrading plant, is beyond the range of the Corporations equipment. The new plant will be able to accept feed down to about 30% heavy mineral. The present cut off grade is set by the equipment available, not economics, and is about 80% H.M.

The areas of mineralisation identified were at Nayaru 16 miles NNW of the plant at Pulmoddai; Pudavakaddu, 7½ miles SSE; and Thevikallu 15½ miles SSE. These deposits extended upto 1¼ miles inland. In other stretches of coastline there was mineralisation but in a much narrower band, generally less than ¼ mile wide.

The report gives the following figures.

Location	No. of holes & pits	Area of deposit in acres (hectares)	Average thickness feet (mtrs)	Average H.M. %	H.M. tonnes millions
Thevikallu (15.5 mls south)	40	631 (254)	7.21 (2.20)	16.1	1.78
Pudavekaddu (7½ mls south)	32	1455 (587)	6.9 (2.10)	17.7	4.31
Nayaru (16 mls north)	13	316 (127)	7.7 (2.36)	18.4	1.09
Remainder excluding present mining area.	61	3578 (1433)	6.4 (1.95)	10.3	5.74
					12.92

By my calculations, working on the areas, depths and H.M. percentages given, the tonnes of H.M. given are about 6% high, but this is of little consequence.

Drilling was done only to the water table because of the hand auger used, so, in most cases, the holes finished still in heavy mineral values. If a "sludger" had been used in addition to the auger to sample the material below water table, the reserve figures would undoubtedly be a lot higher. Mining is not confined to material above water table so there is no reason to reject values below water table.

There was no analyses done on the heavy mineral to break it down into its constituents, ilmenite, rutile, zircon etc. so it is not possible to state with any certainty the reserves in terms of these minerals. If the relationship between the minerals is as at Pulmoddai i.e. 72% ilmenite, 7.7% rutile and a similar amount of zircon these 'new' reserves amount to:-

9.3 mt ilmenite

1.0 mt rutile

1.0 mt. zircon

(see note above)

The 'old' reserves in the 5½ mile stretch presently mined between Kokalai to the north and Arasimalai (the headland 1 mile to the south) amount to some 5 million tones of heavy mineral at a higher grade.

It is again emphasized that these figures must be taken with caution as they cannot be claimed as 'proven' reserves.

Wet Gravity Upgrading and Wet Magnetic Separation Plant

One of the tasks which befell the UNIDO team (at Corporation request) was the assessing of tenders called in 1979 for the above plant. This was on the basis of a tender document drawn up with the aid of previous consultants who recognised the need for such a plant. The reasons have already been given.

A separate tender was called for "part C" meaning a pipe line system to transport raw sand feed as a slurry from the mine site to the plant site, presumably next to the existing "washing plant" used occasionally to remove slime content and surface coatings from back deposit material. The tender document obviously had in mind that this washing plant be incorporated. In addition, a godown to store 150,000 tonnes of ilmenite product was called for, although it is difficult to see what is the point of storing ilmenite in a $2 million plus godown if there is no prospect of sale. When that godown fills up, then what? Do you build another?

It is not now intended to build a godown unless there are sales prospects . Alternate arrangements for storing using traditional skills have been proposed as described in the separate report.

The tender evaluation turned into quite an undertaking as negotiations with the tenderers had to be entered into as none of the original tenders fulfilled the Corporations requirements. Four tenders in all were received and negotiations were conducted with all tenderers, although one tenderer would appear to have been out due to high cost and another due to technical deficiencies.

In evaluating the tenders a technical committee was appointed. Eventually I was unable to agree with the Committee and submitted a separate report to the Ministry. The main point of contention was the technical ability of one of the tenderers to construct the plant. Both the original tender and revised tender showed serious technical deficiencies and lack of understanding of the problems involved. This was to such an extent that it was difficult to imaging a successful plant being built by this tenderer.

The point was resolved when it was agreed that the tenderer would be required to retain the services of a consulting firm to supply the necessary, but missing expertise. This consultant happened to be the same as that retained by another tenderer. I do, however, question the assumption that seems to have been made that the same technically acceptable proposal will now be offered at the lower price. For ethical reasons the consultant must now place a completely new team of people on the tender and draw up an entirely new proposal without these people even looking at the original proposal.

Two long reports were written on the tender and a number of supplementary reports. These are available.

At date of writing the tender, to my knowledge, still has not been awarded and this will invariably mean a period of reduced rutile production as the new plant is constructed. It is estimated that construction will take at least 18 months from date of award of tender. The total cost of the project, some $10 million, obviously exceeded original estimates, so a financial justification was done. (appendix 10)

Some aspects have changed in the 2½ years or so since the projects parameters were set in the tender document. Chief among these is an escalation in electric power costs, previously amongst the worlds cheapest, and the realisation that the capacity of the available electric supply is limited. The Pulmoddai substation has a 3 MVA capacity but the line supplying it does not . unless 11 million rupees is spent on a parallel line.

The projected electrical load is made up thus.

	KVA	KW drawn	KW installed
Present peak load, Pulmoddai plant	950	650	-
plus " " " Yan Oya pump station	110	80	-
less Dry magnetic separation plant(existing)	140	85	
plus sea water pump (existing)	75	55	75
plus wet gravity upgrading and wet magnetic plant	900 est.	630 est.	750-1090
plus pipe line system part C	850 est.	550 est.	780-900
	2745	1880	

The load drawn by the new plant is uncertain as installed K.W. figures vary with different tenderers, but it can be seen that the total load is beyond the capacity of the power line. The KVA load can be reduced by installing power factor correction capacitors for a cost of 500,000 to 600,000 Rs. to bring the power factor up from 0.68 to 0.95. Then the load above should be within the lines' capacity; but there is some uncertainty in the above figure and it must be remembered that at some time in the future, a tailings line will have to be added to deposit the tailings back at mine site. Only a short line is required for quite some time but eventually a line drawing about 300 KW must be added. There will also be an increased domestic load as more workers will be needed and alterations in the present dry mill and wet gravity separation plant will add further load, so it is easy to imagine the load creeping upto the 2500 KW mark. That would also almost certainly be beyond the capacity of the line and the transformer system as well as representing a large operating cost with power currently at 60 cents per unit, plus 25% fuel adjustment, plus Rs.22 per month per KVA maximum demand. The power bill would then be about 1.25 million rupees a month, assuming no increases in rate; and could erode profit margins if there was a substantial increase as during the recent power cut period when the unit cost rose to Rs.2/unit.

Hence need of cutting power consumption must be found.

It has been proposed that the pipe line system be dropped from the tender and that the plant be fed by tractor trailer units as at present. This presents serious problems both in cost and in logistics. To feed 120 tonnes per hour to a plant from 3 miles distance requires 60 tractor trailer units on contract. There would be congestion at the loading point and it would not be possible to cycle the units through the weighing and unloading operations at a rate of one a minute. The weighing operation alone takes 2 minutes and the existing facilities at the unloading point do not have a capacity of 240 tonnes per hour as required; nor is there storage capacity to tide the plant over the middle of the day period when the noon-day heat is too harsh on the labourers, stopping operations.

In addition the mobile equipment workshop facilities would have to be greatly expanded,as even contract equipment draws upon them. There are enough problems now with maintaining mobile equipment without adding more.

The best way to handle the problem would be to make the wet gravity upgrading plant and wet magnetic separation plant mobile, so that it moves to follow the mining operations as they progress, hence for the 3 mile stretch that is to be mined there would perhaps be 8 plant sites, so that neither feed nor tailings would need to be pumped more than a short distance.

The procedure is common practice. The separation plant is mounted on skid bases so that it can be towed (or winched) by bull dozer. Mining is done with a low level feeder, sometimes known as a pot holer, or with a front end loader fed unit and the plant tailings are deposited directly to previously mined areas. A levee bank is made across the mining pit behind the feeder unit and a pumping unit collects the water draining from the tailings to be recycled to the low level feeder to slurry the sand feed.

The procedure is the same as described to the various tenderers, except that the long pipe line system is omitted. It will be necessary however, to instal a three mile 11 KV power line with a trifurcating pole and with an 11 KV/415V 3 phase transformer unit skid mounted to supply the wet gravity upgrading and wet magnetic separation plant and mining system and to supply copious sea water to the plant for washing the sand. A pumping unit will be required to pump excess water from the WGU & WMS plant back to the small lagoon adjacent to the present washing plant if pollution of the sea or adjacent Kokkilai lagoon is to be avoided. Such pollution could have disastrous consequences, killing sea life and raising the ire of the fishing communities living at Kokkilai. Large bore pipe line (12") should be used to minimise power requirements.

Only the relatively small amount of refined products, ilmenite (if there is a sale for it) and the non magnetic concentrate need then be carted to the P moddai plant. Tractor trailer units may be used but a small gauge railway should be seriously considered as these usually represent the cheapest means of moving moderate tonnages over short distances.

It should be pointed out that the WGU and WMS plant has excess capacity. Operating 7000 hours per year, a not unreasonable expectation, the plant has the capacity to produce 230,000 tpy ilmenite and about 50% more rutile and zircon than the dry mill can currently handle. During the years to 1984-1985 however, there will be power cuts and it is proposed that the electrical load of the WGU and WMS plant be shed while CEB power is off. The plant will then have the 150,000 tpy capacity called for in the tender document.

Existing Separation Plant

Dry Magnetic Separation plant

The dry magnetic separation plant is due to be phased out with the new WGU and WMS Plant and there is little incentive to improve its operation. The equipment is in poor condition. The grooves on the rolls, which give the convergence of magnetic field necessary for separation, have largely worn down; and the rotors need regrooving and, in some cases, roll replacement. Parts are not available as these are the only machines of their type in use in the world and their manufacture has long ceased.

Dry Mill & Wet Gravity Separation Plant

It was understand from the job descriptions, the project document and the various briefings that the above plant was fully commissioned. It had commenced operation in 1977. This, however, was not the case and some months were devoted to the urgent task of completing the commissioning process.

There were serious losses in the rutile circuit and useful zircon production was almost nil. Some zircon was produced but of substandard grade. That rutile product which was produced was to standard grade.

Incredibly, most of the rutile loss , amounting to over $2000 per day, was caused by the non availability of some 1 7/16" inch roller bearings for use in the Carpco magnetic separators in the dry mill. Such an item would be easily obtained by a Maintenance Supervisor and a Purchasing Officer who knew bearings in a developed country. Here the problem was of long standing and not on the way to solution. The American supplier, Rexnord of the original bearing type could or would not supply within 6 months. An equivalent was worked out by UNIDO personnel and bearings obtained by air freight from Singapore, but not before both the Team Leader and the Chairman of the Corporation had spent much time personally on the problem. It seemed to be beyond the scope of the personnel who were handling the problem or they gave up too easily. The fact that there is no effective communication between the Colombo Office where purchasing is handled and the plant did not assist. If a telex system was working it would be much simpler to tie down suppliers and Colombo office officials without having to write letters.

This is an example of how normally small problems become big ones. Good technical knowledge in purchasing personnel is important, especially if they are not in easy daily contact with the person writing the requisition who should also know exactly what is required and what are the alternatives.

The larger part of the rutile loss problem was solved when replacement bearings were obtained. The losses were further alleviated by installation of two new magnetic separators of a more modern type at the annual shutdown in January '81. At present losses of rutile in the dry mill ilmenite amount to less than 5% by assay compared with 50% previously. It is doubtful whether significantly better results can be obtained.

Dry mill ilmenite.

The dry mill ilmenite was assayed separately from ilmenite from the dry magnetic separation plant. It was suspected that this ilmenite (dry mill ilmenite) being less magnetically susceptable, contained oxidized ilmenite not suitable for the sulphate process. This was so. It also has a significantly higher titanium oxide (TiO_2) content. Also the dry mill ilmenite is significantly higher in chromic oxide (Cr_2O_3), a feature buyers do not like. It was recommended that this ilmenite be stored and, if possible, sold separately. If not, then it should be dumped.

Zircon product

According to design the dry mill was to produce zircon in both premium and standard grades with recovery of around 50% (rutile recovery is much higher) The accepted standards for these grades are

	standard	premium
$Zr.O_2$	65% min	66% min
TiO_2	0.30% max	0.10% max
Fe_2O_2	0.10% max	0.05% max

There is very little market for zircon of lesser grade than standard.

Zircon was being made but of much lower grade than standard (about 0.7% TiO_2) and recovery was low. The standard grade was achieved and premium is possible in all but the Fe_2O_3 content limit.

The Fe_2O_3 content is attributable chiefly to a limonite and goethite coating on the grains which must be removed by attritioning and chemical action. A circuit is set aside for this purpose. The circuit was set in order, slowly, and trial runs commended.

Unfortunately the locally made rubber lining of the attritioner cells and paddles soon lifted off and, at date of report, epoxy paddles are being produced. It is still doubtful if premium grade can be achieved as 0.05% max Fe_2O_3 is a tall order and can only be achieved by proper operation of both attritioner units, the existing unit in the wet gravity separation plant as well.

Results were obtained from change in electrode positions in the ES separators, from attention to tonnage loading on the rolls and by temperature control. In addition utilisation of the screen plate separators was increased.

The plant can now produce 24 tonnes per day of a good standard grade zircon product which amounts to 50% recovery. The losses are in the tailings of the zircon wet tables where rejection of quartz creates problems. The tables must treat a zircon concentrate containing 10% quartz and reduce this to less than 1%. Much zircon is lost in the process. A further fault was corrected by creating a water cut on the tables in addition to concentrate, middlings and tailings cuts. Previously excessive water was going to the small tailings bin and carrying quartz as it overflowed to the wash water bin in the closed water circuit.

This wash water returned to the tables and entered the concentrate stream, with the quartz, both directly, and via the water added to the concentrate launders to assist their flow. Hence separation performed on the table was being undone.

When the proposed WGU and WMS plant is commissioned a much better grade of concentrate will be presented to the existing wet gravity separation plant. Instead of receiving feed at 60% heavy mineral grade it will receive feed at 95% plus. This is as high as it currently outputs its concentrate. Its requirement will then be greatly reduced and it should be able to output its concentrate at 99% plus grade allowing the feed to the zircon wet tables to be 98 to 99% heavy mineral. The zircon tables will then have a much reduced function and zircon recovery should rise to above 75%, because it will not be necessary to reject so much zircon in eliminating the quartz.

<u>Wet Gravity Separation Plant</u>

This consists of spiral and Wilfley wet shaking tables plus a Stokes

Hydro-sizer to divide the feed material into coarse and fine fractions. The hydrosizer is not essential for separation. For a trial period the mill was run on unsized feed taking all the material into coarse by reducing the upflow current on the hydrosizer which carries the finer and lighter particles up into the overflow by rising current effect.

The hydrosizers function is to reduce the amount of minus 200 mesh i.e. minus 75 micron size rutile in the normal rutile product., since most rutile finds its way into chlorinators for pigment and titanium metal manufacture. (Some 20% of it is used for welding rod coating but here too, a coarse product is preferred.) In the fluidized bed chlorinator the minus 200 mesh material is a nuisance being carried away with the rising chlorine currents.

There is a market for both fine rutile and fine zircon separately in the rutile flour and zircon flour fields.

The hydrosizers performance is variable because the pressure of water supplied to it is variable. A new water pump for its sole supply was contemplated but when the water circuit is inspected it is found that the original provision was quite adequate if water is conserved. In particular, on the spiral separators wash water taps are either not working, or are turned full on resulting in water running to waste. Attention to detail in the water circuit will result in sufficient water being available for hydrosizer operation.

The fine fraction is generally small and makes up only about 10% of the concentrate deposited in the concentrate storage shed. Runs on fine material in the dry mill are infrequent as it is usually not possible to make a rutile product in one pass through the mill. This is of no great consequence as the amount involved is small and can be discarded, or rerun when enough is accumulated.

The coarse wet gravity separation circuit is not performing well for a number of reasons.

1. Insufficient stroke on the wet tables. It may be that modifications are necessary if the stroke is to be increased.
2. The rubber linings on the spiral separators are worn.
3. Poor standard of operation. Workers in the plant seem to have no idea what they are supposed to be doing.
4. At times more tabling capacity is required. This can be supplied by utilising one of the fine tables which is always available. A 0.75 inch hole cut in the bottom of the steady head distributor will provide 10 gallons per minute of feed which can be conveyed to the fines table via a 1½ inch round plastic launder. The direction of the cons, mids and tails launders underneath the table needs changing accordingly.
5. operation invariably falls off on the afternoon and night shifts.

While something can be done about all aspects mentioned above major alterations are not called for since the problem will solve itself when the new WGD and WMS plant is commissioned. The problem is, specifically,

a, the grade of concentrate emerging from the mill at 95% is too low,

b. losses of rutile and zircon from the circuit are too high.

Main Dryer

The main dryer DR 401 has an incredibly complex combustion system. It was intended to produce a reducing atmosphere in the dryer which assists high tension roll separation, but this effect can be produced in a much simpler fashion by visual control of the air fuel mixture. It is best to observe the flame from a peep hole at the opposite, feed end of the counter current dryer and adjust the flame from observations. A bright narrow flame is oxidizing: a dull, red, spreading flame with just a wisp of brown smoke emerging from the stack is a reducing one. The effect can be obtained by cutting back the air supply in a "Major 30 burner", if necessary by restricting air supply to the blower. Such burners have a single lever control which is easily connected to a pneumatic actuator worked from a pneumatic controller which takes its signal from the dryer outfall temperature.

A fan and cyclone on the exhaust system is unnecessary. A natural draft steel exhaust stack with a butterfly valve damper fitted is all that is necessary. The stack should be of at least 24 inch internal diameter.

The present control system is too complex and has not worked to design from time of commissioning. Even the team of experts sent out from England could not make it function. It has only ever worked "after a fashion" with, from time to time, some complicated instrument ceasing to function and remaining so. Spares cost $60,000.

Eventually it will cease to function altogether and then production will stop.

It is recommended that the small fire box be replaced by a brick lined fire box of similar internal diameter to the barrel of the dryer and that a Major 20 or major 30 burner with single arm control be installed. Armstrong Holland should be able to supply such a unit working from the original drawings. A natural draft exhaust system should be fitted. This results in a considerable fuel saving. The consumption figures should range between 1 gallon and 2 gallon (imp) per tonne of material dried. A figure near 1 gallon per tonne can be achieved but not with an excessively reducing flame.

Maintenance

Mr. King put together a very comprehensive preventative maintenance programme and this has been partly implemented. He concentrated heavily on the mobile equipment maintenance, since this was his field of expertise and for want of better guidance. He arrived nearly four months ahead of other team members.

The mobile equipment maintenance does indeed leave much to be desired. Of the eight Corporation owned tractor trailer units it is rare to find 3 operational. However the position is not likely to improve until organisational changes are made to the workshop. The foreman does not have the respect of the men who do as they please. This was pointed out by Mr. King and has since been repeated. However there seems to be some problem in replacing him.

When the WGU and WMS plant is commissioned there will be less need of mobile equipment, since tractor trailer use will be decreased. But if the plan to use tractor trailers to feed the plant is implemented there will be greatly increased demands on the mobile equipment workshop and its staff and facilities will need increasing. It would then be critical to improve its organisation.

Hopefully it will be possible to dispense with the problem personnel on downgrading the operations.

The main maintenance problem however is the separation equipment in the dry mill and wet gravity separation plant where breakdowns contribute greatly to lost productions. Plants of this type can, and do, operate with availabilities of 98 and 99 percent. This is the result of planned maintenance which need not, however, be formally planned. A single plant fitter with enough experience and cunning can see problems before they start. In this case lack of trade skills leads to problems snowballing. A fitter fails to align a V velt drive on a slurry pump and overtightens the belts, so the motor bearing fails, but not before "screaming" for days. No one notices, so the motor burns out because the thermal overloads are not set correctly. This in turn causes a problem like 'sanding' a bin and causing another pump motor to butn out; and so on. The electrical workshop gets a collection of burned-out motors in this and similar ways.

The only cure is improved trade skills and vigilance on the part of maintenance and operating personnel. There is usually some warning.

It may be added that the level of staffing in the maintenance sections is higher than for similar plants in developed countries, but this is not confined to the maintenance sections. All sections appear overstaffed by western standards, particularly in unskilled personnel. This certainly helps with the unemployment problem; but not necessarily with operational and maintenance problems as many men can do one mans job worse than he alone can.

Before leaving Dry Mill and Wet Gravity Separation plant operations it is necessary to point out that the present Supervisor, Mr Fernando, is overpromoted. Many of the problems described arise from lack of leadership. He cannot see his way around small problems and expects consultants to spoon feed him with solutions, virtually taking over the running of the operations. This officer has a pleasing personality and could adequately fill a lower position. He may well develop with more experience. For this critical position. however, a person with a more senior outlook is required.

The loading jetty is in danger of collapse. It has been damaged by high seas and by impacts with tugs and barges and in places the tension reinforcement of the RC construction has been exposed and corroded away. A contract for repair work has been let with another Corporation but there has been no action. It would be disastrous for loading operations in 1982, but preferable to having the jetty collapse while men and machines are operating upon it.

Morale

There is a morale problem at Pulmoddai which manifests itself at most levels. Several senior staff positions remain unfilled after staff members have left, often openly stating their dis-satisfaction.

At junior staff and worker level there is general slackness. Workers don't seem to know their jobs and it is hard to instruct them through a language barrier. Officers concede there is a discipline problem. Sleeping on the job is an obvious one. However, they contend there are special problems in maintaining order. Classic sacking offences go unchallenged because, they claim, it is extremely difficult to sack anyone.

The problem goes beyond this, however, as the workers don't identify with the Corporation, as they should. They are looking after their own personal interests without recognizing that, if the Corporation performs well (along with others), it is better able to give them a comfortable living and a few of the better things of life.

A particular complaint is that there is not enough delegation of authority, "Officers are treated like school kids". Certainly senior staff seem to spend their time endlessly signing paper work. While there is, no doubt, need to guard against pilfering and wasteful practices, it should be possible to see an overall report, of say, overtime worked in a section, expendibles issued from stores etc., without signing every form. It is impossible to build an organization of any size without delegating authority.

Accounts

I do not intend to go deeply into this subject as there are many people capable of reading accounts. A number of comments :

(a) The process of attributing costs to each product, ilmenite, rutile, zircon etc. is rather artificial since, to produce one it is necessary to produce the other. It complicates the reading of the reports and is not usual for establishments of this kind.

(b) the amounts set aside for the wet magnetic plant reserve seem low in comparison to the quotes of the tenderers.

Marketing

The marketing of the products could not be considered satisfactory either in terms of tonnages disposed of or prices received. The ilmenite industries started at roughly the same time in Sri Lanka and Western Australia, that is around 1960. In the intervening years Australian production has grown 6-fold while Sri Lanka's exports have declined to less than half their peak in the late 60s. Neither do prices realized compare favourably. (See chart in appendix 7a)

Shipping of large tonnages of rutile and zircon is relati[illegible] recent so no firm trends have emerged, but production of both could have to stop before the 1982 shipping season, since storage space at Pulmoddai will be full.

The products are all reasonable products (now that the zircon is on grade) comparing well with others available. There is a slight problem with grain size with rutile and zircon but fine grain is an advantage where ilmenite is concerned.

The relative advantages of Pulmoddai ilmenite are its fine grain, its higher than normal $T\ O_2$ content at 54% and its reasonably low $Cr_2\ O_3$ content (at about 0.07%). Its disadvantages are slightly high ferric iron to ferrous iron ratio which adversely affects the acid solubility and the fact that the Cr_2O_3 content is nonetheless higher than some Western Australian ilmenites. Sulphate producers like it as low as possible. (See Appendix T3)

One advantage Pulmoddai should be able to exploit is the closeness to the European market, particularly Italy and France. 70 to 80% of the landed cost of ilmenite can be represented by freight. Australia, Pulmoddai's main rival, is badly off in this regard, being the furthest place from almost anywhere.

The method of loading may have much to do with this as shall be dealt with later.

Buyers for sulphate ilmenite are hard to get but, once obtained, will not readily change suppliers. They value an assured supply of uniform grade material. If the feed to the plant is changed there is a long process of commissioning to the new feed, so care should be taken with bulk samples to potential buyers and no oxidized ilmenite emanating from the dry mill should be sent. Buyers will also be discouraged if they know there are plans to instal a sulphate route plant at Pulmoddai. They may feel that they will just get their plant attuned to the new material and then have their supply cut off for Pulmoddai's own use. It could, however, be a trial shipment to a potential partner to allow them to determine the parameters of the plant.

CMSC formerly handled its own marketing arrangements. This function has now been taken over the Tenders Board. Some 11,500 tonnes of bulk rutile has been sold but with a large delayed payment component and it now appears it will not be possible to ship the material as the shipping season is over. The monsoon has broken and shipment will have to wait till next season, probably next April. Before then, available storage will be full and production must, therefore cease; a situation which is hardly desirable.

The sale was made to a local private organization acting as agent. Marketing of mineral sands is a specialized field and is usually handled by a marketing division or by agents such as Associated Minerals and Derby & Co. Associated Minerals Ltd. (a different company but also an agent for smaller Australian producers) of Australia, the world's largest mineral sands producer has a Marketing Division with a Marketing Manager, who travels extensively visiting customers and keeping abreast of developments.

He keeps market statistics and draws graphs of production and sales from which he attempts to predict stock movements. AMA's Marketing Division has correctly predicted major swings in the market and is seldom caught making the wrong move. Consolidated Rutile has an associate company, Mineral Sales Pty. Ltd. with a Manager who holds an interest in the company and receives a commission on sales. Allied Minerals also handle their own sales with an internal sales division, and Rutile & Zircon Mines (Newcastle) Ltd. hold a number of long term contracts. One of their rutile contracts with Du Pont de Nemours ran for nearly 20 years.

Rutile is usually sold on average of 5 to 10 years ahead of production and relatively little is sold on the spot market. Hence spot market prices swing dramatically with relatively small changes in stock.

All these marketing divisions are sophisticated organizations run by specialists with extensive experience, and are perhaps beyond the scope of C.M.S.C. Other companies sell, or have sold, through agents. Dillingham Mining had sales conteacts with Associated Minerals (both of them) which ran for various periods in which the agent contracted to accept the full production at a fixed minimum price with a 50% split of the remaining price realized. These usually ran for 5 years but at one stage the Australian Government took a hand and restricted the duration to 2 years.

This is the kind of arrangement which, perhaps, would best suit C.M.S.C. for its rutile & zircon, but it does not mean that C.M.S.C. can afford to remain ignorant of developments in the market. A close watch must be kept on developments, otherwise the agent will sign C.M.S.C. to a low price contract just as they know the price is about to rise from watching stock figures decline.

Ilmenite is best sold direct to a buyer since it is a less standard product.

It is doubtful if any of the products will ever be successfully sold on the tender system. C.M.S.C's competitors are selling too aggresively for that.

Water Supply

Water is obtained from a pumping station sited at Yan Oya after passing through 4 miles of open unlined channel from an anicut (small dam) of negligible storage capacity on the Yan Oya river. This river has a catchment area of 570 square miles so there is usually ample flow. However, there have been times when the Corporation's requirements of 600 gallons per minute could not be met and production was interrupted, this during the dry season.

Another problem is the hardness of the water during the dry season rendering it unsuitable for the sulphate process or for cooling water in electro metallurgical smelting operations without extensive treatment.(App 9d)

Lastly, the water is supposed to be chlorinated and filtered to drinking water standard but is not, although of reasonable clarity except during the monsoon season. A chlorination and filteration plant was installed in 1973 but has never worked to specification. The problem was that the slow sand filters were slightly undersized (3 of 100' x 40') and clogged after 2 to 3 days service. It is standard practice with this filter type to manually shovel off the top 1 to 2 inches of sand and wash out the accumulated mud, then replace the sand. But this is usually done only after 4 to 6 weeks of service, so that the work load is tolerable.

At Corporation request, the filtration system became a UNIDO problem and a number of reports were written. The UNIDO team claimed no special expertise, but then expertise in this field seems to be at a premium in the country. I consulted with Mr. Jack Sell, Chief Water Engineer with UNICEF and another water treatment Engineer, showing them my reports in which I recommended a rapid gravity sand filter system as being more in keeping with modern practice. They agreed this was so, but felt that the slow filter system could be made to function adequately with the addition of flocculant and a mixing system immediately thereafter. Mr. Sell felt that 60' x 40' existing settling tank should be adequate if 40 ppm of aluminium sulphate was added and adequately mixed before the raw water entered it. The burden of removing the bulk of the sediment would then be taken from the filters as it would be settled in the tank. Mr. Sell made the point that slow sand filters remove 99% plus of dangerous organisms, an important factor where chlorination systems are seldom operated effectively.

The simplest way of implementation would be to add aluminium sulphate as a concentrated solution from an elevated tank as the water enters the system from the open channel. The water should then be lifted with a low head pump and passed through 2000 feet of 8 inch N.B. pipe before entering the existing settling tank, gently from a weir. The tank is divided into two so that one side can have collected mud removed while the other side remains in operation. Normally, of course, both sides operate.

The physical labour of cleaning the filters can be relieved, if necessary, by a simple washing plant consisting of a bin, pump and hydro-cyclone. The top sand-mud layer is shovelled into the bin and pumped to the cyclone. The thickened cyclone underflow redeposits in the filter for spreading and the muddy cyclone overflow is run to waste. If small enough the unit can be lowered into the filter bed for ease of operation.

Materials Handling

The shipping system is described in the introduction and was correctly identified as a problem area in the job descriptions and project document.

Apart from the inconvenience (and cost) of not being able to ship from October until mid-April inclusive, there is the slowness of the operation adding significantly to costs, sometimes hidden, and the direct considerable costs of maintaining the jetty and the "shipping fleet" meaning the barges and tugs.

The Corporation undertakes to load at the rate of 2000 tonnes per day and there is a penalty applied for delaying a ship. The penalty has been $2000/day, recently increased to $7000/day, but cannot represent the full cost of delaying a ship which is upwards of $10,000/day. In any case, force majeure is liberally interpreted the Corporation's way. A more realistic figure is about 1200 tonnes/day as usually something goes wrong.

Rain stops loading as does even a mildly rough sea, particularly with certain types of ships which roll badly. One Japanese ship was weeks loading a few thousand tonnes. In addition there are problems with the ships gear which must be used. There have been instances of inadequate winches, winches running at the wrong speed, small holds so that only one winch can operate, and so on. When more than one product is loaded the loading system must be thoroughly cleaned between products to prevent cross contamination. The barges present the main problem here.

Finally the operation is obviously spilly. There are wind losses on the conveyor, the jetty loading station, on the barges, and the mineral grabs leak. With the normal form of bulk loading a 1% loss is about average without there being any apparent source of it. Although there is no way of measuring, it is quite easy to imagine, in this case, that 3 to 4 percent is lost in the loading operation.

Most products are shipped in bulk which is fortunate since no system exists for handling in bags. At present, when bagged material is called for, it is bagged in the hold of the barge at the jetty. If the material is bagged before hand there are many problems. The bags deteriorate and are eaten by white ants causing leakage, and to move the bags from storage to ships hold requires some 20 manual handling operations.

In the cynics view a ship is a hole in the water into which you continually pour money. The budget for the shipping fleet in 1981 is 4.1 million rupees, 100 rupees per tonne of material shipped, and it has already been stated the jetty is badly in need of repair.

Some aspects of the operation can be readily improved upon. The conveyor throughput capacity can be raised simply by fitting a different electrical starter to the drive motor, but it is not usually the bottle neck; and a pneumatic conveying system could be used for transferring the mineral products into the ships hold. This could be mounted on each barge or have one separate barge mounted unit. These, however, are only marginal improvements and do not solve another problem. Ships' captains are unhappy, claiming Pulmoddai is not a "safe port" as described in their papers. Even a mile off shore keel clearance is only a fathom or so, and the consequences of dragging at anchor in a sudden blow could be disastrous. There was an incident some years ago when the barges and tugs were grounded.

All these problems must reflect on the Corporation's profit and/or on the price realized for the products, even if the cost is hidden. Standard practice is to road haul the products to a port with an alongside berth and to store in silos or bulk sheds. In the latter case during shipping, the material is reclaimed with large sized front end loaders, Caterpillar 988 size. In either case material is conveyed direct to the ships hold by 36 inch (at least) conveyor systems at rates upto 1000 tonnes per hour. Often two holds are loaded at once and there is provision for "trimming" the hold with "flingers" as the last is being loaded. "Trimming" is another hold up at Pulmoddai, although frequently an excuse to delay departure to a time more convenient to the captain or the shipping company. It means levelling out the mineral in the hold.

The obvious move is to adopt a similar system. Contract cartage rates are about Rs.1.25 per ton mile so material could be into store at Trincomalee for 60 Rs/tonne, less than the apportioned cost of maintaining the shipping fleet. It was not possible to think in these terms for the first shipment in early 1962 since there were then three ferries on the Pulmoddai-Trincomalee road, none of which would have taken a truck of any size. There are still two, still inadequate for trucks but one can be by-passed by adding 5 miles to the 35 mile journey, and building a bridge in place of the other, presents less of a problem than the necessary repairs to the jetty. There is also the possibility of building a causeway across the anicut at Yan Oya, adding a few miles to the journey but at small capital cost.

Certainly the maintenance problems of maintaining a bridge will be less than those of maintaining the jetty, in its exposed position. At the Trincomalee end there are a number of large storage sheds left from the days when Trincomalee was a large British naval base and a disused oiling jetty in the harbour which lends itself to use as a bulk loading facility. Adjacent to this jetty is a large portal framed building with solid cement floor 100' x 40' capable of storing 40,000 tonnes of one product, less if more are stored simultaneously. The Petroleum Corporation is presently using one third as a workshop. CMSC has another third, and the remainder is leased by a French company which has a limited term contract building facilities for the Prima Flour Mill. The foundations would have to be checked to see if they could take such a load, which is by no means certain. The jetty has a number of berths ranging from 6½ fathoms to 5¼ fathoms, adequate for the type of merchant ship which currently hauls from Pulmoddai. These draw about 4½ fathoms to the Plimsoll line. Conveyor runs from the building divide naturally into three of 310 feet, 750 feet and 500 feet respectively. The 310 feet run would have to be elevated as there is a road and train line to cross. These runs could be adequately covered by the present loading conveyor transferred to Trincomalee. This is a total of 1800' long in 3 sections. Naturally a larger conveyor than the existing 20 inch is preferable to load at a higher rate but would involve capital expenditure not only on the conveyor but on larger front end loaders to feed it as well and, it is doubtful if the added expense is warranted or available.

If this building is not available or has unsuitable foundations then there are other disused storage buildingsin Trincomalee and material could be carted from them at time of shipment by a fleet of trucks, as is another standard practice where wharf-side storage is not available. The switch to Trincomalee need not cost the Corporation any capital as money would be realized by the sale of the shipping fleet. The main capital items would be an elevator to initially raise the material over the rail level and the bridge, some of the cost of which should be borne by the Government.

Apart from this there is the possibility of sharing loading facilities with a proposed cement works, which is to use some of CMSC's land at Cod Bay, in Trincomalee harbour.

A move to Trincomalee would also be in keeping with long term plans since the obvious place to site a sulphate plant is Trincomalee, not Pulmoddai for a number of reasons :-

1. There is a port to move large tonnages of material out and in,
2. proximity to deep water for effluent disposal,
3. there is an adequate power supply, 60 MVA,
4. there will be an adequate water supply of good quality needing only removal of about 100 ppm of temporary hardness (not cheap though, 8 Rs/1000 gallon indicated).

CMSC's shipping history for 1981 is :-

Ship	Month	Loading Time	Tonnes loaded
Indus Maru	June	8 days	11,019
Alps Maru	June/July	7 days	10,480
Shinwa Maru	August	7 days	8,935
Carmilla Star	August	4 days	5,427
Cardiff	September	13 days	7,392
Vainci	September/October	6 days	7,167
TOTAL		45 days	50,420

Average : 1,120 tonnes/day.

1980 would not be any better.

So, reckoning the costs of shipping 50,000 tones per year

(a) From Pulmoddai :

Ship waiting time - 45 days at $11,000/day	$ 495,000
Cost of keeping shipping fleet: 1979 : 2.3 m.Rs, 1980 : 2.2 m Rs, 1931 budget 4.1 m. Rs.	$ 150,000
Loading out charges, stevedoring labour etc.	$ 14,000
Jetty & conveyor maintenance	$ 20,000
Spillage 3 percent 1,500 tonnes at $100/tonne	$ 150,000
	$ 829,000

(b) From Trincomalee :

Ship waiting time - $\frac{50{,}000 \text{ tonnes}}{6{,}500 \text{ tonnes/day}}$ x \$ 11,000/day:	\$	85,000
Road haulage :		
50,000 tonnes x 43 miles x $\frac{1.5 \text{ Rs/tonne mile}}{20.7 \text{ Rs/dollar}}$	\$	156,000
Loading out charges, stevedoring labour etc.	\$	5,000
Conveyor maintenance	\$	500
Spillage 1 percent 500 tonnes at \$100/tonne	\$	50,000
Rental on storage facilities & jetty	\$	25,000
	\$	321,500

Note: certain items, such as front end loaders, power etc. not calculated since they are essentially the same cost for both operations.

Hence a saving of \$500,000 is possible, some of which would be in higher prices realized since the ship waiting time charges are largely hidden.

With greater tonnage moved there are two more possibilities :

1. Move the material by barge to Trincomalee since the cost of maintaining a shipping fleet is largely a fixed charge with only a small element varying with the tonnage shifted,
2. construct a railway line, which would cost about \$10 million, but result in lower cartage rates.

Also with greater tonnage a wider conveyor would pay as an investment.

The time to look at changes is now, since the 900 feet long jetty must be re-built (building another alongside is the cheapest way of repairing it) and the shipping conveyor re-located anyway and 11,500 tonnes of rutile is now frozen at Pulmoddai until next shipping season and the storage space is required.

FUTURE STRATEGY

Overall

It is obvious that there is scope to develop a medium sized industrial complex around mining mineral sands and processing ilmenite to ti-oxide pigment. Such an industry will have significant impact on Sri Lanka's exports and balance of payments position as can been seen from the table below extracted from "Statistical Pocket book of the Democratic Socialist Republic of Sri Lanka - 1980", published by the Department of Census & Statistics.

Pigment and mineral sands related products could well replace rubber as Sri Lanka's second largest export as well as replacing imports from hard currency areas.

TABLE 59—COMPOSITION OF IMPORTS(1)

(*Rs. million*)

	1975	*1976*	*1977*	*1978*	1979
1. Consumer goods	2,651	1,732	2,534	5.618	7,824
(*a*) Food and drink	2,520	1,534	2,181	4.127	4,807
(i) Rice	1,062	642	916	689	884
(ii) Flour	1,002	671	871	2,192	1,691
(iii) Sugar	248	63	196	620	929
(*b*) Textile (inc. clothing)	20	49	150	531	1,536
(*c*) Other consumer goods	111	149	203	959	1,481
2. Intermediate goods	1,888	2,256	2,648	5,591	9,143
3. Investment goods	653	643	746	3,367	5,459
4. Unclassified imports	59	54	79	110	134
5. Total	5,251	4,634	6,007	14,687	22,560

Source : Central Bank and Customs Return.

(1)Customs data adjusted for Food Commissioner's and Petroleum Corporation's actual imports.

TABLE 60—COMPOSITION OF EXPORTS

(*Rs. Million*)

Commodity	*1975*	*1976*	*1977*	*1978*	*1979*
Tea	1,932	2,100	3,502	6,401	5,722
Rubber	654	830	931	2,025	2,502
Major Coconut products	397	383	334	971	1,298
(*a*) Copra	7	7	2	10	13
(*b*) Coconut Oil	188	188	40	322	509
(*c*) Desiccated Coconut	193	180	292	639	775
(*d*) Fresh Nuts	9	8	—	—	1
Precious and Semi Precious Stones	180	261	297	531	490
Other Domestic exports	467	1,167	1,103	2,580	3,853
Bunkers Domestic	293	46	448	667	1,363
Total Domestic exports	3,923	4,787	6,615	13,175	15,228
Re-exports	10	14	22	31	45
Total	3,933	4,801	6,637	13,206	15,273

Source : Central Bank and Customs Return.

The deposits are good by international standards, particularly gradewise, and the ilmenite is of reasonable quality for sulphate route pigment production. Quantity-wise the hundreds of millions of tonnes of titaniferous magnetite at Lac Allard, Canada overshadows the Sri Lanka deposits but this material is only 35% TiO_2, whereas Pulmoddai Ilmenite is 54%, quite high compared with the hard rock deposits mined in Norway, Finland and New York State and Lac Allard. (see appendix 13)

An industry supplying 80,000-100,000 tonnes of pigment per annum would be supplying less than 5% of world production. Long term growth rate of pigment consumption is around 5-6% per year; so, on average, such an operation must be started every year somewhere in the world. The added production capacity should not strain the market, but this is something for a foreign partner to decide on the basis of their inside knowledge.

Aspects Already Mentioned

A number of aspects to do with strategy have already been mentioned; these include:

1. The need to set up an exploration to determine the reserve position with sufficient accuracy to satisfy a potential foreign partner. This should include the preparation of mineral samples from the areas. Ilmenite from say, the Thevikallu area may contain excessive chrome or have some other problem. Such a fact should be known before the area is perhaps wrongly classified as a reserve.

2. The need to improve the materials handling operations as far as shipping is concerned.

3. The need to expand the ilmenite producing capacity so that the on-going rutile and zircon needs of the dry mill are met. The existing dry magnetic

separation plant can provide only half the dry mills capacity.

4. The need to set up a pilot plant to see if there are any nasty shocks in store in treating material from prospective areas. This need is some way off since the Pulmoddai deposit will provide the ore reserves for sometime to come. The area of immediate interest is the back of beach deposit at Pulmoddai which is to be worked by the new WGU and WMS plant.

5. Marketing, the need to actively promote and sell the product or to upgrade the ilmenite to a higher value intermediate product or finished ti-oxide pigment. These needs are, in fact, somewhat contradictory as explained, and as below.

Ilmenite Strategy

Also as previously explained the number of possible scenarios regarding ilmenite processing to higher value products was reduced to 4.

1. No further processing: just concentrate on marketing the ilmenite as it is. This represents the best return on capital invested since there is virtually none. Good grade sulphate route ilmenite, such as this, should realize $ A21 per tonne F.O.B. ($24.3) according to recent figures (appendix 7) adding some $2½ million with the expanded production.

i.e. (150,000 t.p.a. - 40,000 t.p.a. x $24.3 = $2,673,000).

It should be realized that the average export price of $A 21 for Australian ilmenite in 1979 was for a range of ilmenites, some of which realized only $A 15 because of impurities rendering them unsuitable for certain uses. Also Du Pont has a majority holding in Allied Minerals and gets its ilmenite from them at a price somewhat below its true market price.

The "straight" sulphate process is, however not the growth process. In fact it is sometimes referred to as "yesterday process" because of the environmental problems previously explained and the fact that the quality of the finished product is claimed to be inherently inferior. "Straight" sulphate production from ilmenite may even decline. The growth potential is for a different kind of ilmenite to Pulmoddai's, i.e. the oxidized ilmenites in which the leucoxenisation process has partially leached out the iron oxides giving a higher average TiO_2 content. These are destined for upgrading to artificial rutile, as at Capel W.A., and for the chloride process to produce ti-oxide pigment.

Such ilmenites are represented by the Eneabba W.A., type where TiO_2 is 60% and where the higher chrome content does not matter because of the above processes.

There is still scope for slagging Pulmoddai type ilmenites, but this is best done on site since the iron content can be recovered for local use.

So the long term market potential is uncertain.

Also, while $2½ million p.a. is undoubtedly a boost to Sri Lanka economy it pales into insignificance beside some of the other schemes as foreign currency earners.

Scheme 2 i.e. the straight sulphate process combined with sulphuric acid and superphosphate production.

This scheme is attractive economically showing 33% return on Capital (see appendix) and about $130 million nett foreign exchange advantage. Capital investment of $230 million is involved.

It is the simplest of the three schemes, a considerable advantage, not only from the point of view of locals handling the technology, but also from the point of view of putting together a consortium to handle the scheme. It might even be possible to get one single party, like Kemira or American Cyanamid to handle the lot. Only three technologies are involved, i.e.

sulphate route pigment production

sulphuric acid production

superphosphate production.

The disadvantages of the scheme are largely in the intangible category.

(1) the pigment quality is inherently lower than for schemes 3 and 4 which are again lower than for chloride production. Colouration causing impurities are lost both the pre-reduction process and the slagging process. As already explained, there is doubt whether the quality difference is noticeable in the final product and this justifies the added productions expense of the chloride process.

(2) the quantity of effluent disposed of is the greatest of all the schemes viz

Effluent	Tonnage '000 tonnes scheme 2	scheme 3	scheme 4
Copperas	350	44	7
acid (diluted)	50	70	48
dust	nil	7.5?	3?
hydrogen fluoride H F	?	?	?
sulphuric acid wastes (gaseous)	?	?	?

Copperas is the chief disposal problem and the chief source of annoyance, although it is not critical in this case. Hydrogen fluoride is a nasty effluent but the quantity is not large and it can be neutralized to form fluorides necessary to treat water supplies.

(3) The iron content of the ilmenite is not recovered to supply the countries steel needs.

(4) Superphosphate production is the lowest of the three. There is also some doubt about whether what is shown on paper can be done, i.e. treating phosphate rock with roughly equal quantities of strong and weak acid. A higher proportion of strong acid might be needed.

(5) The quality of the superphosphate will be lower since it will contain appreciable amounts of ferrous sulphate. The trend recently is to reject superphosphate for the more concentrated phosphate fertilizers such as triple phosphate or ammonium phosphate, the latter also supplying one of the three necessary plant nutrients, nitrogen. Hence any down grading of superphosphate could render it unsaleable. (Sri Lanka currently imports about 40,000 t.p.a. superphosphate at $257/t C.I.F., selling with a considerable subsidy).

Scheme 3 i.e. additionally to scheme 2 electrosmelt the ilmenite to produce slag for the sulphate plant and raw iron.

This scheme is the least attractive on paper indicating only 29% return for a considerably increased investment indicated in the order of $300 million.

Also, the economics are excessively sensitive to power costs because of the big power component and increases in power charges are anticipated (appendix).

Another aspect is the dust nuisance as much of the ash content of the coal, together with 4% of the TiO_2 and iron content, and considerable quantities of the other impurities of the ilmenite charge are discharged to the atmosphere as dust. This amounts to some 10,000 tonnes of dust p.a. The dust nuisance is reduced (but not eliminated) in Scheme 4.

Scheme 3 represents a furthur degree up the ladder of sophistication but everything shown on paper is possible, which it might not be for scheme 4.

Scheme 4 i.e. additionally to 3 and 2, add a pre-reduction stage which effects a 60% reduction in electro smelting capacity and in power consumption.

This is an attractive scheme on paper indicating a 35% return on investment of the order of $ 300 million. Nett foreign currency gain is about $ 170 million p.a.

There are additionally many intangible benefits.

(1) thousands of jobs.

(2) maximum opportunity to exploit two good natural resources.

(3) general development of the Pulmoddai, Trincomalee and Eppawela areas.

(4) import replacement.

Specific advantages over the other schemes are:-

(1) the best pigment quality. Chromium,vanadium and niobium,the discolouring impurities are partially removed in the pre-reducing and electro smelting stages, and there is no need for scrap iron to be added in the sulphate process, so no further impurities are added.

(2) dramatic reduction in copperas effluent output and considerable reduction in waste acid output.

(3) reduced dust nuisance compared with scheme 3.

(4) greatest output of pigment, iron and fertilizer for the same inputs.

(5) It is less sensitive to power charges than scheme 3 and uses a cheaper and more available coal.

Specific disadvantages are

(1) it represents the highest level of sophistication and some of the processes are not properly de-bugged.

It took some time to work out some of the problems with the pre-reduction process and the technology is supposed to be proprietary. A paper on the process "Direct Reduction Technology - The Western Titanium Process for the Production of Synthetic Rutile, Ferutile and Sponge Iron" by B.F.Bracanin, R.J.Clements and J.M.Davey, The Aus. I.M.M. Conference at Western Australia, 1979, refers to a "process licence fee payable to AMC".

None the less, a plant is being installed in India and at other places, and would be available for trial runs.

The electro smelting operation is not without its problems either. Q.I.T. commissioning at both Sorel,Canada and Richards Bay, South Africa was a painful process. The Richards Bay slag for some time was not acid soluble and early operations at Sould lost money. So even if QIT was engaged as a partner or consultant, there is no guarantee of success initially at least.

(2) Since so many technologies are involved in sulphuric acid making, super-phosphate, sulphate route pigment making, electro smelting and direct reduction it is hard to imagine a single partner as distinct from a consortium being involved.

The latter would be harder to find and arrange.

There is also the potential problem of matching Soviet technology, if the All Union Titanium Institute is involved, with western corporations.

(3) Many of the operations shown on paper haven't been tried yet.

The pre-reduction operation requires plant scale testing. To quote the paper;-

"Not all ilmenites and coals will prove totally suitable for the process and the relative value of these raw materials may not be apparent from their compositions alone but will require laboratory and plant scale testing."

Also the electro smelting has not been tried with the prereduced feed.

The acid, superphosphate and sulphate plants are long established technologies but tests should be run with a dressed Eppawela phosphate sample feed for the superphosphate operation to establish its suitability and the parameters of an operation; and there could be some surprises in adopting this particular slag for the sulphate process. Acid solubility tests at least, should be performed.

Summary of Schemes

Summing up, it seems from this analysis that scheme 4 represents the best solution from the point of view of balance of payments and return for capital investment, but many questions remain to be answered.

Scheme 1 represents the best return on capital. but the foreign currency benefits from a balance of payments point of view are minimal, and there is the danger of a limited future for this type of ilmenite.

WHAT REMAINS TO BE DONE

It is obvious from the foregoing that work remains to be done, both because more was involved that was anticipated and because the scope of the project expanded as the phosphate possibility became apparent.

A number of these needs have already been identified. These will simply be listed with appropriate comments.

Identified Needs

(1) Establish the heavy mineral reserves both in the Pulmoddai area and in other parts of Sri Lanka. This includes mineral species make up and sizing information and pilot plant tests to identify potential problems.

(2) Since many millions of dollars are involved, carefully rework the economics of the four schemes using accurate figures. The lack of library facilities and reference material hampers this work in Sri Lanka especially at Pulmoddai. It would also be helpful to talk to personnel from chemical companies manufacturing ti-oxide pigment to get their point of view and identify any points missed.

(3) Conduct plant scale pre-reduction tests on a bulk sample of Pulmoddai ilmenite and laboratory and/or plant scale tests on bulk samples prepared from other areas if differences are seen to exist.

This work may be done in India at the new sponge iron facility.

(4) Conduct electro-smelting tests on the pre reduced sample. These tests would be plant scale and should establish the parameters of an operation i.e. furnace size, units per tonne, coal per tonne etc. It may be necessary to identify coal sources for both this and the pre reduction tests.

Other Needs

Other needs, needing more elaboration are:-

(1) establish the Eppawela phosphate reserves. These reserves need to be established to the point of being satisfied that there are sufficient reserves to support the operations described. Ideally, the phosphate reserves would last as long as the ilmenite reserves, an indicated 60 years.

While it is indicated that the reserves are extensive, not enough is known at this stage.

(2) The phosphate deposits need technical evaluation in two forms -

(a) mineral dressing tests to determine what treatment is necessary to reduce the I & A (iron oxides and alumina) content. Possibly a mixture of flotation and magnetic separation is involved, after crushing.

(b) run tests to determine the parameters of the superphosphate producing operation and to determine the minimum strength of acid that can be used in economic operations. It may turn out that the operation shown in schemes 2 and 3 and, for that matter, even 4, are not possible economically and the whole scheme has to be rethought.

(3) Establish potential sources of the coals, oil and sulphur required. The coals need to be watched from the point of view of introducing unwanted and deleterious impurities.

It is anticipated that the sulphur may be available from a proposed oil refinery at Trincomalee if it is treating a high sulphur crude.

(4) Establish the suitability of the raw iron emanating from the electro smelting furnaces for upgrading to steel in the country's available equipment. It is anticipated that this is possible and some discussions with the Steel Corporation have been encouraging, but the point needs to be definitely established. Some information is shown in appendix 12

(5) Conduct preliminery discussions with the other Corporations involved, both with the Eppawela phosphates and with the Steel Corporation. This may need to be initiated at higher government level, to bring the plans into line. The Steel Corporation, for instance, is promoting a small underground iron ore deposit at Seruwila as the source of Srk Lanka's future steel needs, either by blast furnace or by a direct reduction process. I find it difficult to take this plan seriously, being somewhat familiar with the deposit.

(6) There is some doubt that superphosphate is the right ferilizer to make, particularly for export. The stronger phosphate fertilizers, triple phosphate and ammonium phosphate are more modern and find a readier market.

To make them it is necessary to make orthophosphoric acid H_3PO_4 from sulphuric acid and react the phosphate rock with this. In the case of ammonium phosphate a furthur processing step is needed to form ammonium phosphate.

A preliminary market study is needed to see if the extra complication is warranted, remembering that projected outputs of superphosphate exceed Sri Lanka's needs.

PROJECTED UN ROLE

I see the UNIDO role as putting together a package to offer a foreign partner or consortium of foreign partners, as a basis of negotiations. It is anticipated that a deal would run along the lines that the partner would contribute the capital cost of the ilmenite upgrading project(s), paying a fair price for phosphate rock, or bringing the mining and processing of this rock intc the scheme as well.

The Sri Lankan Corporation would contribute the reserves and the existing plant. Management would be the responsibility of the foreign partner who may require certain assurances as to the disposal of the raw iron product, repatriation of profits, security from nationalization, and an agreement on handling labour problems.

Profits would be split 50/50 or 60/40 (6o to the foreign partner) after paying taxes depreciation, etc.

The Government may requтre a royalty of 1 to 2 percent on the value of minerals extracted from the ground and certain assurances that the products would not be sold at an artificially low price to, say, a subsidiary company of the foreign partner.

In negotiating such a scheme the Corporation would need to have thoroughly done its homework, i.e. have before it a study showing the technical feasibility and economics of every scheme proposed. If the feasibility work is done by reputable organizations in good faith the foreign partners may well see no necessity of repeating it.

To enter such negotiations prepared in this way would greatly increase their chances of success and of an outcome favourable to the Corporation and the Sri Lankan people and economy. A foreign partner is needed for capital, expertise etc but Sri Lanka needs to make the best deal possible.

It shouldn't enter negotiations underprepared.

Future UN Involvement

Obviously there is scope for a modest outlay in aid funds to lead to the start of a major industry, but I am still reluctant to recommend further expenditure, both for general and specific reasons.

The general reasons are the general shortage of aid funds which must be shared amongst many projects most,admittedly, without the potential of this one.

The specific reasons are to do with the way the affairs of the Corporation are being conducted and with having the teams recommendations implemented. The former will be apparent from remarks earlier in the report and from the Audotor Generals remarks in recent annual reports.

The latter means that Consultants must be listened to and should not have artificial restraints imposed upon them. Wilska and Harrach, for instance, worked on the premise that the site of future upgrading of ilmenite operations must be Pulmoddai, which is clearly out,considering power, water, effluent disposal and materials handling problems.

Presuming the Corporation and Ministry can meet UNDP half way, I see the following as the scope of future aid involvement.

(1) Aid in establishing reserves, both mineral sand and phosphate rock. The services of a geologist with experience particularly in mineral sand exploration would be required for at least 12 months.

(2) Aid in establishing the technical feasibility and parameters of the flow sheet shown in scheme 4. Involved would be

(a) large scale prereducing tests with Pulmoddai ilmenite, probably in India or Australia.

(b) large scale electro smelting tests of the prereduced ilmenite, probably at Zaporozhee

(c) acid solubility tests on the slag produced by (b) above; also probably Zaporozhie

(d) An investigation on a sample of Eppawela phosphate to establish the mineral dressing required to reduce the I & A content and then on the dressed sample, establish the process parameters for productions of both superphosphate and triple phosphate fertilizer using sulphuric acid. This should include tests to establish the lowest concentration of sulphuric acid it is possible to use and whether the in-evitable entrainment of some ferrous sulphate with the medium strength sulphuric from the sulphate process will materially affect results.

(3) Having done the above or, to save time, in conjunction with the above aid the Corporation in putting together a proposal to offer potential foreign partners. There will necessarily have to be some flexibility about the proposal. This work involves both technical and business matters and would need at least 2 persons, one of whom was described in the job description "Expert in Titanium Di-oxide Pigment Technology" together with his functions. To these duties should be added the over-seeing of the work described in 2 above.

The second would be a management consultant who would assist in the financial aspects of drawing the proposal and suggest commercial considerations. He would also assist in upgrading of current operations implementing management schemes along standard business lines and attending to the aspects raised by the Auditor General.

Both these experts would need a 12 month term to have the necessary impact.

A C K N O W L E D G E M E N T S

The author wishes to thank the following for their co-operation and help in the project and in preparation of this report.

The team members named

Mr. Y.Y. Keri, Resident Representative
UNDP Colombo

Mr. V. Lavides, SIDFA
UNIDO Colombo

Mr. F.B.P. De Silva, Chairman, Managing Director
Ceylon Mineral Sands Corporation

Mr. S.A. Nandedeva, Plant Manager/Operations Manager
CMSC and my counterpart

Dr. E.T. Balazs, Acting Head
Metallurgical Industries Section
Industrial Operations Division
UNIDO, Vienna

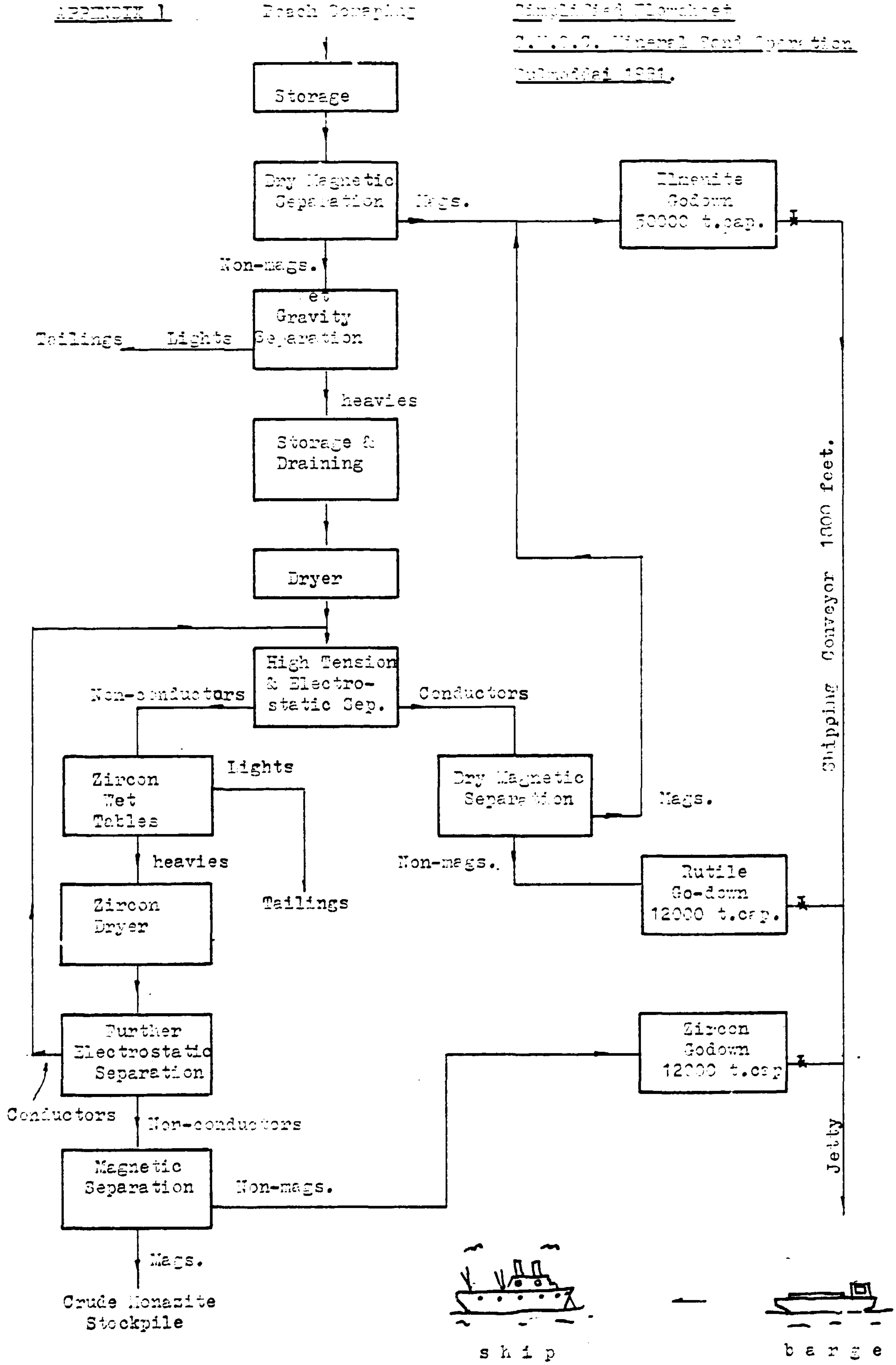
(4) In addition, assistance is needed to upgrade current maintenance operations, mainly by imparting trade skills and the ability to foresee problems.

Such a person would need to take up the tools and show by example. He would have long experience in operating maintenance with this type of plant or a trade teaching background in fitting, turning, welding etc. The person need not necessarily be professionally qualified.

Again at least 12 months would be required for the necessary impact.

APPENDIX 1

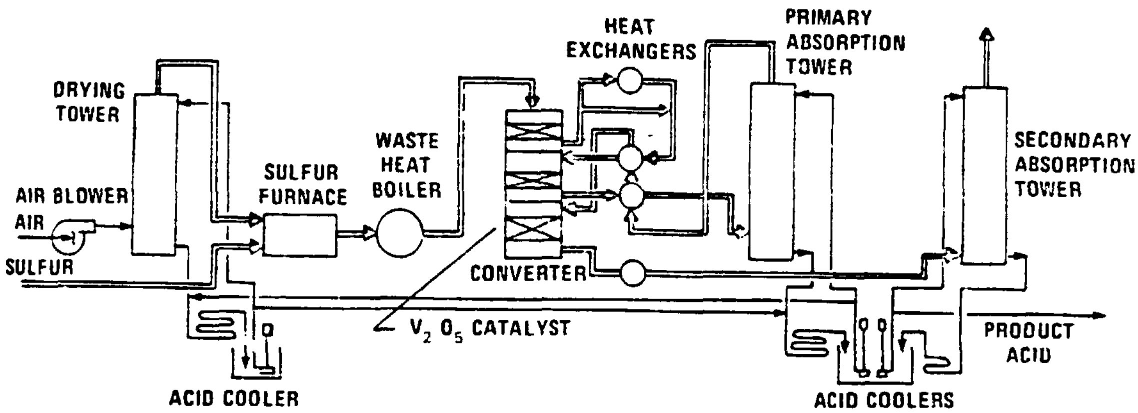
Simplified Flowsheet
C.M.S.C. Mineral Sand Operation
Pulmoddai 1981.



K.L.

Appendix 2

SIMPLIFIED FLOWSHEET OF DOUBLE-CONTACT SULFURIC ACID PLANT



SOURCE: INDUSTRIAL MINERALS AND ROCKS, AIME.

Figure 2.—Simplified flowsheet of a double contact sulfuric acid plant.

From: "Mineral Facts & Problems"

US Bureau of Mines

Centennial Edition

1975

Appendix 3A

In Sri Lanka phosphate rock (apatite) was discovered by the Geological Survey Department in April, 1971 at Eppawala (Fig. 15) 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 are 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 percent 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 percent 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 20 is presented to show the chemical analyses of the phosphate rock from the phosphate rich ore zone. The mineralogy is also listed.

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 percent available P_2O_5. Triple phosphate is a much more concentrated fertilizer which contains from 45 to 50 percent 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."

TABLE 20

CHEMICAL COMPOSITION OF PHOSPHATE ROCK (APATITE) — SRI LANKA

Constituents	Theoretical $3[Ca_3(PO_4)_2]$.CaF	*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	42.3	36.60	36.04	33.00
CaO	55.6	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
Ma O ?	-	0.09	0.08	0.19
F	1.88	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
Excess Ca O		4.98	4.11	0.35
Total		100.17	99.96	100.07

MINERALOGY — Apatite (primary) insoluble, Francolite (secondary apatite) partly soluble, Martite (secondary iron) Rutile and geothite.

Geological Survey Department,
Colombo 2.

From: " Mineral Resources of Sri Lanka"

J. Herath

Geological Survey Publication

Appendix 3a From:- "Proceedings of the 7th Annual Sessions of Institute of Chemistry" Colombo 24-6-78

Apatite.

The apatite deposit occurs as six elevated hillocks at Eppawela in the Anuradhapura district. The mineralogy and chemistry of this deposit has been studied in some detail both at the Geological Survey Department laboratories and at the Institute of Geological Sciences, U. K. A brief study on a single powdered sample was also made in the laboratories of the Tennessee Valley Authority, U. S. A. A summary of the more important characteristics of this deposit is given below:—

(1) The rock phosphate forms a so-called "leached zone" which is derived from a fresh "carbonatite" rock seen at a depth of about 200 ft. below the higher elevations of the deposit. The fresh primary apatite which is

green in colour is of igneous origin. Because of its low water and citrate solubilities, this variety is of little or no value as a source of plant nutrient phosphorous if applied in the raw state.

(2) Apart from the green primary apatite this "leached ore" zone consists largely of the secondary apatite, francolite, together with martite and a pale brown mineral consisting of rutile and goethite.

Francolite - $Ca_5(PO_4CO_3OH)_3F$ is a secondary carbonate fluo-apatite, soft and powdery, forming the bulk of the matrix of this deposit. Francolite is very characteristic of some secondary phosphate deposits developed on carbonatites elsewhere in the world (e g. Uganda).

Martite - Fe_2O_3 - is a secondary iron mineral derived from magnetite. This mineral too occurs in the matrix of the rock as large grains, brown in colour, which is the hard material that cements together the green primary apatite. A mixture of rutile and goethite (FeO - OH) also occurs in the matrix of the leached apatite zone and is pale - brown in colour.

From the chemistry and mineralogy of the Eppawela apatite bearing ore it is established that the material which is mined for direct application is composed of the following materials:—

(a) The primary apatite that occurs as a greenish vitreous mineral forming crystals.

(b) The matrix forming the binding materials for the primary green apatite composed of the following minerals.

(i) Francolite $Ca_5\ (PO_4\ CO_3\ OH)_3\ F$.

(ii) Martite - secondary iron oxide, with rutile and goethite (FeO - OH).

When this bulk apatite is crushed, the matrix is also crushed and there will be a combination of all these minerals.

A model analysis of a sample at the T. V. A. has given the following approximate composition:—

Apatite	72·7
Calcite	9·0
Dolomite	0·2
Goethite	6·0
Quartz	2·0
Amorphous Al-silicates	5·5.

The Sri Lanka apatite has a complex chemical composition. It is basically a fluo-apatite with significant amounts of chloride and hydroxyl ions.

TABLE 4.—Chemical Composition of Apatite

Sample Constituent	M/R 564	EP/Z/P	EP/3/P
SiO_2	4·70	0·30	0·60
Al_2O_3	2·71	2·23	7·05
FeO	—	0·70	0·54
Fe_2O_3	5·40	2·30	7·70
TiO_2	—	0·78	0·60
P_2O_5	29·10	36·04	33.00
CaO	45·20	51·60	43·63
MgO	0·17	0·23	0·29
SrO	—	0.65	0·60
BaO	—	0.26	0·62
Na_2O	0·16	0.08	0·19
K_2O	0·06	—	—
CO_2	5·10	—	—
S	0·11	—	—
F	2·20	2·43	1·74
Cl	0·72	1·04	0·98
ThO_2	—	0·03	0·01
H_2O	—	2·63	3·60
Less O — F and Cl	1·09	1·34	1·08
	94·55	99·92	100·07

Analysis of MR/564 at T.V. Authority, U.S.A., EP/2/S and EP/3/S, Geological Survey Dept., Colombo.

In an evaluation of this ore the following points are therefore noteworthy:—

(i) The comparatively high content of *rhombic carbonates* (normally the calcite) can cause a large CaO : P_2O_5 ratio which can make it not very favourable for wet-process superphosphate manufacture.

(ii) If we denote R_2O_3 to represent *iron and aluminium oxides* present in the ore, the R_2O_3 content of this ore (8·1%) would be considered high (using industry standards) for feed materials in the wet-process superphosphate manufacture. The maximum value generally preferred is about 5% R_2O_3.

(iii) The *chloride* content of the Sri Lanka apatite is high (0·72%) compared to the industry standard of about 0·02%. The release of chlorides at this concentration during acidulation represents a potentially serious corrosion problem for plant equipment. The mineral study has shown that the chloride is associated with the apatite in the lattice.

(iv) *Reactivity* The apatite in the Sri Lanka phosphate ore is not very reactive. The neutral ammonium citrate solubility is about 2·8% which is about 40% of the solubility of Tunisian phosphate and 20% less than the minimum value recommended for direct application so that grinding would have to be finer than usual for use even in superphosphate production. From the chemistry and mineralogy of this ore, it is evident that some beneficiation will be necessary before it could be used effectively for fertilizer manufacture.

Physical beneficiation such as attrition grinding of this rock, to remove iron oxide coating from the surface of the apatite particles, followed by de-sliming, should remove most of the R_2O_3 in the ore, significantly increasing its grade and improving its potential use in fertiliser process.

(v) *Free Carbonates:* Removal of free carbonates by calcination (about 700 - 1000°) can significantly increase the R_2O_3 contents of the ore. Because the Sri Lanka apatite is of igneous origin, calcination temperatures necessary to decompose the carbonates should have little effect on the characteristics of the apatite. A calcination could also result in a reduction of R_2O_3 solubility in the wet process.

(vi) *Fluoride and Chloride:* It has been established that F, Cl are present within the apatite structure and cannot be easily removed. Calcination of the rock at about 1200° in the presence of steam will cause the apatite to expel the chloride and fluoride from its structure and be converted to hydroxy apatite. Thermal de-fluorination is considered to offer several important advantages in the case of the Sri Lanka apatite. The elimination of fluorine and chlorine is assisted by mixing an acidic additive - silica is commonly used for the purpose.

Another possible alternative for the manufacture of a fertiliser end product is to fuse the Eppawela apatite with serpentinite (which is a magnesium silicate) in an electric furnace at about 1550°C, quench with water, dry and grind to a fine powder. The final product is known as fused magnesium phosphate.

As *serpentinite* of a high quality has been noted in the Uda Walawe area this material could be readily used for this process. Initial field surveys carried out by the Geological Survey Department reveal that the serpentinite is spread over an area of about 300 acres in the Uda-Walawe. Some experiments have been carried out both in the Geological Survey laboratories and elsewhere, with encouraging results. The fused magnesium phosphate fertilizer is as good or even superior to soluble superphosphate as a source of phosphorous under the right tropical soil conditions. This type of thermal phosphate fertiliser will not be subjected to serious phosphate losses as compared to water-soluble fertilisers especially in tropical countries. Adequate field trials by the various agricultural organisations would be necessary to ascertain the suitability of this product for our soils, before embarking on large scale production.

With regard to the world situation in respect of apatite, it should be noted that *Phosphate rock* is at present no longer a cheap mineral raw material as it used to be in the pre-1973 era. The increase in prices and changes in supplies of oil and petrochemicals has had its effects on prices of raw materials such as phosphate rock. A buyer formerly paying $ 14 per ton of N. African phosphate rock, in 1974 paid $ 63 per ton.

The Sri Lanka apatite deposit is estimated at about 25 million tons with an inferred ore reserve of an additional 15 - 20 million tons. Considering the price hikes of phosphate rock and the properties of our apatite arising from its complex character, careful consideration should be given to the development of the Eppawela phosphate deposit as a potential end-use for fertiliser. More detailed investigations are obviously necessary both on laboratory and Pilot Plant scale followed by field trials before any decision should be taken concerning the future use of this valuable deposit or the kind of process which should be adopted for conversion to a fertiliser product, that would be most advantageous to Sri Lanka As I mentioned earlier, phosphate rock beneficiation could also lead to a recovery of rare-earth minerals in the apatite even at low levels of concentration, and when one considered the magnitude of the ore and its estimated reserves the recovery of the rare-earths from our apatite could be considerable.

Phosphate rock

The main mining areas are Florida and Morocco. The rock is sold on a moisture free basis rated as "bone phosphate of line" B.P.L. which is

$Ca_3(PO_4)_2$

The grades and their corresponding P_2O_5 contents are shown below.

Grade	B P L (%)	P_2O_5 (%) (mid range)	I & A max(%)
	77-76	35.0	3 to 4
	75-74	34.1	3 to 4
	73-72	33.2	3 to 4
	72-70	32.5	3 to 4
	70 68	31.6	3 to 4
	68-65	30.5	3 to 4
	66-64	29.8	5

I & A is "iron oxides and alumina". In the range 3 to 4%, 2 units of BPL are deducted for one unit I &A. Assays are on a moisture free basis, but moisture limits are

H_2O not more than 3.5% for grades 1 to 5.
" not more than 5% for grades 6 & 7,

Prices, Oct. '74

Grade	$/ST,FOB Tampa	$/ST, FOB Morocco
77/79	-	69.4 calcined
77/76	56.25	-
75/77	-	61.7
72/70	43.55	
66/64	32.66	

Consumption

	'73	'85 est
	112 million S.T.	200 million S.T.

On this basis EP/1/P and EP/2/P represent high grade phosphate except for I & A. EP/3/P is a lower grade. Magnetic separation should remove the iron oxides.

See also appendix 7d.

Appendix 3C

Phosphorus Fertilizer Materials

Historically, bones served as a source of phosphorus, yet as recently as 1840 the value of bones as a fertilizer was found to result largely from their phosphorus content. At about this same time, Liebig suggested that bones be treated with sulfuric acid to increase the solubility or availability of the phosphorus. This marked the beginning of the modern day fertilizer industry because it led, in 1842, to the patenting of a process for the manufacture of superphosphate by the treatment of mineral rock phosphate with sulfuric acid.

The only important source of mineral phosphate used to manufacture fertilizers today is rock phosphate (see Fig. 12–3). The production of ordinary superphosphate by the acidulation of rock phosphate with sulfuric acid is shown in Equation 2.

$$3[Ca_3(PO_4)_2]\cdot CaF_2 + 7H_2SO_4 \rightarrow 3Ca(H_2PO_4)_2 + 7CaSO_4 + 2HF \quad (2)$$

(rock phosphate) sulfuric acid monocalcium phosphate gypsum hydrogen fluoride

The ordinary super phosphate produced by reaction 2 consists of about half monocalcium phosphate and about half gypsum. The hydrogen fluoride can be recovered and in some cases is used to fluorinate water. Ordinary superphosphate has a phosphorus content of about 9 percent P or 20 percent P_2O_5.

Under proper conditions the reaction of rock phosphate with sulfuric acid will yield phosphoric acid. By treating rock phosphate with phosphoric acid, a more concentrated superphosphate can be produced as follows:

$$\text{rock phosphate} + 14H_3PO_4 \rightarrow 10Ca(H_2PO_4)_2 + 2HF \quad (3)$$

The same phosphorus compound is produced with sulfuric acid and phosphoric acid, but without the production of any gypsum when phosphoric acid is used. This more concentrated superphosphate contains about 20 percent phosphorus or the equivalent of 45 percent P_2O_5. Concentrated superphosphate is commonly called triple superphosphate. Both types of superphosphates are of about equal quality as fertilizers when the same amount of phosphorus is applied.

Ammonium phosphates are produced by neutralizing phosphoric acid with ammonia. The two popular kinds produced are monoammonium phosphate and diammonium phosphate. Ammonium phosphates are good sources of both phosphorus and nitrogen, the phosphorus being water soluble. Some ammonium phosphate is produced as a by-product of the coking industry by using the ammonia produced in the coking of coal to neutralize sulfuric or phosphoric acid.

Endamentals of Soil Science
H.D.Foth @ L.M.Turk
Wiley Eastern Private Limited

APPENDIX 4

Scheme 2 based on Wilska Report

Treat 175,000 t.p.a. of Pulmoddai ilmenite into 79,000 t.p.a. of ti-oxide pigment by the sulphate process. This is integrated with a 250,000 t.p.a. sulphuric acid plant and the waste acid from the pigment plant and some from the acid plant used to treat phosphate rock from Eppawela into superphosphate fertilizer.

Location assumed:- Trincomalee

(a) Capital Costs

		$ m
79,000	t.p.a. pigment plant (sulphate route)	100
115,000	t.p.a. superphosphate plant	30
250,000	t.p.a. sulphuric acid plant	35
	infrastructure, ware houses, loading and unloading facilities, housing	20
		185
	allow 25% contingency	46
	Total	231

(b) Running Expenses, per annum

			$ m
175,000	tonnes ilmenite	@ $ 25/t landed	4.37
17,000	tonnes scrap iron	@ $120/t landed	2.04
80,000	tonnes sulphur	@ $145/t landed	11.60
2,100,000	c metres water	@ Rs8/- per 1000 gall.	0.18
	chemicals, spares, consumables		3.50
2,500	workers	@ $750/a	1.88
	expatriate supervision		0.15

...-/ Over

		$ m
7,500 tonnes distillate	@ $400/t	3.00
3,750 tonnes kerosene	@ $350/t	1.31
205,000 tonnes sulphuric acid - supplied		
750 tonnes titanium tetrachloride - supplied		
ex rutile (252 tonnes reqd)	@ 250/t	0.06
54,500 tonnes heavy fuel oil	@ $200/t	10.90
8,000,000 units of electrical power	@ 4c/u	0.32
68,000 tonnes Phosphates(Eppawela)	@ $50/t	3.40
	Sub-total	42.71
	allow 25% contingency	10.68
	Total	53.39

(c) Outputs.

Tangible

		$ m
79,000 tonnes ti-oxide pigment	@ 72c/lb	125.36
115,000 tonnes superphosphate fertilizer	@ $210/t	24.15
		149.51
	less running expenses	53.39
	less depreciation (straight line over 12 years)	19.25
	nett profit	76.87

$$\% \text{ return on investment} = \frac{76.87}{231} = 33.3\%$$

(d) Outputs. intangible (or not accounted for in above)

(1) shipping problem for rutile and zircon solved since facilities will be available at Trincomalee.

(2) jobs for 2500 workers

(3) assured sale for ilmenite, yielding $4 million

(4) assured sale for phosphate yielding $3.4 million

(5) 72,000 tonnes of contained sulphuric acid in the waste at 10 - 20% concentration available for making super phosphate fertilizer from Eppawela phosphates, together with 45,000 tonnes of concentrated acid.

(6) construction jobs offered and skills developed.

(7) general development of Pulmoddai and Trincomalee.

Notes.

Capital cost based on Wilska estimate factored upwards.

Infrastructure :- estimated

Quantities

Sulphate plant quantities based on figures in the Wilska report plus some estimates. Credit has been allowed for the heat output of the sulphuric acid plant in arriving at heavy fuel oil consumption figures. The 54,500 tonnes of fuel oil could be replaced by 86,000 tonnes of coal for steam raising purposes at a saving of $ 5m per annum but at extra capital cost.

Other

(1) See remarks regarding effluents

(2) Plant should be sited carefully with regard to air borne effluents.

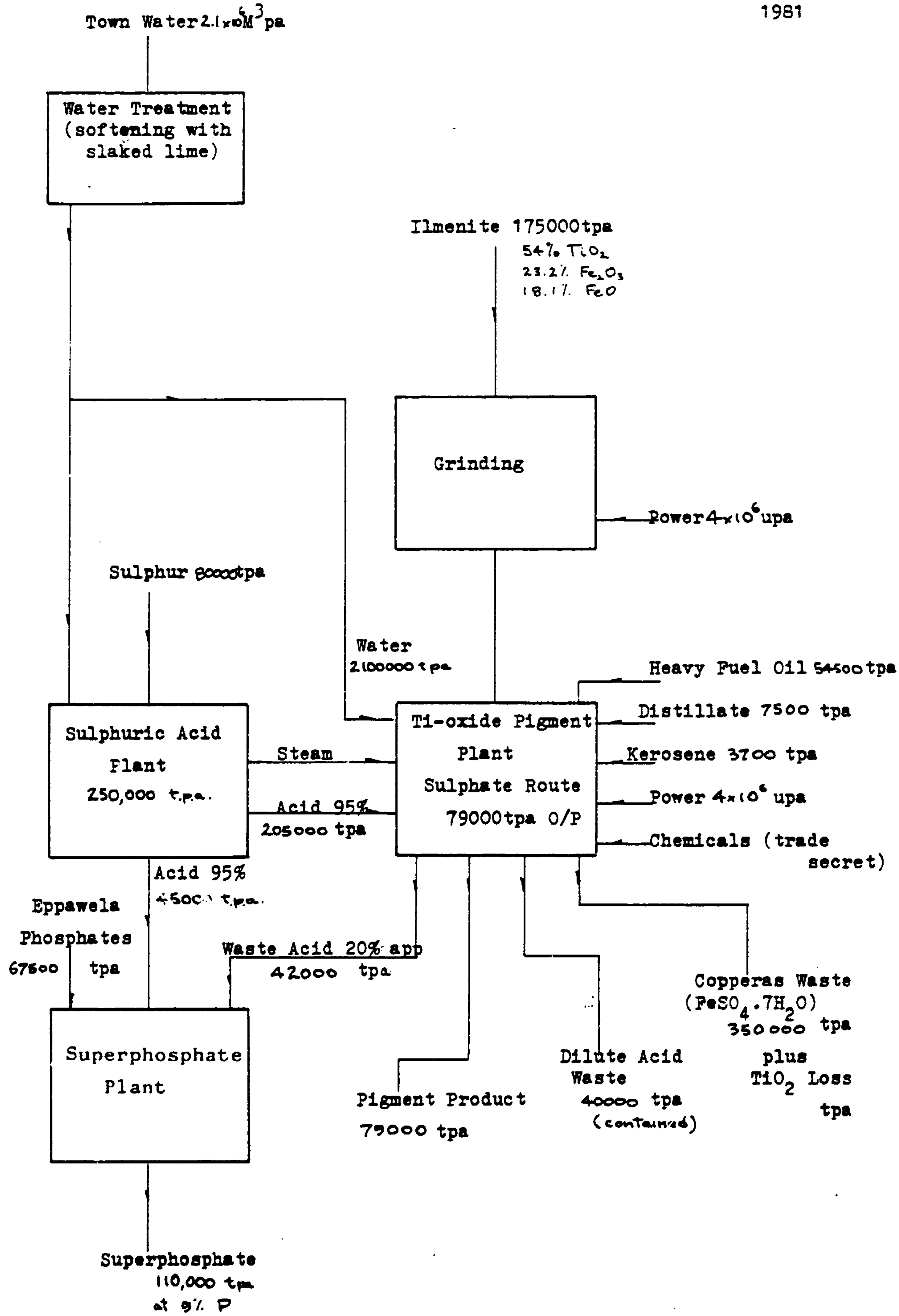
(3) Recovery of TiO_2 assumed to be 85%

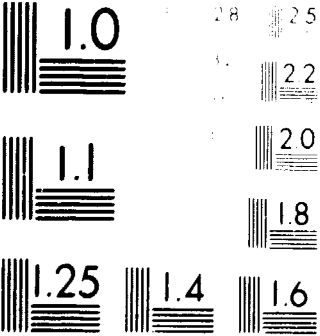
(4) Sulphur cost may be 2 to 3 million lower due to availability from a proposed oil refinery at Trincomalee.

SCHEME 2 SCHEMATIC ILMENITE TREATMENT C.M.S.C. Pulmoddai

Sri Lanka

1981





1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

Appendix 5

Scheme 3 based on Harrach and Wilska reports and on Zaporozhye report and figures.

Process 175,000 t.p.a. Pulmoddai ilmenite (54% TiO_2, 18.1% FeO, 23.2% Fe_2O_3) into 85,000 t.p.a. of ti-oxide pigment and 43,000 t.p.a. of raw iron by first electro smelting the ilmenite with anthracite coal into titanium slag and iron, cooling and crushing the slag and then converting the slag to pigment by the sulphate process.

A sulphuric acid plant produces the necessary acid and some of the heat requirements of the sulphate plant. Excess acid from the sulphuric acid plant and waste acid from the sulphate plant is used to convert Eppawela phosphate rock to superphosphate fertilizer.

(a) Capital Costs

	$m
Pigment plant, sulphate route, 85,000 t.p.a.	85
Sulphuric acid plant, 250,000 t.p.a.	35
Electro smelting & crushing plant, 105,000 slag t.p.a.	60
Infrastructure - warehouses, loading and unloading facilities, housing, etc	23
Superphosphate Plant 220,000 t.p.a.	45
Sub-total	248
allow 25% contingency	25
Total	310

(b). Running Expenses

			$ m
175,000 t	Ilmenite	@ $25/tonne landed	4.37
80,000 t	sulphur	@ $145/tonne landed	11.60
2,100,000 t	water	@ Rs8/- per 1000 gall	0.18
	chemicals, spares, consumables		3.70
9,000 t	distillate	@ $400/t	3.60
4,000 t	kerosene	@ 350/t	1.40
52,000 t	heavy fuel oil	@ $200/t	10.40
230×10^6	units electricity	@ 4c/u	9.20
2050 t	electrodes	@ $1750/t	3.60
30,000 t	coal (anthracite)	@ $85/t	2.55
170,000 t	acid 95% (supplied)		
800 t	titanium tetrachloride manufactured but needing 260 t of rutile @ 250/t		.07
500 t	oxygen	@ 250/t	.13
3,000	workers	@ $750 p.a.	2.25
	expatriate supervision		.20
120,000	Phosphate rock, Eppawela @ $50		6.00
		Sub-total	59.25
		allow 25% contingency	14.81
		Total	74.06

(c) Outputs tangible

			$ m
85,000 t.p.a.	pigment	@ 72c/lb	134.9
43,000 t.p.a.	carbonized pig iron	@ $230/t	9.9
220,000 t.p.a.	superphosphate	@ $210/t	46.2
			191.0
	less running expenses		74.06
	less depreciation, straight line over 12 years $m 254/12		25.83
	nett profit		91.11

Return on investment $= \frac{\$91.11}{\$310} \times 100 = 29.4\%$

(d) Outputs intangible

as for schemes 2 and 4 excepting

(1) large reduction in copperas effluent output, compared with scheme 2 (but less than for scheme 4)

(2) opportunity to make 210,000 t.p.a. superphosphate fertilizer worth $46.2 million

(e) Note.

(1) The economics are likely to be affected by power costs. The above is based on a factored present cost of power. Estimated unit cost of power for 1984 is Rs.1.4/unit (6.75c/unit)

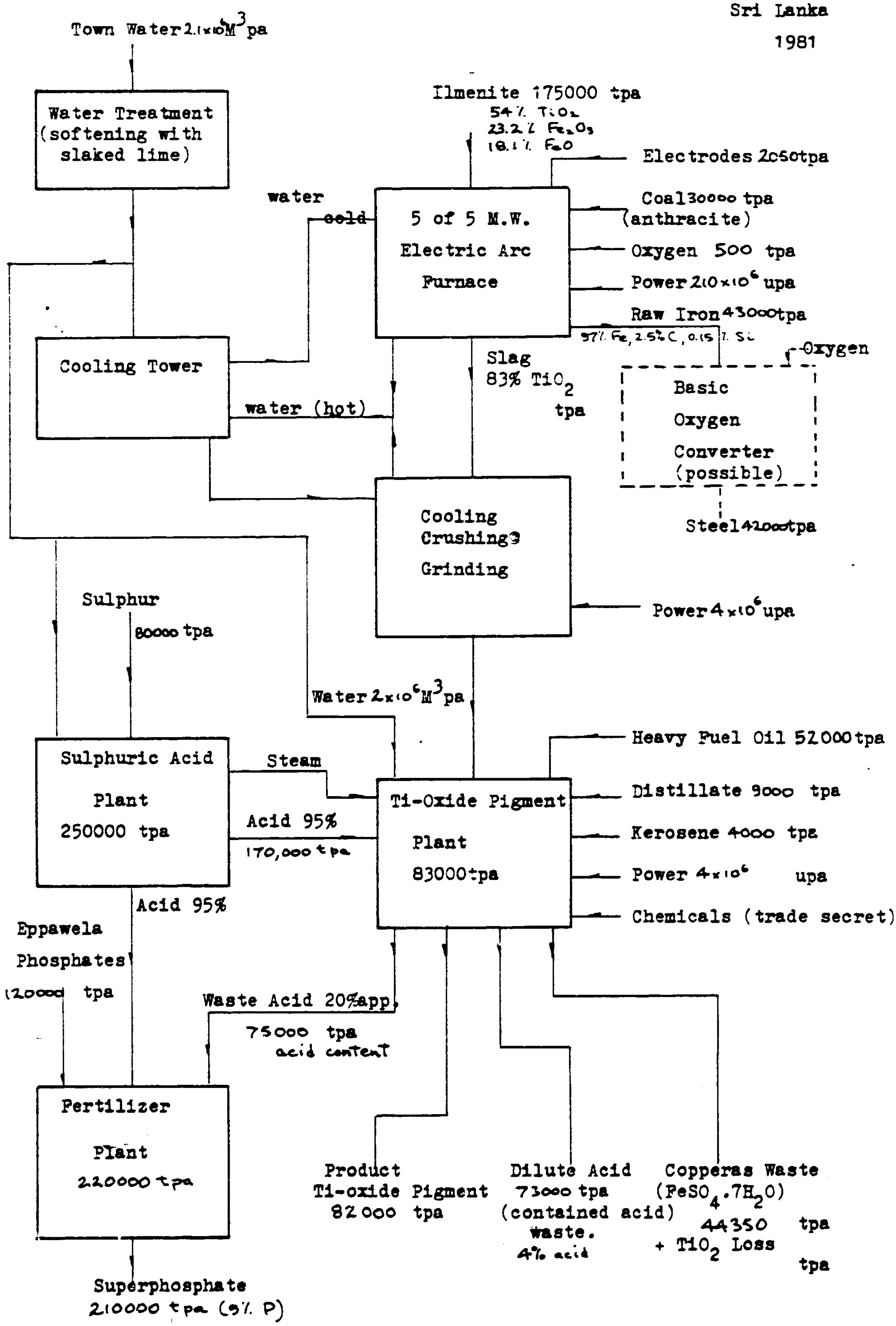
(2) The 52,000 t.p.a. heavy fuel oil could be replaced by approx. 85,000 t.p.a. coal at a cost saving of about $ 5m but at slightly increased capital cost.

(3) There is considerable dust given off in the electro smelting process.

S CHEME 3 SCHEMATIC ILMENITE TREATMENT C.M.S.C. Pulmoddai

Sri Lanka

1981



K.L.

Appendix 6

Scheme 4

Pre-oxidise and reduce 175,000 t.p.a. ilmenite with assay

$54\%\ TiO_2$, $20.2\%\ FeO$, $22.2\%\ Fe_2O_3$

to make 154,000 t.p.a. of reduced ilmenite with 95% conversion of iron oxides to metallic iron. Then to electro-smelt this to produce 10,000 t.p.a. of 90% TiO_2 titanium slag plus 52,000 t.p.a. of raw iron suitable for conversion to steel or cast iron.

The slag then to be treated by a sulphate route plant to manufacture 85,000 t.p.a. of titanium oxide pigment of various grades. A sulphuric acid plant is included to manufacture the sulphuric acid required.

Some waste acid from the sulphate plant (20% plus H_2SO_4) and acid from the sulphuric acid plant used to produce superphosphate fertilizer.

Location assumed :- Trincomalee

(a) Capital Costs

	$m
85,000 t.p.a. pigment plant, sulphate route	75
250,000 t.p.a. sulphuric acid plant	35
175,000 t.p.a. thruput reduction plant	25
2 of 5 MW electric arc furnaces with ancilliary transformers etc	25
265,000 t.p.a. superphosphate plant	55
infrastructure, warehouses, loading and unloading facilities, housing	25
	240
allow 25% contingency	60
Total	300

(b) Running Expenses per annum

		$ m
4,700 tonnes heavy fuel oil	@ $200/t landed cost	0.94
80,000 tonnes coal	@ $65/t " "	5.20
175,000 tonnes ilmenite	@ $25/t " "	4.37
875 tonnes electrodes	@ $1750/t " "	1.53
80,000 tonnes sulphur	@ $145/t "	11.60
2,250,000 tonnes water	@ Rs.8/- per 1000 gall	.20
200 tonnes oxygen	@ $250/t	.05
105,000 tonnes Sulphuric acid supplied		
800 tonnes titanium tetrachloride	(made from rutile 260 t @ $250/t)	.07
100×10^6 units of power	@ 4c/u	4.00
9,000 tonnes distillate	@ $400/t landed	3.60
4,000 tonnes kerosene	@ $350/t landed	1.40
48,000 tonnes heavy fuel oil (for sulphate plant)	@ 200/t landed	9.60
150,000 tonnes phosphate rock (ground)	@ $50/t	7.50
chemicals, spares, consumables		4.00
3,500 workers	@ $750/year	2.60
expatriate supervision		0.20
	Sub total	56.86
	allow 25% contingency	14.22
	Total	71.08

(c) Outputs tangible

			$ m
85,000 t.p.a. pigment		@ 72c/lb	134.9
52,000 t.p.a. carbonized pig iron		@ $230/t	12.0
265,000 t.p.a. superphosphate		@ $210/t	55.7
			202.6
	less running expenses (as above)		71.08
	less depreciation (striaght line over 12 years)		25.00
	nett profit		106.52

% return on investment = $\frac{106.52}{300}$ = 35.5%

(d) Outputs intangible

(a) Jobs for 3500 workers

(b) 95,000 tonnes of contained sulphuric acid waste (10 - 20% concentration) for superphosphate manufacture from Eppawela phosphate deposits.

(c) assured sale for ilmenite @ $22/tonne

(d) large reduction in effluent output (as against scheme 2)

(e) steady electrical load for hydro electric schemes (to help pay these off)

(f) sulphuric acid to form the basis of a heavy chemical industry.

(g) construction jobs generated and skills developed

(h) shipping problems for rutile and zircon solved by handling facilities generated.

(i) general development of the Trincomalee, Pulmoddai area

(j) sale for 150,000 tonnes phosphates worth $ 7.50 million

Notes

Basis of estimates.

(a) Capital.

Sulphate plant - S. Wilska estimate factored upwards. This is a smaller plant than an ilmenite fed sulphate plant and therefore does not cost the same dollars per tonne output.

Pre-reduction plant - factored estimate in "Direct Reduction Technology - The Western Titanium Process for the Production of Synthetic Rutile, Ferutile and Sponge Iron" by B.F.Bracanin, R.J.Clements, J.M.Davey.

The Aus. IMM Conference Western Australia 1979 papers. This is allowing for no "wet" end components

Electro Smelting Plant	-	estimate
Infrastructure	-	estimate
Super phosphate plant	-	estimate

Quantities

Pre-reduction plant - estimates given in paper named above.

Electric arc furnaces - Zaporozhye figures and W.Harrach figures. The power consumption and coal use are well down because of the pre-reduction Electrodes consumption is based on power consumed.

Sulphate plant - based on figures in the Wilska report and other material. Sulphuric acid consumption is lower and recovery of $Ti\ O_2$ is higher because of the increased solubility of the slag and lower consumption of sulphuric acid in making copperas ($Fe\ SO_4\ 7H_2O$)

Credit has been allowed for the heat output of the sulphuric acid plant for steam raising. This has replaced some 60,000 t.p.a. heavy fuel oil consumption. The $\frac{48,000}{24,000}$ t.p.a. heavy fuel oil net consumption allowed can be replaced by 76,000 t.p.a. coal at a cost saving of $4 m per annum but for added capital expense.

Wilska's estimate of sulphuric acid consumption is lower than figures given in other publications.

Other

(1) Care needs to be taken with the siteing of the plant since sulphur dioxide SO_2, sulphur trioxide SO_3 and some sulphuric acid is emitted in the air.

(2) Associated Minerals Corporation AMC, now RGC regard themselves as entitled to a process licence fee for the reductions process, according to the paper..

(3) Coal for the reduction process should have "none, or weakly caking properties and the free swelling index as measured by British Standard 1016, part 12 should not exceed 1.5". Sub-bituminous coals with the above are suitable.

(4) Recoveries assumed.

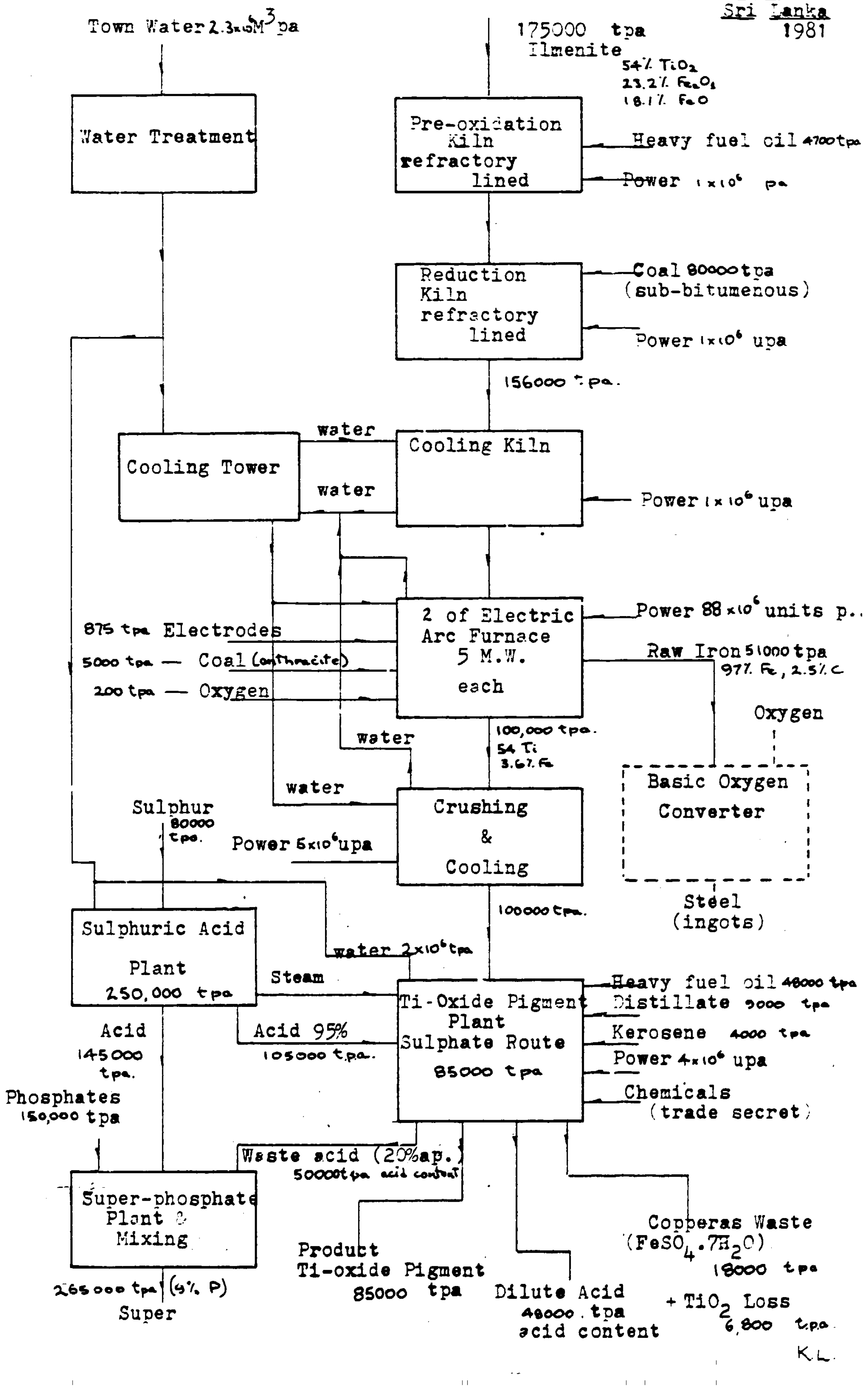
TiO_2 -	99%	reduction
	98.5%	electric arc
	92%	sulphate
overall	89.9%	recovery

This may be low.

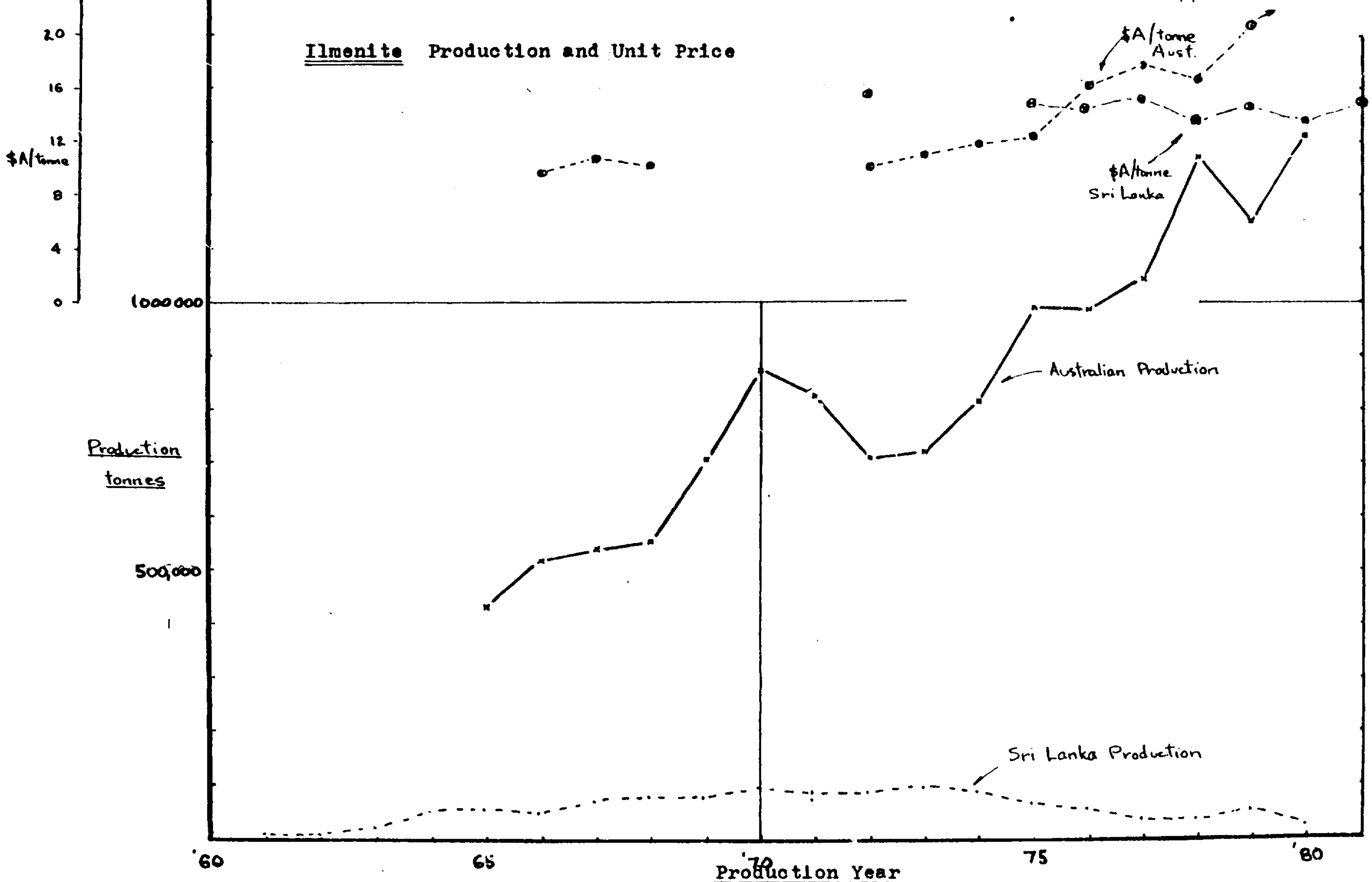
(5) Sale price of the pigment is somewhat low to allow for 3 cents a lb levy for customer services and research and development.

(6) The sulphur price may be considerably reduced due to availability of a proposed oil refinery at Trincomalee. 2 to 3 million would thus be saved.

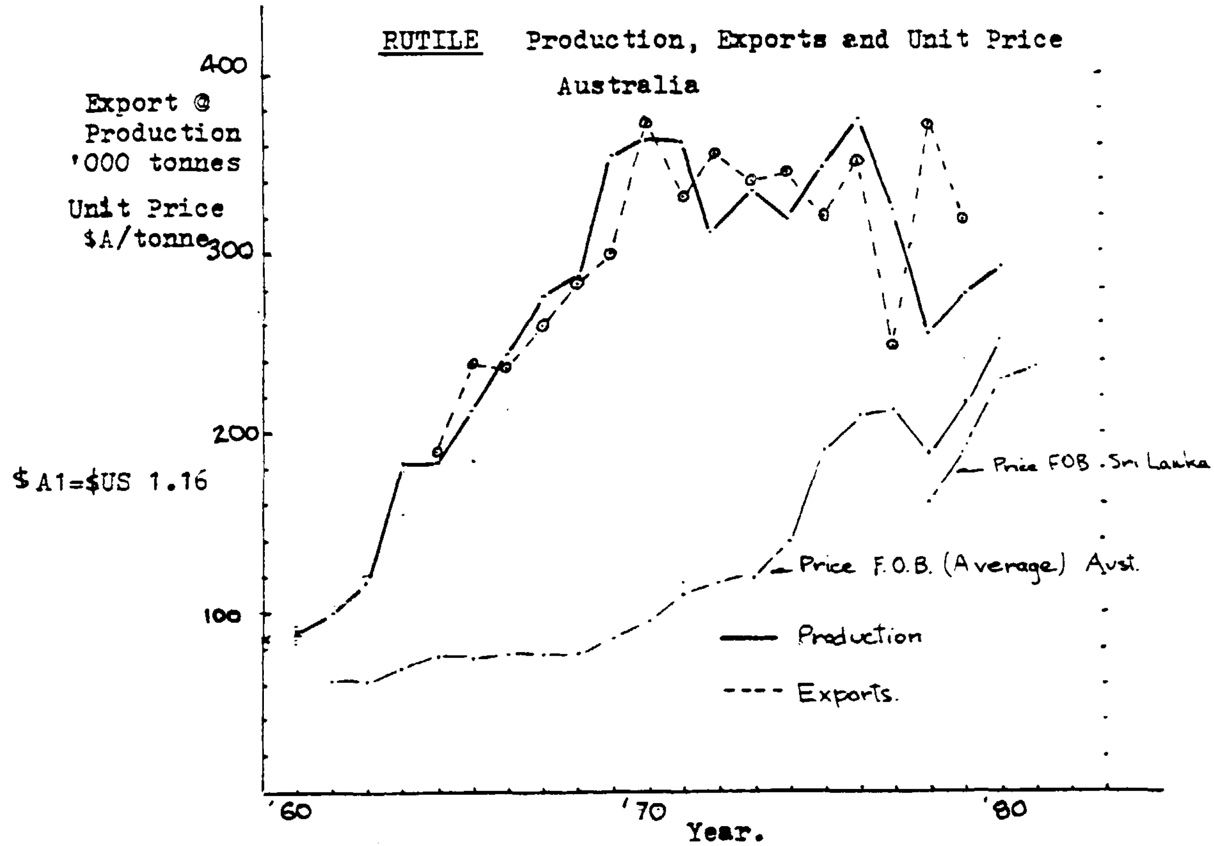
Scheme 4 SCHEMATIC ILMENITE TREATMENT C.M.S.C. Pulmoddai Sri Lanka 1981



Appendix 7A

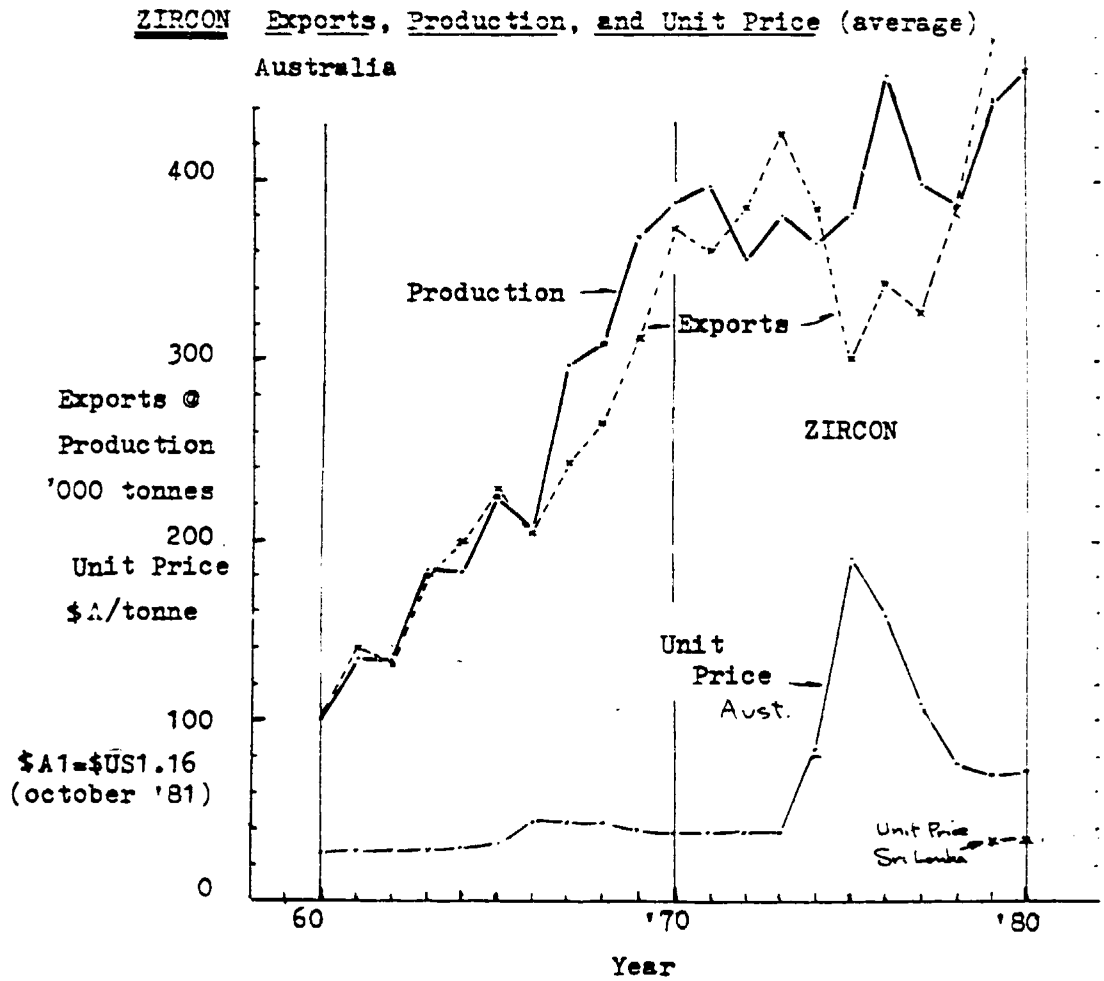


N ote:- Final production tonnage shown (Australian) may be unreliable.



The chart covers three distinct phases, '60 to '70 a period of steady growth as the "chloride" market expanded, '70 to '76 a no growth period due to a number of reasons (a) ilmenite was taking over some of the rutile chloride market (b) production problems with environmental pressure on mining areas (c) general slow-down in Western economies,and '76 on, a sharp fall in production. For '78 @'79 demand much exceeded production according to the figures shown above but recent figures arent reliable at times. During much of the period shown the above represents virtually the whole of the world production. In the last few years significant tonnages have been produced in South Africa, Sierra Leone, Sri Lanka and U.S.A.

The chart shows the effect of relatively small changes of stock levels on both production and price. In '74 stocks ran out and this lead to a sharp rise in both price and production. The spot price rise was much more spectacular peaking at over $400/tonne but little rutile is sold on the spot market, so it would be misleading to graph it.



The zircon chart shows a steady period of demand growth from '63 to '73. From '66 to '72 stocks were accumulating. Zircon was being produced as a by product of rutile production, demand for the latter governing production. After '73 stocks ran out, triggering a spectacular price rise (even more so on the "spot" price chart), and a subsequent drop in sales volume. Since zircon is sold only an average 2 to 4 years ahead, against rutiles' 5 to 10 years, the average unit price peaked and fell fast.

If the figures given are correct (and it seems to take the Australian department about 2 years to settle on a figure) a short supply situation is developing for both rutile and zircon.

At times of high price zircon is replaced in the foundry application by chromite.

The charts illustrate the value of market intelligence in obtaining a good price for the product.

For much of the period shown Australia produced the bulk of the worlds zircon output.

UK non-ferrous semis

ALUMINIUM

Prices for selected Alcan rolled products in "product of an ingot" quantity (unless otherwise stated) delivered UK Eff. February 1, 1980 *Per kg*

EQ plate—Std sizes, 12.5mm thick 5083M £1.618

EQ sheets—Std sizes and widths up to 1524mm, 6.35mm thick
5251M £1.411 5454M £1.433–£1.453 5083M £1.483

EQ sheet—Std sizes and tempers 1mm thick
1200 £1.146 3103 £1.166 5251 £1.236

EQ wide coil—Std sheet price less £20 per metric ton

EQ narrow coil (50–399mm wide) 1mm thick
1200 £1.196 3103 £1.216 5251 £1.286

Duralcote coil (one side coating) AD20, 1.7mm over 900mm 3105 £1.863

EQ circles—Std diams and tempers, 1mm thick, 20 ton order, 1 ingot item 1200 .. .. £1.332

Aircraft plate, AQD/CAA, one side ultrasonic tested std sizes
30mm thick, min 2 tons 2024 £2.496 7075 T7351 £2.564

The following stockist prices are for ex-stock and forward delivery: spot prices are not necessarily geared to current UK mills prices 1 ton lots. (*Source: International Metals Ltd.*)

Pure sheet, 0.9mm and thicker std imp/metric £1.010
NS4 Sheet standard sizes, 1·6mm £1.090
Pure strip-in coil 250–499mm, 1.6mm £1.060
NP8 plate, 96<48in., 0.5in; £1.360

BERYLLIUM COPPER 100kg lots and over basis price *Per kg*
BS2870 CB 101 Strip, 0.015" x 3" £10.18 Rod, 1" and over £9.48

BRASS *Per 100kg delivered*
Strip sheet—63/37 basis £105.20
Sheets, ton lots, 1200 x 600 x 1mm £167.55 0.7mm £179.30
Strip ton lots, 150 x 1mm £149.75 150 x 0·5mm £156.30
Tubes—s/d 70/30 basis £74.80
16 swg 500<1000kg 1" od £217.90 Ditto 1½ od £211.80
Wire (63/37) 3–3.99mm £126.00–£129.00 6mm and over £124.00–£125.00
Rods—BS 2874 & 2872 22–30mm £97.75
Condenser Tubes: ¾" od x 18 swg 500<1000kg *Pence per ft delivered*
70/30 39.14 70/29/1 40.76 76/22/2 39.57

COPPER *Per metric ton delivered*
C.C.R. pickled rods 8.0mm coils £891.10

Per 100kg delivered
Rods 12.5—18mm £142.10
HC wire 3.15mm 1000<2000kg less 2½% £111.60
Sheets—CR basis .. .. £1?4.90
CR 1200 x 600 x 1mm ton lots; £153.15 1.2mm £149.55
Strip—CR coils ton lots 150 x 0.2mm £182.55 0.8mm £161.70
Tubes—s/d basis.. .. £90.30–£113.68
1" od<16 swg 500<1000kg.. .. £169.80–£177.69
BS 2871/1971 Table Z 2500m or 1000kg lots *Per 100 metres d/d*
15mm od £47.50–£48.60 22mm £80.50–£82.30 28mm £100.60–£103.00
BS 2871/1971 Table X 2500mm or 1000kg lots
15mm od £50.30–£51.30 22mm £92.00–£93.90 28mm £117.00–£119.60
Tube *Per 20 metre coil delivered*
¾" od—22 swg refrig 500 x 1000kg £5.22

COPPER NICKEL *Per 110kg delivered*
Condenser tubes 70/30 basis £177.20
Pence per ft delivered
18 swg 500<1000kg ¾" od 68.80 1" od 68.40

LEAD *Per metric ton delivered. Eff. Dec. 18*
Pipes 2000kg lots £544 Sheets 2000kg lots £544

MAGNESIUM *Per metric ton delivered*
Bars 1" dia. 1000kg lots.. .. n.a.

NICKEL SILVER *Per 100kg delivered. Eff. Dec. 15*
Sheet & Strip 10% basis £207.65 Strip 150 x 0.6mm 100<150kg £27?.15
Wire: 10% basis £259.65 1·5mm coil 100<150kg £336.15

PHOSPHOR BRONZE *Per 100kg delivered*
Wire 95/5 Spring temper, 3–3.99mm £190.25 6mm and over £186.25
Rods–Solid BS1400 PB1 (per kg) £2.73
Strip PB 102 150 x 0.9mm £205.40

TITANIUM (2000kg lots delivered. Approx. price) *Per kg*
Rod 50mm dia. £18.74 Wire 2mm dia £27.47 Sheet 1mm thick £18.18
Plate 12mm thick £14.84 6/4 Alloy Billet, 200mm dia. £14.59
Tube 1" od. x 20 swg. (1500 metre lots) .. .. £11.71 *per metre*

ZINC *Ex-warehouse, Per 100kg* *Eff. June 16*
Sheets (0.5mm basis) flat on 1000kg pallets (5 tons) £79.65

Non-ferrous ores in Europe

ANTIMONY *Per metric ton unit Sb. Cif*
Sulphide ore conc. 50–55% Sb .. .. nom.
Lump sulphide ore, 60% Sb .. .. $23.50–$25.00

BERYL *Per short ton unit of BeO*
Cobbed lump min. 10% BeO Cif .. .. $80–$86

BISMUTH *Per kg Bi*
Conc. oxide min. 60% Bi CIF .. .. nom.

CAESIUM ORE *Per metric ton unit Cs_2O*
Pollucite conc. min. 24% Cs_2O FOB .. .. $12.40–$13.00

CHROMITE *Per metric ton*
Transvaal, friable lumpy, basis 44% Cr_2O_3 FOB .. .. $60–$70
Albanian, hard lumpy, min 42% FOB .. .. $82–$93
Albanian, conc. 51% FOB .. .. $96–$110
Turkish, lumpy, 48% 3:1 (scale pro rata) FOB .. .. $130–$135
Russian, lumpy, 40% min 36% .. .. nom.

COLUMBIUM ORES *Per lb. pentoxide content*
Columbite min. 65% Cb_2O_5 + Ta_2O_5, 10:1 CIF .. .. $9.00–$11.00
Pyrochlore conc. FOB Brazil $2.55

LEAD CONC. *R/C per metric ton*
70/80% Pb £160 basis CIF .. .. $90–$100

LITHIUM ORES *Per long ton unit Li_2O*
Petalite, 395–4.5 Li_2O (basis 3%) CIF .. .. £1.60–£2.00
Spodumene 4-7% Li_2O (basis 6%) CIF .. .. £1.80–£2.30

MANGANESE ORE
48/50% Mn max. 0.1% P CIF *Metallurgical per mtu Mn* .. $1.70–$1.73

MOLYBDENITE *Per lb. Mo in MoS_2*
Conc. FOB Climax basis min. 85% .. .. $9.20 (Sept. 26)

Conc. some other origins CIF.. .. $7.75–$8.50

MONAZITE *Australian per metric ton*
Conc. min. 60% REO + Thoria, FOB/FID .. .. A$350–A$400

TANTALITE *per lb. Ta_2O_5*
Ore min. 60% Ta_2O_5 CIF .. .. $110.00–$115.00
25/40% basis 30% Ta_2O_5 CIF .. .. $108.00–$111.00

TIN CONCENTRATES *R/C per metric ton*
70/75% Sn (including deduction) .. .. £205–£235
30/65% Sn (including deduction) .. .. £275–£325
20/30% Sn (including deduction) .. .. £310–£360

TITANIUM ORES *Australian per metric ton*
Rutile conc. 95/97% TiO_2 bagged, FOB/FID .. .. A$320–A$350
Rutile bulk conc. 95/97% TiO_2 FOB/FID .. .. A$290–A$330
Ilmenite,bulk conc. min. 54% TiO_2 FOB .. .. A$20–A$22

TUNGSTEN ORE *Per metric ton unit WO_3*
Wolframite std. min. 65% CIF .. .. $139.00–$142.50
ITI December 1st half: tons 1,009.3 (71.54%) $141.97

URANIUM *Per lb. U_3O_8* *Per lb U_3O_8*
Conc. contract basis, FOB mine $37–$42 Hexafluoride $38–$43

VANADIUM *Per lb. V_2O_5*
Highveld, fused min. 98% V_2O_5 CIF $3.14
Other sources .. .. $3.00–$3.15

ZINC CONC. *R/C per metric dry ton. May be subject to currency adjustment*
Sulphide 52/55% Zn basis $825 CIF .. .. $80–$105

ZIRCON *Australian per metric ton*
Sand Min 65% ZrO_2 std. FOB/FID .. .. A$70–A$75
Premium max. 0.05% Fe_2O_3 FOB/FID .. .. A$85–A$95

LME stocks

Week ending December 12 1980 (in metric tons)

	COPPER: Wirebars first, Cats second			TIN: H.G. first, Std. second			LEAD: d/f first, bond second			ZINC: H.G. first, GOB second*			SILVER (Troy oz.)			ALUMINIUM		
	L'dngs	Delv's	Total	L'dngs	Delv's	Total	L'dngs	Delv's	Total	L'dngs	Delv's	Total	L'dngs	Delv's	Total	L'dngs	Delv's	Total
London	—	—	900	—	—	10	—	—	500	—	—	—	20,000	—	6,480†	—	—	—
	—	—	575	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—
Birmingham	—	—	150	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	25	2,800	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Liverpool	—	25	38,425	—	5	25	—	—	800	—	—	175§	—	—	—	—	—	—
	150	100	6,300	—	5	25	—	—	—	—	—	75§	—	—	—	—	—	—
Hull	—	—	50	—	—	50	300	—	8,475	—	—	—	—	—	—	—	—	—
	—	—	2,225	150	15	1,565	—	—	—	—	—	875§	—	—	—	—	—	—
Newcastle	—	—	—	—	—	—	—	—	4,800	—	—	125§	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Glasgow	—	—	—	—	—	—	—	—	4,350	—	—	—	—	—	—	—	—	—
	—	—	175	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Avonmouth	—	—	375	—	—	—	—	—	25	—	—	—	—	—	—	—	—	—
	—	—	175	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rotterdam	—	50	22,325	495	305	2,135	—	—	—	1,925	25	28,250	—	—	7,820†	3,200	100	67,100
	—	375	2,300	—	75	130	—	250	44,200	400	—	46,250	—	—	—	—	—	—
Bremen	825	—	6,400	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hamburg	250	725	27,325	—	—	—	—	—	—	—	—	2,050	—	—	3,260†	—	—	—
	100	600	6,400	—	—	100	25	—	425	—	—	—	—	—	—	—	—	—
Antwerp	100	—	3,625	85	15	275	—	—	—	—	—	600	—	—	8,580‡	975	—	2,175
	—	—	50	—	—	5	—	—	8,850	—	—	775	—	—	—	—	—	—
Gothenburg	—	—	1,300	—	—	—	—	—	—	—	—	875	—	—	—	—	—	—
	—	—	—	—	10	5	—	25	450	—	—	200	—	—	—	—	—	—
Genoa	—	50	400	—	5	10	—	—	—	—	—	425	—	—	—	—	—	350
	—	—	—	—	—	—	—	—	—	—	—	50	—	—	—	—	—	—
Total	1,175	850	101,375¶	595	360	2,520**	300	—	18,950	1,925	25	32,500	20,000	—	26,140†	4,175	100	70,575
	450	1,100	21,025	150	105	1,835	25	275	54,350††	400	—	48,225	—	—	—	—	—	—

† '000 Troy oz. ‡ Amsterdam '000 Troy oz. § Duty free * In bond ¶ Incl. 100 WB in Flushing ** Incl. 15 HG in Flushing †† Incl. 425 in Bond in Flushing

UK non-ferrous semis

Aluminium

Prices for selected Alcan rolled products in "product of an ingot" quantity (unless otherwise stated) delivered UK *Eff. July 13, 1981*

	Per kg
EQ plate — Std sizes, 12.5mm thick	5083M £1.747
EQ sheets — Std sizes and widths up to 1524mm, 6.35mm thick	5251M £1.524
	5454M £1.558
	5083M £1.602
EQ sheet — Std sizes and tempers 1mm thick	1200 £1.145
	3103 £1.166
	5251 £1.236
EQ wide coil — Std sheet price less £20 per metric ton	
EQ *narrow coil (50-399mm wide)* 1 mm thick	1200 £1.196
	3103 £1.216
	5251 £1.286
Duralcote coil (one side coating) AD20, 1.7mm over 900mm	3105 £1.863
EQ circles — Std diams and tempers, 1mm thick, 20 ton order, 1 ingot item	1200 £1.332
Aircraft plate, AQG/CAA, one side ultrasonic tested std sizes 30mm thick, min 2 tons	2024 £2.496
	7075 T7351 £2.564

The following stockist prices are for ex-stock and forward delivery: spot prices are not necessarily geared to current UK mills prices 1 ton lots. *(Source: International Metals Ltd.)*

Pure sheets, 0.9mm and thicker std imp-metric	£0.950
NS4 Sheet standard sizes, 1.6mm	£1.020
Pure strip-in coil 250-499mm, 1.6mm	£1.050
NP8 plate, 96<48in., 0.5in	£1.450

Beryllium Copper

	Per kg
100kg lots and over basis price BS2870 CB 101 Strip, 0.015"×3"	£10.18
Rod, 1" and over	£9.48

Brass

	Per 100kg delivered
Strip sheet — 63/37 basis	£122.90
Sheets, ton lots, 1200×600×1mm	£185.25
0.7mm	£197.00
Strip ton lots, 150×1mm	£167.45
150×0.5mm	£174.00
Tubes — s/d 70/30 basis	£92.20
16 swg 500<1000kg 1" od	£232.90
Ditto 1½ od	£235.30
Wire (63/37) 3-3.99mm	£150.75
6mm and over	£146.75
Rods — BS2874 & 2872 22-30mm	£117.00
Condenser Tubes:	
¾" od×18 swg 500<1000kg	*Pence per ft delivered*
70/30	42.24
70/29/1	44.25
76/22/2	42.39

Copper

	Per metric ton delivered
CCR pickled rods 8.0mm coils	£1,019.50
	Per 100kg delivered
Rods 10—18mm	£163.90
HC wire 3.15mm 1000<2000kg less 2½%	£125.40
Sheets — CR basis	£127.50
CR 1200×600×1mm ton lots	£165.75
1.2mm	£162.15
Strip — CR coils ton lots 150×0.2mm	£195.15
0.8mm	£173.80
Tubes — s/d basis	£108.10-£113.68
1" od×16 swg 500<1000kg	£177.68-£195.10
BS2871/1971 Table Z	
2500m or 1000kg lots	*Per 100 metres d d*
15mm od	£51.70
22mm	£88.70
28mm	£111.00
BS2871/1971 Table X 2500m or 1000kg lots	
15mm od	£55.60
22mm	£103.00
28mm	£133.00
Tube	*Per 20 metre coil delivered*
¼" od—22 s g rering 500<1000kg	£5.94

Copper Nickel

	Per 100kg delivered
Condenser tubes 70/30 basis	£232.90
	Pence per ft delivered
18 swg 500<1000kg ¾" od	79.16
1" od	102.44

Lead

	Per metric ton delivered. Eff. Oct 24
Pipes 2000kg lots	£635
Sheets 2000kg lots	£635

Magnesium

	Per metric ton delivered
Bars 1" dia. 1000kg lots	n.a.

Nickel Silver

	Per 100kg delivered. Sept. 30
Sheet & Strip 10% basis	£233.35
Strip 150×0.6mm 100<150kg*	£295.85
Wire: 10% basis	£282.35
1.5mm coil 100<150kg	£355.85

Phosphor Bronze

	Per 100kg delivered
Wire 95/5 Spring temper, 3-3.99mm	£219.75
6mm and over	£215
Rods-Solid BS1400 PBI (per kg)	
Strip PB102 150×0.8mm	

Titanium

(2000kg lots delivered. Approx. price)

Rod 50mm dia.	
Wire 2mm dia	47
Sheet 1mm thick	£18.18
Plate 12mm thick	£14.84
6/4 Alloy Billet, 200mm dia.	£17.75
Tube 1" od×20 swg. (1500 metre lots)	£11.71 *per metre*

Zinc

	Ex-warehouse, Per 100kg. Eff. Sept 9
Sheets (0.5mm basis) flat on 1000kg pallets (5 tons)	£101.20

UK non-ferrous foundry ingots

Aluminium

	5 ton lots £ per metric ton
BS 1490 LM2 delivered	625-670
LM4 delivered	715-755
LM6 (secondary) delivered	805-840
LM24 delivered	635-670
LM25 (secondary) delivered	795-835
LM27 delivered	665-700
AFFIMET prices (Ffr/t) *November*	
AS 12	8900
AS 12 UN	8700
AS 9 U3	7300
AS 5 U3	8880

Aluminium Bronze

BS 1400	
AB1 delivered	1055†
AB2 delivered	1130†

Brass

60/40 (to BS 218 or 249) ex-works	695‡
65/35 (BS 1400 SCB3) delivered	741†
BS 1400 SCB6 delivered	1018†
High Tensile HTB1 (30 tons) delivered	903†

Gunmetal

BS 1400	
LG2 85/5/5/5 delivered	983†
LG4 87/7/3/3 delivered	1251†
G1.1½ Pb delivered	1527†

Magnesium

Elektron C alloy 10 ton lots delivered	1238.00§

Phosphor Bronze

PB1	1818†
PB4	1704†
LPB1	1273†

Phosphor Copper

10% P ex-works	995-1097‡
15% P ex-works	1002-1087‡

Phosphor Tin

5% P ex-works	9670†

Zinc Alloys

BS 1004A 10-ton lots delivered	842.25*
BS 1004B 10-ton lots delivered	852.25*

*†Oct 28 prices. ‡Oct 29 prices. §Eff Apr 1. *Eff Oct 1.*

Non-ferrous ores in Europe

Antimony

	Per metric ton unit Sb. C
Sulphide ore conc. 50-55% Sb	non
Lump Sulphide ore, 60% Sb	\$21.00-\$23.0

Beryl

	Per short ton unit of Be
Cobbed lump min. 10% BeO Cif	\$80-\$8

Bismuth

	Per kg
Conc. oxide min. 60% Bi Cif	nor

Caesium Ore

	Per metric ton unit Cs
Pollucite conc. min. 24% Cs_2O FOB	\$12.40-\$13.0

Chromite

	Per metric to
Transvaal, friable lumpy, basis 44% Cr_2O_3 FOB	\$60-\$7
Albanian, hard lumpy, min 42% FOB	\$82-\$9
Albanian, conc. 51% FOB	\$96-\$11
Turkish, lumpy, 48% 3:1 (scale pro rata) FOB	\$130-\$13
Russian, lumpy, 40% min 36%	nor

Columbium Ores

	Per lb. pentoxide conter
Columbite min. 65% $Cb_2O_5+Ta_2O_5$, 10:1 CIF	\$6.50-\$7.50 nor

Lead Conc.

	R/C per metric tc
70/80% Pb £160 basis CIF	\$90-\$10

Lithium Ores

	Per long ton unit Li_2O
Petalite, 3.95-4.5 Li_2O (basis 3%) CIF	£1.60-£2.0
Spodumene 4-7% Li_2O (basis 6%) CIF	£1.80-£2.3

Manganese Ore

	Metallurgical per mtu M
48/50% Mn max. 0.1% P CIF	\$1.70-\$1.7

Molybdenite

	Per lb Mo in MoS
Conc. FOB Climax basis min. 85%	\$7.90 (Aug
Conc. some other origins CIF	\$5.00-\$6.0

Monazite

	Australian per metric tc
Conc. min. 60% REO+Thoria, FOB/FID	A\$350-A\$40

Tantalite

	per lb. Ta_2O
Ore min. 60% Ta_2O_5 CIF	\$48.00-\$60.0
25/40% basis 30% Ta_2O_5 CIF	\$44.00-\$55.0
Green bushes 40% basis	\$8

Tin Concentrates

	R/C per metric tc
70/75% Sn (including deduction)	£205-£23
30/65% Sn (including deduction)	£275-£32
20/30% Sn (including deduction)	£310-£36

Titanium Ores

	Australian per metric tc
Rutile conc. 95/97% TiO_2 bagged, FOB/FID	A\$300-A\$32
Rutile bulk conc. 95/97% TiO_2 FOB/FID	A\$280-A\$30
...k conc. min. 54% TiO_2 FOB	A\$24-A\$2

Tungsten Ore

	Per metric ton unit WC
Wolframite std. min. 65% CIF	\$132-\$13
... Oct 1st half: tons 1,027.5(72.47%)	\$142.6

Uranium

	Per lb. U_3
Nuexco exchange value	\$23.5

Vanadium

	Per lb V_2O
Highveld, fused min. 98% V_2O_5 CIF	\$3.1
Other sources	\$2.90-\$3.0

Zinc Conc.

R/C per metric dry to
May be subject to currency adjustme

Sulphide 52/55% Zn basis \$925 CIF	\$85-\$1

Zircon

	Australian per metric tc
Sand 66/67% ZrO_2 std. FOB/FID	A\$75-A\$
Premium max. 0.01% TiO_2 FOB/FID	A\$90-A\$1

UK oxides, etc.

Arsenic Trioxide

	Per metric tc
Min. 10 tons (cif Europe)	£850-90

Cobalt Oxide

	Per metric tc
(delivered UK) Black 71.5% Co	£13.64

Lead

	Per metric t
White (dry) 2000 to<5000 kg. d/d	£854.25
Calcium Plumbate 2000 to<5000 kg. d/d	£637.00
Red (dry) 2000 to<5000 kg. delivered	£565.75
Litharge 2000 to<5000 kg. delivered	£566.75

Zinc

	Per metric t
Dust 95/97% 10 ton lots delivered	£795.0
Oxides 10 ton lots delivered: Red Seal £628†† Green nom.	White no

Zirconium Oxide

	Per metric t
Ceramic grade 1 ton ex-works	£1 497.00

*†Eff. Oct 1, '81; *Eff. Oct 1, '81; ‡Eff. Sept 7, 80 based on zinc producer price of \$825; **Eff. Oct 23, '81; ††Eff. July 79.*

UK non-ferrous scrap

The following table represents our evaluation of current market values in the UK. The price ranges cover the normal variation between the selling price of smaller and larger merchants; the higher prices thus typify consumers' buying levels. There are, however, normally some regional variations. Prices of lead scrap are the consumers' buying prices delivered to their works in London and the Midlands. Owing to the nature of the scrap market it is impossible to quote precise prices and it is important that the indications should be read in conjunction with the relevant market comment. Prices are £ per metric ton unless otherwise stated.

Attention is drawn to the fact that the following are based on Wednesday's markets.

Copper	£
No 1 Bright Wire (proc.)	750-820
No 1 Bright Wire	755-825
No 1 Wire (Burnt)	700-740
No 2 Wire (basis 94%)	630-700
Tinned Wire	690-735
Clean Heavy	680-730
Electro Cuttings	735-800
Braziery	545-635

Ashes and residues refining

For 10 ton lots and over delivered buyer's works with Cu contents of up to 30%, a deduction of 2.5 units is made, while for material containing 30%-50% Cu and for material containing over 50% Cu, a deduction of 2 units is made. Cu content is paid for at lowest LME Cu quotation on the day less £60. A treatment charge is then deducted: £130-£145 per ton for material up to 30%, £145-£155 per ton for material 30%-50% and £152-£165 per ton for material over 50%.

Brass	
Heavy	395-470
Cuttings	575-655
Rod ends	495-550
Rod swarf	465-525
Cartridge cases	545-620
Mixed brass	375-440
Radiators (comp.)	475-570
Gunmetal	
Commercial	740-795
Admiralty	845-915
Nickel-Silver	
Collected	400-440
Nickel	
Pure nickel scrap	2600-2900
Nimonic 75	1850-2150
Monel (fab. scrap)	1350-1600
Lead	
Scrap	317-330
Cable strippings	318-332
Battery plates Grade A	143-158
Battery plates Grade B	133-147
Whole batteries (drained)	106-123
Storage plates	156-176

Ashes and residues

Lead contents 65% and upward paid for at the lowest London Metal Exchange price less a Treatment Charge of £130-£140 per ton of material.

Zinc	
Remelted (98%)	430-450
Remelted zinc alloy (94%)	330-345
Old zinc	225-240
Cuttings	340-355
Zinc base (90%Zn)	205-215
New unplated diecast scrap	370-390
Collected diecast scrap	185-205
Hard zinc (ex-works)	315-330
Galv. Ashes 80% Zn	160-185
Whitemetal	
Close-cut solder joints	790-820
29% Plumbers' Solder	2060-2110
43% Tinmans' Solder	3135-3215
Pewter	4745-4815
Syphon tops	3915-3995
Aluminium	
Group 1: Pure cuttings	460-515
Group 2: Cuttings (Al-Cu)	350-380
Group 3: Cuttings (Al-Mg)	350-375
Group 5: Extrusions	460-510
Mixed alloy cuttings	370-400
Old rolled	370-400
Commercial cast	350-380
Turnings under 1% Zn	240-275
Titanium	*Per lb. cif*
Cuttings, commercially pure	$0.75-$1.35
Turnings, commercially pure	$0.70-$1.00
Turnings, unprocessed (90/6/4)	$0.45-$0.55
Mercury	*Per lb.*
Scrap	2.35-2.55

Japanese home special steel

Yen/metric ton (gross prices.) *Oct 19* (40 mm bars unless otherwise stated)

Tool steel *(cold drawn flat bars)*:	
SK1-7	215,000
SKS2-3	400,000
SKD1	550,000
SKD4	580,000
High speed steel (HR):	
SKH4(BT1)	5,000,000
SKH9(BT4)	1,900,000
SKH55(BT5)	2,800,000
SKH57(BM2)	4,700,000
Spring steel (SUP 6-9):	
flats	117,000
rounds	122,000
Bearing steel (SUJ 2):rounds	195,000
Stainless steel: bars (25-100 mm)	
SUS 403 (13 Cr)	270,000
SUS 304 (18/8)	470,000
SUS 316 (18/12)	700,000
sheet SUS 403 (13 Cr) 1.0 mm	370,000
sheet SUS 430 (18 Cr)	
0.3 mm	465,000
0.7 mm	405,000
1.0 mm	375,000
2-3 mm	335,000
sheets SUS 304 (18/8):	
0.3 mm	620,000
0.7 mm	570,000
1.0 mm	545,000
2-3 mm,	510,000
heavy plates (7-14 mm):	
SUS 316 (18/12)	760,000
Free cutting steel: S15CF-S55CF	112,000
Heat resistant steel: SUH 3	n.a.

Japanese home steel

Small merchants' and consumers' buying prices yen/metric ton *Oct 19*

Reinforcing rounds:	
9 mm	57,000
16-25 mm	58,000
Light angles: 5×40 mm	62,000
Medium angles: 9×130 mm	70,000
Heavy angles:	
10×100 mm	62,000
12×150 mm	71,000
Joists: 7×100×200 mm	81,000
10×150×300 mm	105,000
Medium plates: 3.2 mm×4'×8'	79,000
Heavy plates:	
6 mm×4'×8'	79,000
9 mm×5'×10'	80,000
CR sheets: 0.5 mm×3'×6'	99,000
Chequered plates, 4.5 mm×4'×8'	95,000
Deformed Bars (SD30):	
10 mm	55,500
13 mm	54,000
16-25 mm	54,000
32 mm	55,000

Spanish home steel

Madrid Pesetas/Kg. *Oct 14*

Source: MyM.

Plain rounds 8mm	33.50-33.80
Light angles 35mm	35.40-35.80
Heavy angles 80mm	33.40-33.80
Flats 40-100 × 10mm	35.00-35.40
PEs 300mm	31.60-32.00
Channels 160mm	31.40-31.80
CR sheets 0.90<1.25mm	49.20-52.10

Ferrous scrap

MB Ferrous Scrap Index

Following indices of UK ferrous scrap prices were compi[led by] Metal Bulletin from information supplied by UK private [and] public sector steelmakers and ironfounders (Sept-Nov average 100).

Week ended	*Oct 17*	*Oc[t]*
"A" Basic Scrap	90.2	90.[illegible]
"B" Low Residual Scrap	83.7	83.[illegible]
"C" Cast Iron Scrap	90.1	90.[illegible]
"D" Low Grade Scrap	94.0	94.[illegible]
Master Index	88.8	88.[illegible]

UK ferrous scrap

Steelmakers' buying prices, £/metric ton, delivered Mid[lands] (MB assessment of representative prices)

OA Old heavy steel	30-32
OB Old heavy steel	30-32 nom
1 Old steel	23-26 nom
2 Old Steel	24 nom
3A fragmentised	nom
3B fragmentised	37-40 nom
3C fragmentised	nom
4A New steel bales	43-47
4B New steel bales	nom
4C New steel bales	41-43
4D New steel bales	nom
4E New steel bales	nom
4F New steel bales	nom
5 Old light compressed	11 nom
6 Old light steel	14-16 nom
7A Heavy steel turnings	17-18
7B Heavy steel turnings	15 nom
8A New loose light cuttings	30-32
8B New loose light cuttings	30-32 nom
9 Heavy cast iron	28-30
10 Light cast iron	28-30 nom
11 Cast iron borings	nom
12A New production steel	33-35
12B New production steel	nom
12C New production steel	35-37
12D New production steel	35-37

Alloy steel scrap

Steelworks' buying price: October 29*

UK stainless *(Metric ton)*	
18/8 solids	£280-300
18/8 turnings	£230-240†
12-14% Cr solids	£50-60
16-18% Cr solids	£65-75
Cif Europe stainless *(Metric ton)*	
18/8 solids	$610-640
18/8 turnings	$550-600
UK home high speed *(Per kg)*	
18-4-1 solids	143.0-153.0p
18-4-1 turnings	88.0-100.0p†
6-5-2 solids	80.0-86.0p
6-5-2 turnings	55.0-62.0p

**UK prices may also reflect export business*

†Nominal

Japan

Ex. yard, yen/metric ton	*Oct 22*
No. 1 heavy melting	20,000
No. 2 heavy melting	17,500
Basic open hearth	22,500
Electric furnace	21,500
Foundry	32,000
No. 1 bushels	22,500
No. 1 bundles	23,500
No. 2 bundles	14,500
Baled turnings	17,500
Rerolling: over 6mm	32,000
under 6mm	29,000

Belgium

Source: L'Usine-Het Bedrijf, Belgium	Oct 21
Merchants' selling prices, d/d	
Bfr/metric ton	
Heavy open hearth	3,000
Electric furnace	3,100
Mixed turnings	1,700
Short steel turnings	2,500
Machinery cast iron (prime)	4,800

Per M T (Stated)

GYPSUM
Crude, ex-mine or CIF UK ... £5.00 min.

ILMENITE
Bulk concentrates, Australian, min. 54% TiO_2 FOB ... $A24-$A25
Indian, 'Q' grade, 58/60% TiO_2, FOB Neendakara ... nom.
Sorel titanium slag, TiO_2, long ton, FOB Sorel ... $135.00

IODINE
Crude iodine crystal, 50 kg drums, 99.5% minimum, per kg ... $14–$15

IRON OXIDE PIGMENTS
Spanish ochre
Standard grinding (53 microns), FOB Spanish port ... $115 min.
Micronised grades, FOB Spanish port ... $200 min.
Ochre, FOB Cartersville, Ga, CL/TL, short ton
Light ... $210
Dark ... $145

KAOLIN
Refined, principal grades, bulk FOB:
Coating clays ... £50–£70
Filler clays ... £15–£40
Pottery clays ... £20-£55

LEUCOXENE
W. Australian, min. 87% TiO_2, max. 1% ZrO_2 bagged, FOB ... $A220-230

LITHIUM MINERALS metric ton CIF
Petalite, 3½–4½% Li_2O minus 200 mesh ... £125-£165
Spodumene, 4–7% Li_2O ... £185–£235
Lithium Carbonate, FAS E. Coast USA, CL or TL, bags or drums, per lb ... $1.41

MAGNESITE
Greek, crude lump, CIF ... £55-£60
Calcined, agricultural grades, CIF ... £70-£80
Calcined (natural), industrial grades, CIF ... £100-£140
Calcined (seawater) industrial grades, ex works ... £140-£240
Dead-burned, maintenance grades, ex UK works ... £110-£130
Dead-burned, brickmaking grain, ex UK works ... £130-£200

MANGANESE
Battery grade MnO_2, unground, 78–85%, CIF ... £93–£110
Chemical grade 74–84% MnO_2, bulk, CIF ... £56–£86

MICA
Ground mica powders, ex-works, UK:
Dry ground ... £115–£180
Wet ground ... £220–£300
Mine scrap, muscovite, free of foreign matter, CIF ... £60–£80
Micronised ... £160–£210

NEPHELINE SYENITE
Canadian, CL-car lots TL-truck lots
Glass grade, 30 mesh, bulk CL/TL Sh. ton ... C$22–C$25
Ceramic grade, 200 mesh, bagged 10-ton lots Sh. ton ... C$42–C$47
Norwegian,
Glass grade, 32-mesh (Tyler), bulk, CIF ... £38
Ceramic grade, 325-mesh (Tyler), bagged, CIF ... £58

NITRATE
Chilean, sodium nitrate, about 98%, metric tons, ex-store ... £109

OLIVINE
Bulk, crushed (for blast furnace), CIF ... £11-£14
Bulk, dry, graded refractory aggregate, CIF ... £17-£23
Foundry sand, bagged, del. UK ... £45-£50
Foundry sand, bulk ... £36-£40
US FOB plant mine
Foundry grade bulk ... $49-$62.50
bags ... $62-$75.50
Flour, bags ... $78-$110
Aggregate, bulk ... $36

PERLITE
Raw, crushed and graded, loose in bulk, CIF ... £25–£32
Filter-aids, expanded, milled, del. ... £245–£270
Aggregate, expanded, ex-works, UK ... £155-£205

PHOSPHATES
Florida, land pebble, run of mine, dry basis, unground, bulk, ex-mine, average

	Domestic	Export
60–66% BPL	$23.46	$23.05
66–70% BPL	$19.14	$26.87
70–72% BPL	$24.61	$28.65
72–74% BPL	$22.82	$32.15
74% BPL	$23.44	$36.26

Morocco, 75–77% BPL, metric ton, fas Casablanca ... $48.50
70–72% BPL, metric ton, fas Casablanca ... $4[illegible]
Tunisia, 65–68% BPL, metric ton, fas Sfax ... —
Nauru, 83% BPL, long ton, FOB ... $30–$3[illegible]

POTASH
Muriate of potash, standard, bulk, 60% K_2O, CIF ... £58–£65
Muriate of potash, standard, 60% K_2O, FOB Vancouver ... $100–$120
FOB Saskatchewan, bulk, per K_2O unit
Standard ... $1.1[illegible]
Coarse ... $1.20
Granular ... $1.22
FOB Carlsbad, bulk, 60% K_2O min, per unit
Coarse Muriate ... $1.2[illegible]
Standard Muriate ... [illegible]
Granular ... [illegible]
FOB Vancouver ... [illegible]

PYROPHYLLITE
Australian, bulk, ex-store
Refractory grade ... $25–$3[illegible]
Ceramic and Filler Grades ... $35–$4[illegible]
US, min 20 ton lot, for export, short ton, FOB ... $73–$8[illegible]

RARE EARTH MINERALS: REO = rare earth oxides
Bastnaesite concs, 70% leached, per lb. REO ... $
Monazite, min. 55% REO, long ton, FOB Australia ... $A350-40[illegible]
Xenotime, Malayan min. 25% per lb. Y_2O_3, CIF ...

RUTILE
Australian concentrate, min. 95% TiO_2, FOB/FID
Bulk (large volume, for pigments) ... $A290-30[illegible]
Bagged (small parcels, for welding rods, etc.) ... $A300-32[illegible]

SALT
Ground rocksalt, 10 ton lots, av. price del. UK ... £15–£1[illegible]

SILICA SAND
Foundry sand, ex-works ... £7–£8.50
Glass sand, flint container, ex-works ... £6.50

SILLIMANITE MINERALS
Andalusite, Transvaal, 52-54% Al_2O_3, bulk, CIF ... £7
Andalusite, Travsvaal, 60% Al_2O_3, CIF
Kyanite, USA, 59–62% Al_2O_3, 35–325 Tyler mesh, raw calcined, 18 ton lots, CIF ... £90-£15
US kyanite FOB plant, CL
Raw ... $80-$14
Calcined ... $120-$16
Sillimanite, South African, 70% Al_2O_3, bags, CIF ... £17

SLATE bulk powder ex-works (Fullersite) 90%-200 mesh ... £1

SODA ASH
US natural, FOB Wyoming, Dense ... $9
US synthetic, FOB Syracuse ... $13

STRONTIUM MINERALS
British celestite, ground, washed and graded, min. 94% $SrSO_4$, bagged, ex-works, 240 mesh ... £78.

SULPHUR
US Frasch, liquid, bright, ex-terminal, Tampa ... $1
US Frasch, liquid, bright, CIF N. Europe ... $137-$1
French, Polish, liquid, CIF N. Europe ... $138-$1
Canadian, solid/slate, FOB Vancouver, spot ... $120-$1
Canadian, solid/slate, FOB Vancouver, contract (average) ... $110-$1

TALC
Australian, cosmetic (ex-store) UK ... £105-£1
Norwegian, ground, metric ton (ex-store) UK ... £55-£
Norwegian, micronised, metric ton (ex-store) UK ... £85-£1
French, fine ground CIF ... £105-£1
Italian, cosmetic grade CIF ... £1
Chinese normal, ex-store UK, 200 mesh ... £110-£1
Chinese normal, ex-store UK, 300 mesh ... £115-£1
New York, ceramic, min 20 ton lot, for export, FAS ... $96-$1
New York, paint, min 20 ton lot, for export, FAS ... $111-$1

VERMICULITE
South African crude, bagged, short ton, CIF ... £80-£1
bulk, FOB, N. Europe ... $125-$1
Raw, FOB US plant, bulk, sh. tons ... $81-$1
South African, crude bulk FOB barge, Gulf coast, sh. tons ... $105-$1

WOLLASTONITE
>3 ton lots, bagged, del. UK, approx. 300 mesh approx ... £1
FAS N.Am. port, 20 ton lot, for export, short ton ... $100-$1

ZIRCON bulk, FOB, Australia
Standard (foundry) grade, min. 65% ZrO_2 ... $A90-$A
Intermediate, 65.5–66% ZrO_2, 0.06–0.1% Fe_2O_3 ... $A95-$A1
Premium, min. 66% ZrO_2, max. 0.05% Fe_2O_3 ... $A100-$A1

Industrial Minerals September 1981

REGISTERED

Appendix 8A

My No. D/CSP/T/B/94,
Office of the D.M.N.,
Ceylon Electricity Board,
Anuradhapura. 1981-07-14.

Mr. F.L.P. de Silva,
Chairman/Managing Director,
Ceylon Mineral Sands Corporation,
167, Sri Wipulasena Mawatha,
Colombo 10.

Dear Sir,

Supply of Electricity to Pulmoddai Plant
Ceylon Mineral Sands Corporation

With reference to your letter of 1981-July-4th, it is not possible to change the conducters on the existing pole line as it would necessitate the change of the other components on the line.

It is suggested that a new line be drawn from the Trincomalee Grid substation to Pulmoddai taking a direct route, a distance of approximately 35 miles using pole structures and 7/161 conductor, or a tower design and lynx conductor to meet the proposed load demand of 5 MVA.

You may please discuss with the Chief Engineer, System Planning, C.E.B., Colombo regarding the feasibility of above proposal.

An approximate cost of 3 lakhs per mile will be required for the construction of a new line. The Chief Engineer, Construction Designs, C.E.B., Colombo will be able to advice as to the approximate cost of the new line based on standard tendered costs.

Yours faithfully,

Divisional Manager(North)

Copy to: C.E., System Planning - Please advice Consumer regarding the feasibility of providing a 5 MVA supply within permissible voltage regulation limits.

" C.E., Construction Designs - The Consumer requests an approximate cost basis per mile to provide a 5 MVA supply to Pulmoddai Mineral Sands Corporation.

" E.E., Trincomalee.

Appendix 8A

ලංකා ඛනිජ වැලි සංයුක්ත මණ්ඩලය

இலங்கை கனிப்பொருள் மணல் கூட்டுத்தாபனம்

CEYLON MINERAL SANDS CORPORATION

(ESTABLISHED UNDER THE STATE INDUSTRIAL CORPORATIONS ACT. NO. 49 OF 1957)

දුරකථන : පුල්මුඩේ 9
தொலைபேசி: புல்மோட்டை 9
Telephone: PULMODDAI 9

Telex: "SANDSCOMIN"
COLOMBO-1219

ඔබේ අංකය :-
உங்கள் இல :-
Your Ref :-

මගේ අංකය :-
எமது இல :-
Our Ref :-

ඉල්මනයිට්, රූටයිල් සර්කෝන් කර්මාන්තශාලාව, පුල්මුඩේ
இல்மனைட், ரூட்டைல், சேர்கோன் தொழிற்சாலை, புல்மோட்டை
Ilmenite, Rutile Zircon Factory
Pulmoddai

30th Sept. 1981.

The Chief Engineer,
Systems Planning,
Ceylon Electricity Board,
P.O. Box 540,
Colombo 2.

Dear Mr. Kotandeniya,

Re Supply of Electricity to C.M.S.C. Plant at Pulmoddai.

In reply to your letter dated 31st July 1981 - CE/SP/GD/150

In view of proposed new plant the adequacy of the Trincomalee to Pulmoddai power line to supply the 3 MVA capacity of the Pulmoddai Sub-station has come into question and has been the subject of discussions with yourself and correspondence from the Divisional Manager (North).

I also recently had discussions with Mr. Sivathasan, Chief Engineer, Maintenance, who acted as the Corporation's Consultant for the construction of the sub-station.

The Divisional Manager (North) suggests that the existing line is inadequate and that a new line costing some 11 million rupees be constructed in parallel to the existing line. The cost of this would be to the Corporation.

Mr. Sivathasan, however, points out that the 33 KV/11 KV transformers at Pulmoddai are the automatic tap changing type designed to accommodate a 5% rise in supply voltage and a 15% fall (in supply voltage at the transformer).

Contd / 2

He feels that the existing power line will be 'just adequate' for the load.

My own calculations indicate that, from the Corporation's point of view, voltage regulation would be too high (at 20%)! and, from the C.E.B.'s point of view, line losses at 16% would be excessive. This is calculated for 3 MVA low voltage supply at 0.7 power factor (2100 Kw). The present 550 Kw load has a power factor of only 0.65 (850 KVA).

However, by correcting the power factor (by the use of capacitors) to 0.95 the voltage regulation can be reduced to an acceptable 12% and line losses to 7.7% using the exising line. This should be acceptable to the C.E.B.

In addition, from the Corporation's viewpoint, the installation charges of around 6 lakhs would be recouped in less than 3 years in savings on maximum demand charges (Rs. 22/KVA/month), and a slight saving on unit charges through lower I^2R copper losses in the transformers.

This is illustrated by the attached vector diagrams.

Please let me know if you are agreeable to this solution.

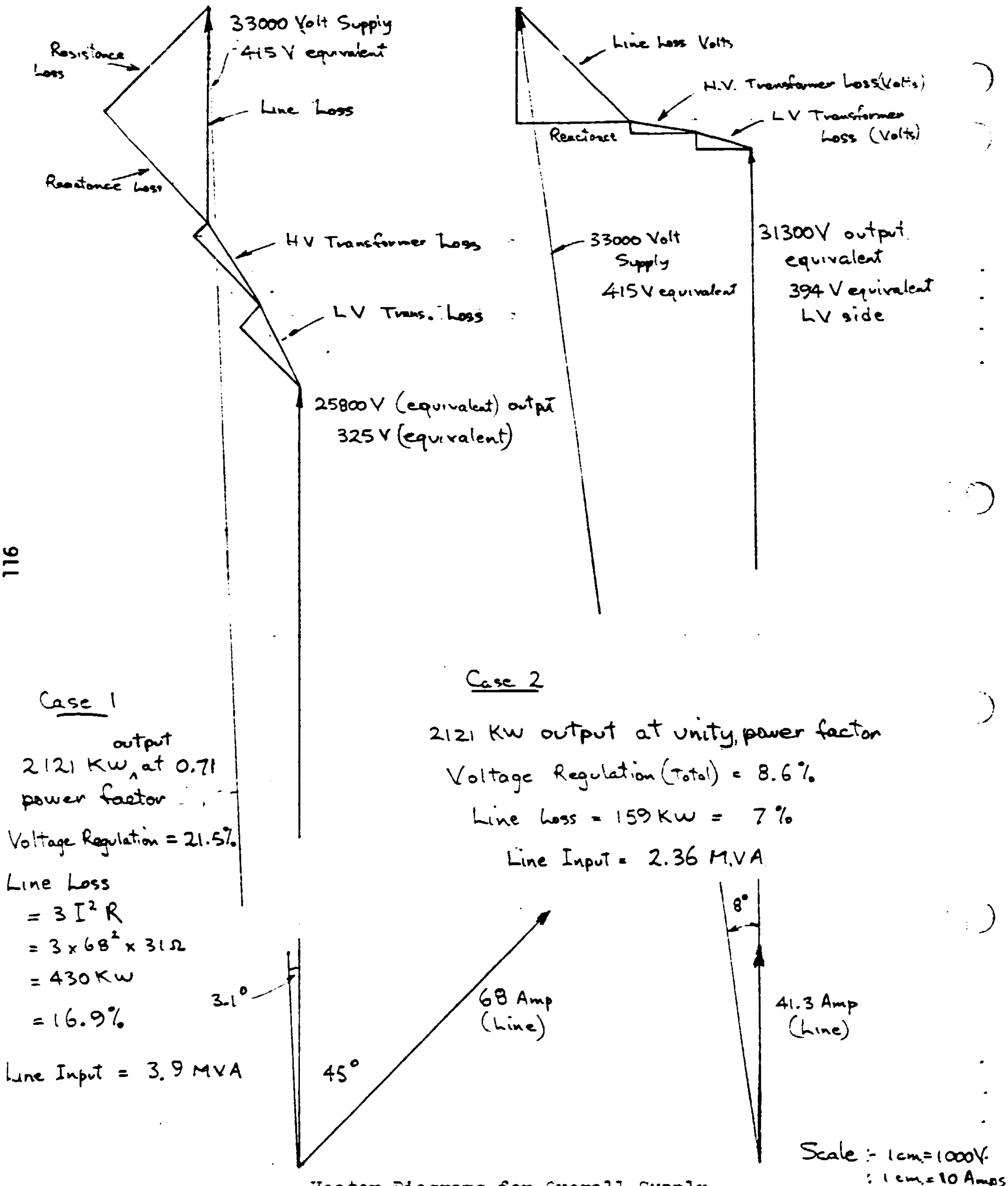
Yours faithfully,

KL

K.L. LITTLE,
Team Leader/Expert in Mineral Sands Processing,
United Nations Industrial Development Organisation
attached to Ceylon Mineral Sands Corporation.

KLL/nnj

c.c: The Chairman/Managing Director.
The Plant Manager/Operations Manager.
Mr. Sivathasan (Chief Engineer - Maintenance, C.E.B.).
General Manager.
Electrical Engineer.



Vector Diagrams for Overall Supply

Trincomalee to pulmoddai power line with high voltage and low voltage transformers.

Line :- 33KV, 48 miles of 7/161 SCA ,3 phase and neutral,31 Ohms resistance , 31 Ohms reactance (lagging).

Transformers :-

33KV/11KV, 2 of 1.5 MVA, 5.5% reactance, 1% resistance with automatic tap changing allowing -5% and -15% input voltage variation.

11KV/415V, many of, average 4.75% reactance, 1.5% resistance.

Pulmoddai.
14th August, 1981.

MEMO TO THE CHAIRMAN/MANAGING DIRECTOR.

SUB : REPORT ON DISCUSSION WITH THE CEYLON ELECTRICITY BOARD RE -

(1) Adequacy of Trincomalee - Pulmoddai Power-Line.

(2) Availability of large supplies of electrical energy for a possible electro-smelting operation.

(3) Future price of Electrical Energy.

(1) Adequacy of Trincomalee-Pulmoddai Power-Line :

The adequacy of Trincomalee-Pulmoddai power-line to supply the 3 MVA capacity of the Pulmoddai sub-station has been in doubt for sometime and has been the subject of a number of reports and of correspondence with the CEB. A recent letter received from the Divisional Manager (North), CEB, suggests the construction of 35 miles of power-line taking a direct route from Trincomalee to Pulmoddai to run in parallel with the existing 45 miles power-line. The cost of such a power-line at 3 lakhs per mile would be of the order of 10 to 12 million rupees.

To see if this expenditure can be avoided I had discussions with Mr. Kotindeniya, Chief Engineer, Systems Planning for CEB.

The installation of power factor correcting capacitors has been suggested by an independent electrical consultant as a possible solution. Mr. Kotindeniya gave the capacity of 7 x .161, 33 KV power-line as 68 MVA miles. For the 45 miles power-line this calculates to 1.5 MVA. He said, however, that the power-line should take the 2 MVA without 'further regulation'. Mr. Kotindeniya was in favour of the installation of a parallel line for the purpose of guarantee performance. However, he suggested that the existing line should be sufficient if a number of steps were taken.

Contd ... 2

(a) The installation of power factor correction by means of low voltage capacitors connected directly to the larger motors.

(b) The use of the voltage taps on the secondary transformers at Pulmoddai. These transformers transform 11 KV to 450 volts. They have taps for voltage correction which are not currently used.

(c) The transference of one tap on the main transformers (33 KV to 11 KV). These transformers currently have 3 lower taps and 2 higher taps, each of 2½ percent. He suggested that the higher taps were not necessary since the instance of excessively high voltage would almost never arise and if one of the higher taps was to a lower tap it would allow voltage regulation over the larger expected range of low incoming voltage.

For (2) above :

The unused voltage taps on the low voltage transformers should be made to operate automatically as on the high voltage transformer.

Effecting the above three (3) steps should allow 2.1 kilowatts at a power factor in excess of .9 to be transmitted by the existing line.

The cost of power factor capacitors was ascertained from Walkers Ltd., who have available 20 KVAr capacity units which are made up in banks. These cost Rs. 7,000/= each. Some 1,100 KVAr is necessary, switched directly with the larger motors. The cost of these capacitors would be Rs. 385,000/=. Installation costs are minimal.

I left in abeyance the larger legal question of how the Corporation came to have a 3 MVA sub-station fed by a power-line which is inadequate to transmit 3 MVA. The original contract with the CEB should be studied to see if the CEB was not in fact obliged to supply 2 power lines at CEB expense.

(2) Availability of Power :

I questioned Mr. Kotindeniya on the availability of electrical

Contd ... 3

power within the next few years and in the longer term. Mr. Kotindeniya said that electrical power would be in short supply until mid 1984 when the large hydro electric power stations of the Mahaveli Scheme come into operation. The present generating capacity in Sri Lanka is 480 megawatts. It is planned to add to this some 1,070 megawatts over a period extending into the 1990's. The attached table gives the names of the power stations and their capacities.

Hence, ample power should be available from mid 1984 onwards.

Trincomalee is at the end of a 132 KV line currently of 30 megawatts capacity. However, it is planned to upgrade this to 60 megawatts as the line is a double tower structure only singly strung. At present Trincomalee has 20 MVA sub-stations, of which 10 are already taken. The Prima Flour Mill itself takes 7 to 8 MVA.

(3) Cost of Future Power Supply :

Electrical energy in Sri Lanka has historically been inexpensive. However, in the last 30 months cost per unit has escalated alarmingly. As recently as 30 months ago power costed 12 cts. per unit plus a small surcharge for the KVA maximum a month. A recent power bill shows the cost of energy at Rs. 2/= per unit. This is largely due to the introduction of gas turbines which are notoriously fuel hungry and were introduced only as an emergency measure until further hydro capacity was introduced.

In the future it is intended to use the gas turbines only for peaking, i.e : to take some of the load only during peak hours.

I was referred to the Commercial Manager of CEB, Mr. Senathipathi for estimates of future power costs. Mr. Senathipathi estimated that hydro power alone in 1982 and 1983 would be 83 c/unit.

He said that in the past commercial power had been heavily subsidised by the domestic sector and this would not be the policy in the future. The days of cheap power apparently are over.

Contd ... 4

In 1985 and 1986 when ample supplies of power will be available the cost will not be cheap because of the large capital costs of the hydro schemes.

As an instance, he gave the cost of the Kotmale Project which was originally estimated to cost 3 Billion Rupees. The current estimate of the cost is 6 Billion Rupees but it is widely expected that the end cost will be somewhere in the range of 8 to 12 Billion Rupees, this is for 210 MVA power station which is fairly small by world standards.

Mr. Senathipathi said that the hydro scheme would be handed to the CEB on completion and they would then be saddled with a large loan re-payment. Hence, the unit cost of the power could not be small. He estimated that power in 1984 to 1986 would cost Rs. 1.50 per unit without the present oil surcharge. A quick calculation shows that 1.5 Rs. per unit is of the right order since the interest and depreciation charges on 9 Billion Rupees would be around 2 Billion Rupees per annum and the 210 megawatts power station would produce around 1 Billion units per annum at 55 percent utilization factor. Hence, the money cost alone of this power station would be Rs. 2/= per unit to which must be added the running cost and the cost of the distribution system.

Mr. Kotindeniya said that he would be writing a letter to the Corporation including the outcome of the discussion.

Kh 15-8-81

K.L. LITTLE,

'UNIDO' Team Leader.

KLL/nnj

MEMO TO THE CHAIRMAN/MANAGING DIRECTOR.

Analyses Of Electrical Load - Pulmoddai

An analyses of the electrical load at the Pulmoddai Plant is necessary both for reference and to determine how much electrical capacity remains for the proposed Wet Gravity Upgrading and Wet Magnetics Separtion Plant.

The existing sub-station is a dual 1.5 MVA, 33,000 V system (giving 3 MVA) but the power line feeding the sub-station is of lower and somewhat indeterminate capacity (see separate memo).

1. Incoming Load :

On 10th August, 1981 CEB Engineers serviced the main meters measuring units and KVA maximum demand. Previously, only the watt hour meter appeared to be working. The KVA meter was obviously reading low and not responding to changes in load. The Engineers said that the meters had previously been calibrated in the workshop to an accuracy of ± 2% but had been wrongly connected.

The new reading of the meters is considerably higher than the older reading, by at least 50 Kw and by some hundreds of KVA. At present power rates, the Corporation may well be paying an extra Rs.70,000/= per month, viz :-

60Kw x 30.5 days x 24 hrs x 1.40 Rs/Kw hr + (950KVA - 620KVA) x 20 Rs/KVA demand = 68,088 Rs/month.

With about 1 million Rs/yr. probably involved it is of some concern to the Corporation to see that the CEB meters are not reading in excess of the correct amount. Unless the Corporation power factor meters are repaired there is no way of checking the Kw demand, hence the units charged. The KVA now indicated by the CEB meters is considerably in excess of that indicated by the Corporation meters, so the latter should be checked.

Contd (2)

Nor are the Corporations ammeters consistent within themselves. The sum of the current meters on low voltage indicates higher KVA than the main Corporation meter in the sub-station. Also, meters supposedly reading the same current do not agree. It is therefore recommended that one ammeter, one voltmeter and one power factor meter preferably working on the bus bars for the 11 KV supply ex the main transformers be sent for calibration to the CEB laboratories together with their current transformers. There would then be an independent check on the CEB's charges.

According to the CEB meters then the maximum demand is likely to be

950 KVA

6$\overset{5}{3}$0 Kw,

and power factor from 0.62 to 0.75, average 0.66.

2. <u>Individual Load</u> :

The KVA demands of individual sections such as Dry Mill, Southern Housing Complex etc. can be obtained from current and voltage meters, but these are of doubtful accuracy.

The Kw load of individual stations can not be obtained because there are no power factor meters or watt hour meters. However, it is possible to make an educated guess from the overall power factor, the nature of the load (heating, lighting, small induction motors partly loaded, etc) and from overall power factors at times when one load predominates in the overall load.

Bearing all this in mind the following is the approximate position :

Section		KVA	Kw Estimate	Remarks
Dry Mill		205	131	Constant loads
Wet Mill		300	192	when
Ilmenite Plant		150	92	operating.
Office	min	01	01	Variable loads peak-
	max	15	11	ing at different
Workshop	min	01	01	times.
	max	15	11	

Contd (3)

Section		KVA	Kw Estimate	Remarks
Leading	min	00	00	
	max	35	24	
Southern Housing	min	35	30	Variable loads
	max	185	160	peaking at
Northern Housing	min	06	05	different times
	max	25	22	
Total Maximum		930	643	

3. Load Limits Imposed On New Plant :

The proposed plant will have to be confined to certain electrical load limits depending on what changes are made.

According to CEB's own formula the present power line has a capacity of 1.5 MVA, viz : 68 MVA miles ÷ 45 miles = 1.51. The Chief Systems Planning Engineer says however that 2.0 MVA could be obtained without regulation. Hence, the new load would be confined to 2.0 MVA minus the existing load, which equals 1.05 MVA.

With power factor correction to the existing and new load and full use of the tap changing facilities of the transformers the available supply for the new plant would be approximately 1,450 kilowatts at power factor in excess of 0.9.

With a new power line in parallel to the existing power line the available load could be extended to the capacity of the sub-station minus the existing load, i.e: 3 MVA minus 0.95 MVA = 2.05 MVA, so with power factor correction 2 megawatts could be obtained for the new plant.

KL 14-8-81

K.L. LITTLE,
(UNIDO).

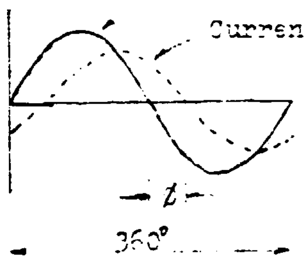
12th Aug. 1981.
KLL/nnj

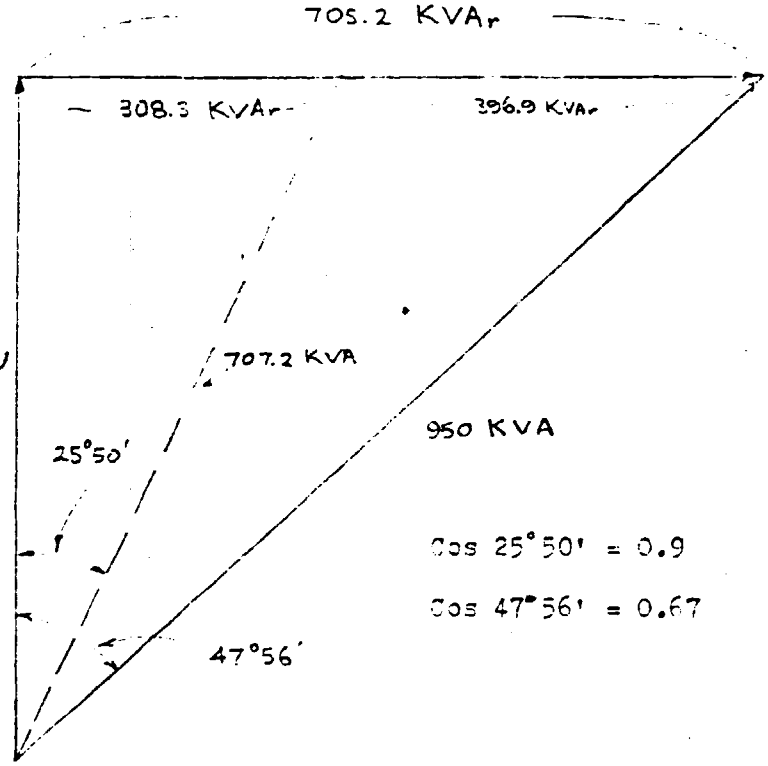
Appendix- Relationship Between K.W., K.V.A., and K.V.A.r

$$K.V.A. = \frac{\sqrt{3}\ \text{Volts} \times \text{Amps}}{1000} \qquad K.W. = \frac{\sqrt{3}\ \text{Volts} \times \text{Amps} \times \cos\phi}{1000}$$

$$\cos\phi = \text{Power Factor} = \frac{K.W.}{K.V.A.}$$

, ϕ is the angle by which the Voltage leads the current in the alternating current circuit.

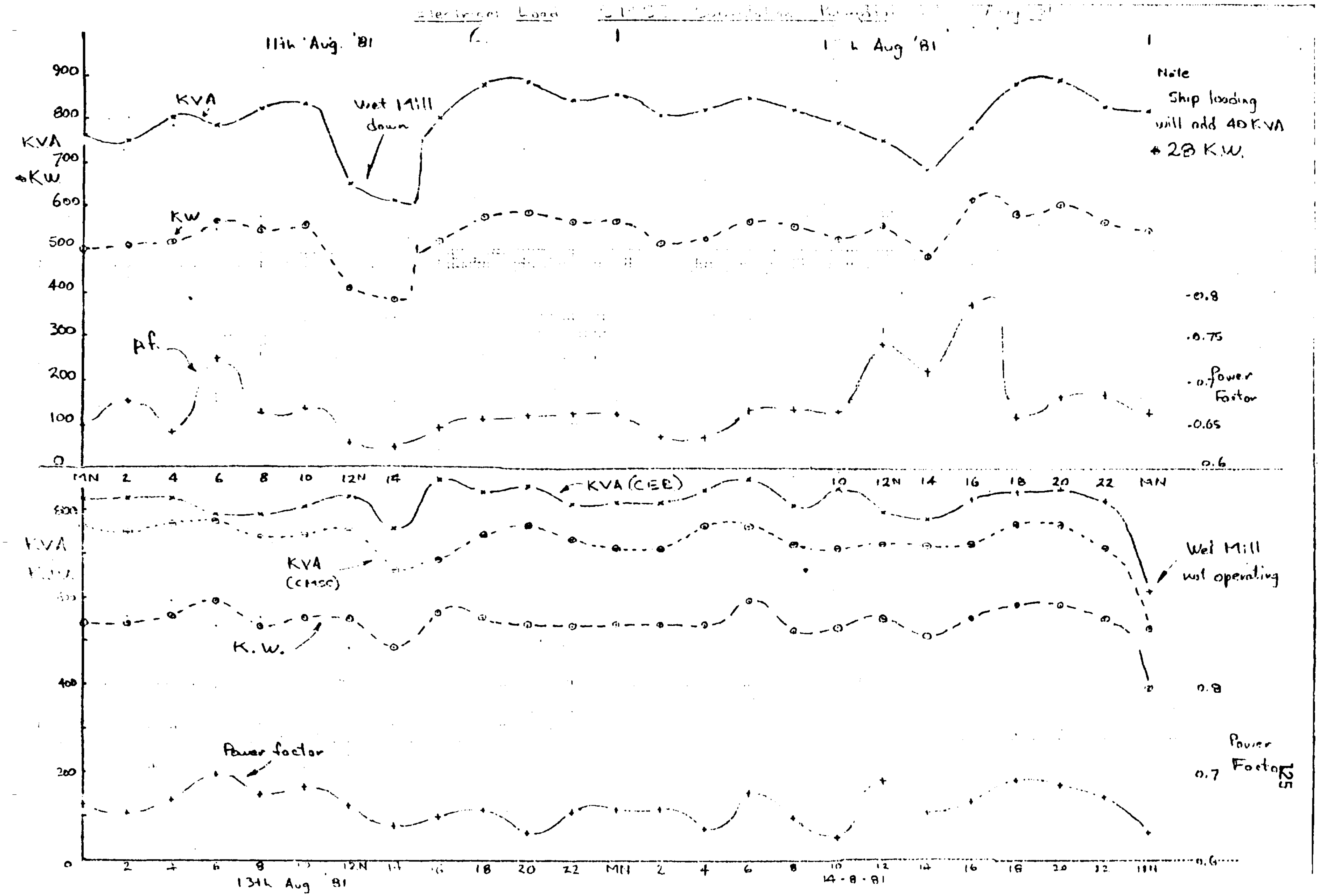




$$\frac{K.V.A.r}{K.V.A.} = \sin\phi \quad , \quad \frac{K.V.A.r}{K.W.} = \tan\phi$$

$$K.V.A. = \sqrt{K.V.A.r^2 + K.W.^2}$$

The Diagram shows the relationships and the way the addition of 400 KVAr of power factor correction capacitors would increase the power factor to 0.9 from 0.67 reducing KVA maximum demand from 950 to 705. This would save 245x 20Rs = 4900 Rs per month (58000 Rs per year) and would cost 140,000 Rs for the capacitor units.


11th Aug. '81
Aug '81
KVA
KW
Wet Mill down
Note
Ship loading will add 40 KVA + 28 K.W.
KVA + KW
Pf.
Power Factor
KVA (CEB)
KVA (CMSC)
K.W.
Wet Mill not operating
Power factor
13th Aug '81
14·8·81
Power Factor

REPORT ON DISCUSSIONS WITH THE NATIONAL WATER SUPPLY BOARD ON 10TH JULY, 1981

The possibility of establishing a titanium oxide pigment factory at Trincomalee has to be considered. There are problems about establishing such a factory at Pulmoddai, including water supply.

Such a factory at Trincomalee will need water. Usage is estimated in the range of 900 - 1,000 gpm operating 8,000 hours a year. To establish whether such a water supply is likely to be available I had discussions with Mr. Ratnakumar, Project Manager for the National Water Supply Board at his office in Trincomalee.

The present Trincomalee water supply was established in 1942 for the Naval Base then in the area. It is rated at 1 million gpd. This water supply presently supplies the needs of the Air Force Establishment and Naval Establishment at Trincomalee, and gives a limited supply of drinking water to the town of Trincomalee. This is available only for a few hours a day.

Mr. Ratnakumar said that it was proposed to extend this water supply to 8 million gpd. Completion date would be March 1983. It is proposed to establish a filtration and chlorination plant, beside the Kantalai Tank and to run 34 kilometres of 600 mm internal bore cast iron pipeline to a holding tank at Pallacuttu near Trincomalee. From here it is proposed to run branch-lines to Nilaveli, China Bay and Kinniyai. The sizes of these lines would be 300 mm, 400 mm, and 250 mm respectively.

The tank would have a capacity of 4,500 cu. mtrs. and it is proposed to establish three secondary reservoirs at Mankanai 2,400 cu. mtrs., Fort Federick 1,200 cu. mtrs. and Makkaluttu 4,000 cu. mtrs.

The 8 million gpd has been variously assigned as shown in the attached table. It would be noted that 1.53 million gpd has been set aside to a Free Trade Zone and 1.3 million gpd has been set aside

(Contd / 2)

for a proposed Tourist Complex at China Bay. The balance has been set aside for various other purposes. These figures are intended to represent the needs upto the year 2000. Beyond then there is provision to extend the supply from the same pipeline to 12 million gpd.

The requirements for the pigment factory should not exceed 1.3 million gpd and could be considerably less depending on the configuration of the factory. As an indication only, Ratnakumar gave a price of Rs. 8/- per 1,000 glns. for industrial water.

Kantalai tank, the source, is an ancient tank built in the fifth century. It has a capacity of 110,000 acre feet and presently irrigates 13,000 acres of paddy and 7,500 acres of sugar. While its catchment area is fairly small it received a minimum of 50,000 acre feet per annum from the Mahaveli scheme. The catchment area of Kantalai system is given as 174 sq. miles, giving an annual run off of 221,000 acre feet. The requirement of the water scheme amounts to 10,000 acre feet. No information regarding the quality of the water was available, It is assured that it will be a reasonably soft water. Any further information will have to be obtained from the Head Office of the National Water Supply Board at Ratmalana.

From above it can be seen that there is the prospect of obtaining a reliable water supply from the new water scheme for Trincomalee. This would be of the order of 1½ m.g.p.d.

Regarding power supply, there is presently a 10 MVA sub-station at Trincomalee most of which is already assigned and there is to be another 10 MVA supply added in the near future.

K L Little UNIDO
17-7-81

TRINCOMALEE WATER SUPPLY SCHEME - MARCH 1983

FLOW ASSIGNMENT		CONTINUOUS		PEAK DISCHARGE	
		M.G.D.	l./s.	Peak Factor	l./s.
Upstream		0.60	31.60	1.0	31.60
North (Nilaveli)	Nilaveli Town	0.28	14.70	2.5	37.00
	Tourist Complex	0.65	34.20	2.5	86.00
Centre (Trincomalee)	Air Force & Navy	0.60	31.60	1.0	31.60
	Town	2.71	142.60	2.0	285.00
South (Kinniyai)	Free Trade Zone (Proposed)	1.53	80.50	1.0	80.50
	Prima Flour Mill	0.05	02.60	1.0	02.60
	Tourist Centre (Proposed)	1.30	68.40	2.5	171.00
	Kinniyai	0.28	14.70	2.5	37.00
TOTAL		8.00	421.00		762.3

New Water Supply project for Trinco

(14-7-81) 129

By J. E. O. Madawela B.Sc. (Eng) Lon., M.I.C.C. F. I. E (SL) Resident Manager— Degremont and
O. D. Liyanage, B Sc. Diploma D'Ingenieur (France) Project Engineer — GERSAR.

Trincomalee is a very important and fast growing town due mainly to the large natural harbour. In addition, the areas to the north and south of Trincomalee are fast becoming very popular tourist resorts, especially with the declaration of these areas as tourist development areas, by the Government of Sri Lanka.

Trincomalee, at present, depends on a water supply scheme constructed in 1942 by the British Navy to meet the requirements of the armed forces stationed in Trincomalee at that time. The capacity of this scheme is one (1) million gallons per day which now is sufficient only for the requirements of Navy and Air Force establishments and for a very restricted supply to the central part of the town. The civilians get pipe borne water only for a couple of hours each day.

GROWTH

The commercial and industrial growth of these areas have been handicapped by the insufficiency of good purified drinking water. Aware of this short coming, the Government of Sri Lanka had been persuing various avenues to obtain the necessary Foreign Assistance to implement a modern purified water supply system to cater to the needs of the town and the surrounding areas. At this juncture in 1980 the French Government gladly agreed to finance the foreign costs of the project. It should be mentioned that the financing of this project materialised with the visit to Sri Lanka of Mr Monory, the then Minister of Finance and Economic Planning of France and the signing of the Financial Protocol for French Aid by Mr. Monory and Mr. Ronnie de Mel the Minister of Finance and Economic Planning of Sri Lanka.

AUTHORITY

The National Water Supply and Drainage Board of the Ministry of Local Government, Housing and Construction, which is the Authority responsible for all Water Supply and Sewage Schemes in Sri Lanka, will be in charge of the execution of the new project. The National Water Supply and Drainage Board had previously carried out preliminary studies on this project with regard to the source, supply area and water demand, both at present, and projected for the year 2000 AD.

The French Authorities recommended to the Sri Lankan Government a consortium of three French Companies, made up of GERSAR, DEGREMONT and SOBEA to prepare the proposals for this project, and to subsequently undertake its construction and commissioning. The Government of Sri Lanka agreed to this recommendation, as each of these companies were well-known, both in France and Internationally in their respective spheres of operation. Further all three companies also have much experience in Sri Lanka.

GERSAR, which is a semi-government organisation is a well known Consultancy Group. This group in addition to its international activities, are responsible for all the design, construction and operation of all irrigation, water supply and regional development projects in the Southern regions of France. In the Trincomalee Project GERSAR are reponsible for the engineering studies and supervision of construction. They have been engaged in Sri Lanka in investigations and designs for Nilwala Ganga Basin flood projecton scheme.

DEGREMONT is internationally well recognised in the treatment of drinking water sewage and industrial effluent. At present they are executing contracts in over eighty countries of the world, in addition to permanent organisations in twenty six countries (17 subsidiaries and 9 licences). Their treatment techniques are the most advanced and efficient processes in the world. Here in Sri Lanka, DEGREMONT treatment plants are in operation in Kandy and Ambatale and at the Raddoluwa Urban Development Scheme. In the Trincomalee Project, DEGREMONT are responsible for the specialised studies and designs of the treatment plant and pumps and the supply, installation and commissioning of these.

PROJECTS

SOBEA is an Internationally well-known Civil Engineering Contracting Group operating in many countries in the world. In the past they have constructed in Sri Lanka the Towns of South-of-Colombo and Kandy Water Supply Projects. In the Trincomalee Project they are responsible for the laying of all pipes, and construction of all Civil Engineering structures. The pipes and specials that are used for this project are supplied by PONT-A-MOUSSON of France the well-known pipe manufacturers.

In conformity with aforementioned preliminary studies of the National Water Supply and Drainage Board the new project has been designed by the French group of companies (GERSAR-DEGREMONT-SOBEA). The present designed capacity of the project is eight (8) million gallons per day (1515 m3/hr). This capacity would be sufficient up to 2000 AD. Accordingly, necessary provision has been made to increase the capacity of the treatment plant and the pumping systems to twelve (12) million gallons per day (2272 m3/hr) after 2000 AD.

DESIGNED

Taking into consideration the supply area recommended by the National Water Supply and Drainage Board the project has been designed to supply water to Trincomalee Town and up to Nilavely in the North and Kinniya in the South which includes the proposed tourist resorts. Supply is also provided for Kantalai and Thambalagam.

The nearest reliable source is Kantalai Tank. As such raw water from this reservoir will be pumped to a Treatment Plant sited nearby. The treated water will then be pumped to a regulation tank sited on a hill in the near vicinity, and at an elevation of 120 metres. From this tank water will flow by gravity, through a 600 mm diameter pipeline 34 km long to a reservoir at Palliootou near Trincomalee to supply this town. From here the supply will continue to reservoirs at Mankani, near Nilaveli and Manalitu near Kinniyai. All these reservoirs, with a total capacity of 11600 m3 ensure a satisfactory will uninterrupted supply the pipe lines from Kantalai to these areas are of ductile iron of diameters 600 mm to 250 mm, and the total length is approximately 65 Km.

CONTRACT

The proposals and designs were approved by the National Water Supply and Drainage Board. The contract for the execution of the Project was signed in September 1980 between the National Water Supply and Drainage Board on behalf of the Government of Sri Lanka and the companies of SOBEA DEGREMONT and GERSAR. The contract as signed was for 112.5 million French Francs and 103 million Rupees. The foreign component (French Francs) is being provided as a loan by the Government of France while the Rupees component is being supplied by the Government of Sri Lanka.

It is heartening to know that the field work has now commenced on this project and it is scheduled to be completed by end of 1982 satisfying urgent need which has been long overdue.

WORTHY

Here again is another worthy instance of friendly co-operation and assistance from France to Sri Lanka, especially in the field of basic necessities for Sri Lankans. This is most appreciated as we are aware that still there are many towns and villagers in Sri Lanka, very badly in need of purified drinking water and good sanitation. These needs have been brought out most forcebly during the last outbreak of cholera in various parts of the Island.

As such, we are all the more grateful to the Government of France for making the Trincomalee Water Supply Project a reality. At the same time we look forward to much more similar generous assistance from France in the future, to achieve these basic amenities for good healthy living for Sri Lankans.

From James Bay in Canada to Libya, th current flows betwe the industrialized a industrializing countric and a French firm b the name of "Ceraver which holds top place i the world for the manu facture of insulators i tempered glass for hig — and medium-volta electric cables.

This firm in Sain Yorre, near Vich achieves 60 per cent c its turn-over figure i experts. Its internati nal clientele includ Western countries an Third-world countri which have a large d mand for electrical a other equipment. This the case for Iraq, Ir for Mozambique, L laya, Venezuela a Brazil. "Ceraver" is i fact on nearly eve market, except for t Eastern European bloc India and China. I four years, the firm h supplied the 1,600,0 insulators intended f the 2,000 kilometres electric cables at Jam Bay in Canada, order by "Hydro Quebec."

This bold expo policy has given t company a remarkab boom in the last t

Warmest felicitations

192 years back, tod marked the storming the Bastille pris which paved the w for the establishme of constitutional fo of government France. On the occas of the Fete Nation commemorating t event the Associat of Franco Ceylon Technologists is pr to extend our warm felicitations to the publie of France.

France and Sri La ka have strong bo of friendship and e nomic cooperation Lanka has been enri with French tech cal 'know how' in field of energy, hous transport railw irrigation, telecommu cation and techn training through se ral development schemes and bil ral agreements. dawn of a Socia Dominated Gove ment in France harbinger for the b terment of future r tions between the countries.

Our Associati proud of its li with a nation wh has kept its place the vanguard of te nological developme rends its Greetings the Government the people of Repu of France on this he day.

S. H. C. DE SILVA
President
Association of Fra Ceylonese Technolo gists.

Appendix 9B

Pulmoddai.
14th August, 1981.

MEMO TO THE CHAIRMAN/MANAGING DIRECTOR.

QUALITY OF THE PROPOSED TRINCOMALEE WATER SUPPLY

The previous memo has dealt with the availability of the proposed water supply to a possible Titanium Dioxide Pigment Plant located at Trincomalee. This information was obtained from the Project Manager at Trincomalee. He could not however give any information as to the quality of the water. On Friday the 31st of July 1981 I visited the National Water Supply & Drainage Authority Offices at Ratmalana to obtain information regarding the expected quality of the proposed Trincomalee water supply from the Kantalai Tank. From the Chief Chemist I obtained analysis of the Kantalai Tank water taken once a month during the year 1980. This gives a profile of the water through the various seasons.

The samples were taken from near the spillway and one foot below the surface. In some cases, two other samples were taken, one at greater depth and one from the bottom of the tank. The results, however, did not differ greatly except that in one instance only, the bottom sample had significantly higher iron content.

The analyses show the water to be fairly soft with a 2 to 1 range in total hardness depending on the season. Most of the hardness is temporary hardness which is cheaply treated with quick lime or Hydrated lime. In many cases, the total alkalinity, representing mostly temporary hardness, exceeds the total hardness. This is unusual and I was told it was due to the presence of hydroxide alkalinity or 'sodium salts'.

The water is much softer and much lower in total dissolved solids than the Yanoya water supplied at Pulmoddai, and would therefore be better for sulphate route titanium dioxide pigment plants and/or electro smelters.

K.L.

K.L. LITTLE,

'UNIDO' Team Leader.

KLL/nnj

KANTALAY TANK WATER ANALYSES

APPEARANCE	30-12-80 Turbid	23-11-80 Turbid	21-10-80 Turbid	18-09-80 Turbid	13-08-80 Turbid	03-07-80 Turbid
Turbidity						
unsettled	12.00	17.00	17.00	16.00	22.00	15.30
settled						
pH	06.90	06.60	07.20	07.40	07.30	07.20
Elect Cond megohm/cm^3	150.00	148.00	175.00	185.00	280.00	275.00
Chlorides	18.00	14.00	17.00	17.00	26.00	23.00
Total alkalinity as $CaCO_3$	75.00	70.00	81.00	101.00	128.00	158.00
Total hardness as $CaCO_3$	72.00	67.00	84.00	88.00	118.00	126.00
Total diss solids	97.00	93.00	112.00	119.00	179.00	178.00
Nitrates ppm	tr	nt	nt	tr	tr	tr
Nitrites ppm	min tr	nt	tr	nt	nt	nt
Free Ammonia	00.10	00.08	00.08	00.08	00.04	01.56
Albuminoid ammonia	00.90	00.10	00.15	00.20	00.12	01.88
Iron (1) Total	00.70	01.10	00.70	00.85	01.35	00.72
(2) Aerated settled						
Colour Hazen Scale	20.00	20.00	45.00	45.00	48.00	25.00
Fluorides (as F)	00.40	00.40	00.40	00.40	00.40	00.40
Sulphates (as SO_4)	05.00	04.00	04.00	03.00	04.00	04.00
Manganese	nil	nil	nil	nil	nil	nil

Units : ppm unless otherwise stated (parts per million).

Continuation

APPEARANCE	07-05-80 Turbid (slight)	08-04-80 Turbid	18-03-80 Turbid	26-02-80 Turbid	21-01-80 Turbid
Turbidity unsettled	06.80	10.20	08.80	09.00	16.80
settled					
pH	07.30	07.00	07.30	07.60	07.60
Elect Cond megohm/cm^3	290.00	275.00	275.00	260.00	330.00
Chlorides	24.00	26.00	23.00	24.00	21.00
Total Alkalinity as $CaCO_3$	134.00	119.00	120.00	120.00	114.00
Total Hardness as $CaCO_3$	124.00	120.00	118.00	116.00	126.00
Total diss solids	189.00	181.00	180.00	171.00	218.00
Nitrates ppm	tr	tr	tr	tr	nt
Nitrites ppm	nt	nt	nt	nt	nt
Free ammonia	00.10	00.03	00.04	00.26	00.16
Albuminoid ammonia	00.15	00.15	00.16	00.52	00.40
Iron (1) Iron	00.36	00.40	00.42	00.62	00.72
(2) Aerated settled					
Colour Hazen Scale	12.00	15.00	15.00	20.00	23.00
Fluorides (as F)	00.40	00.40	00.40	00.40	00.40
Sulphates (as SO_4)	04.00	04.00	04.00	04.00	04.00
Manganese	nil	nil	nil	nil	nil

Units : ppm unless otherwise stated (parts per million).

Appendix 9C

Ceylon Mineral Sands Corporation,
Pulmoddai.

27th April, 1981.

Chairman/Managing Director,
Ceylon Mineral Sands Corporation,
COLOMBO.

Report on Discussions with Irrigation Department.

In order to assess the adequacy of the Yan Oya anicut to supply the Corporation's present, projected and possible future water needs, I had discussions with the Irrigation Department at Trincomalee on Monday, 6th April, 1981 and Wednesday, 8th April.

Officers interviewed were :

M/s. K. Thevasagayam - I.E. Hq. 2.
T. Nadarajah - Draftsman.
V.R. Loganathan - Technical Assistant.

Mr. Hajireen, Technical Superintendent was not available.

The Corporation's present needs amount to 600 imperial gallons per minute (164 c.m./hr.) or 1100 acre feet (1.37×10^6 c.m.) per year (assuming 8000 hours operation). A pigment plant at Pulmoddai would at least treble this requirement and other operations and personnel requirement would add considerably.

Last year, before the onset of the monsoon, production had to be interrupted because of shortage of water,and extra-ordinary measures had to be taken to obtain supply. The subsequent monsoon was very poor, yielding less than half normal rain fall. Hence similar problems can be expected around August and September this year.

The problem lies largely in the 4 mile long open, unlined channel which conveys the water from the anicut to the pump inlet site. Seepage and evaporation losses are excessive since the channel frequently spreads to a wide area of pondage and swamp, and since wild elephants frequently break the banks. The other part of the problem is that flow in the Yan Oya drops to dangerously close to requirements (i.e. 600 gpm). For months, last year, diesel driven pumps had to be installed below the anicut to pump water to the intake site and the anicut was left open. The seepage and evaporation in the river bed apparently, were below those of the channel.

Cont'd..../2-

A tank, the Omarakawa or Kandura tank lies 4 miles upstream of the Anicut on a tributory of the Yan Oya and is available to supply the Anicut. A rating in acre feet for this tank was not available, but it appears quite small on the map and its water is lost to seepage and evaporation and heavily pillaged as it comes down stream. Hence, last year it was not of much assistance.

The following statistics re. the Yan Oya were obtained.

Yan Oya -

Total catchment area	:	590 sq. miles, 1500 km^2.
Average yearly rainfall	:	55 inches , 1400 m.m.

Hence :

Total rainfall in catchment	:	1.73 million acre feet, 2135 x 10^6 m^3.
Run-off, yearly average	:	319000 acre feet, 395 x 10^6 m^3.
Minimum yearly run-off	:	100000 acre feet, 123 x 10^6 m^3.
Minimum flow rate	:	850 g./min. , 232 cm/hr.

The anicut, being slightly upstream of the river mouth, misses 13 square miles of catchment and the Huruluwewa tank of 55000 acre feet capacity collects water from the top 77 square miles of catchment. Hence, the catchment area available to the Anicut reduces to 495 square miles and the above figures reduce in proportion.

Up to the present the Huruluwewa tank has proved to have excess capacities for its catchment area. It never overflows and some of its projected 10000 irrigable acres have had to be abandoned.

From the Corporation's point of view the bad news is :-

1) Work has started on a scheme to irrigate 1400 acres from the Yan Oya anicut. The area is downstream from the Corporation's pump intake site on the same open unlined channel, so the Corporation's needs are met first. However, as previously stated, the Corporation's requirements cannot be met at times so a bad situation could develop, with angry farmers demanding water.

2) There is a plan to site a new tank 6 miles upstream of the anicut on the Yan Oya. This will be the Veddatalawakanda tank, also called the Yan Oya tank. It will have :

   527 sq. miles catchment area.
   46000 acre feet storage capacity.
   9000 acres irrigable area.

Cont'd...../3-

Also the Wahalkada Wewa, an old tank is to be restored and there is a plan to build another tank, Ratmale, a further 14 miles upstream. This willhave :-

398 Sq. miles catchment area.

26000 acre feet storage capacity.

5000 acres irrigable area.

Cont'd......./4-

There is, some doubt the latter plan will be implemented. The Veddatalawakanda tank could, however, be as little as 12 months away or as much as 10 years.

During some stages of construction at least flow may be interrupted and the Corporation will run short of water.

Properly managed, however, the tank could ultimately stabilize the Corporation's supply by holding back water for release in the day dry season. This depends on the Corporation's requirements being scheduled into the Irrigation Department's plans.

The good news is that the Huruluwewa tank, 42 miles upstream of the anicut is soon to be supplied with water from the Mahaveli Scheme. The water eminates from the Amban Ganga, a tributory of the Mahaveli, and comes via the Elahera anicut and the N.C.P. canal. The overflow from the Huruluwewa irrigation area, assuming there is one, will then supplement catchment water in the Yan Oya; and so improve minimum flow at the anicut, whose storage capacity is so small as to be hardly worth considering.

Recommendations and Conclusions :

There is a need to liase with the Irrigation Department to ensure the Corporation's current and future water needs. The proposed Veddatalawakanda tank has the potential to supply current and even modestly expanded water needs provided its outflow is controlled, but this has to be arranged with the Department.

The Department should be querried, preferably at a Ministry chaired conference about its plans, particularly :

1) regarding the timing of the tanks construction.
2) whether flow will be interrupted during construction.
3) whether the Corporation's requirements have been taken into account.

If the tanks construction is to be delayed indefinitely a large bore pipe line is required from the anicut to the Corporation's pump intake site to avoid heavy losses in the channel currently used.

K.L. Little.
(UNIDO Team Leader).
KLL/lm.

A P P E N D I X ~~- A -~~ 9 d

CHEMICAL ANALYSIS RESULTS.

Source - Yan - Oya

Point of collection of samples - At proposed Anicut

						Max. Concentration Acceptable/allowable for drinking purpose (P.P.M.)		
Date of collection	10.5.73	6.6.73 •	28.6.73	12.7.73	26.7.73		27.7	10.8
Appearance	Slightly Turbid	Coloured	Coloured	Turbid	-			
Turbidity (Silica scale)	5.0	9.5(J.T.U)	1.7	2.8 (J.T.U)	1.9	5.25(Silica)	3.9	6.8
Colour (Hazen Scale)	25	80	30	30				
Colour (after filtration)	-	40	-	-				
pH	7.7	7.6	7.6	7.4	7.6	(7.0-8.5 / 6.0-9.2	7.4	7.2
Electrical Conductivity (1/Megohm per cm 3)	940	550	1220	2200	2400		2710	800
Chlorides	241	146	374	520	564	(200 / 600	668	122
Total Alkalinity (as $CaCO_3$)	262	120	236	270	224		212	140
Total Hardness (as $CaCO_3$)	308	220	456	600	652	(100 / 500)		204
Total Solids	623	360	812	1458	1585	(500/1500)	1793	500
Nitrites	Minute Trace	Minute Trace	Minute Trace	Minute Trace	Trace		Trace	Trace
Nitrates	Minute Trace	Minute Trace	Minute Trace	Minute Trace	Trace		Trace	Trace
Free Ammonia	0.044	0.493	0.128	0.108	.39	0.06	.2	.384
Albuminoid Ammonia	0.212	0.427	0.64	0.288	.63	0.15	.61	.564
Total Iron	0.2	0.2	0.32	0.36	.36	0.3/1.0	.32	.5
Sulphate	-	-	-	14.5	-		-	-

Note: (i) All results given above are in ppm unless otherwise stated.

(ii) • Sample collected after slight rains.

/ps

FINANCIAL JUSTIFICATION of WGU & WMS Plant

(1) Without up-grading of ilmenite and limited sales of ilmenite

Ore assay assumed :-

within the heavy mineral component :-

Ilmenite	Rutile	Zircon	Other Magnetics & Non Magnetics
72%	8%	7%	13%

Note :- there is some doubt on these figures as there are conflicting reports from 85% heavy mineral to 40% heavy mineral - average 60% H.M.

7 years mining at 59 to 125 t.p.h. - 85 t.p.h. average

7000 hrs/year out of 8550 possible - 82% operating time

tonnes of ore mined :- 7 years x 7000 hrs x 85 t.p.h. = 4,165,000 tonnes

Recoveries assumed :- %

	Mining	x	Wet gravity up-grading	x	Wet magnetic separation	x	Tabling plant & dry Mill	=	Overall
Ilmenite	100	x	97	x	98	x	Not applicable	=	95.1
Rutile	100	x	97	x	95	x	98	=	90.3
Zircon	100	x	97	x	95	x	65	=	59.9

Tonnes per hour produced :-

Ilmenite	85 t.p.h.	x 60% H.M.	x 72% assay	x 95% recov.	=	34.9	tph
Rutile	" "	x " "	x 8% "	x 90% "	=	3.67	"
Zircon	" "	x " "	x 7% "	x 59.9 "	=	2.14	"

Tonnes per year produced :-

Ilmenite	34.9 t.p.h.	x 7000 hrs/year	=	244300 tonnes
Rutile	3.67 "	x " " "	=	25690 "
Zircon	2.14 "	x " " "	=	14980 "

31-01-81
KL:GA

RETURNS

	t.p.y	A $/tonne F.O.B.	S $ Total	Rs.($A = 21.2 Rs)
Ilmenite	35000*	20	700,000	14,840,000
Rutile	25400	300	7,620,000	161,544,000
Zircon	14800	70	1,036,000	21,963,200
Total			9,356,000	198,347.200

* Sales only, allowances made for shipping losses

Capital Investment

	M Rs
Wet Magnetic Separation Plant including mining, pipeline, wet gravity upgrading, wet magnetic separation, excluding dryer and go-down	
tenderers contribution	150
Corporation's contribution(electricity supply)	15
Alterations to existing plant for greater throughput. (existing plants capacity :- 15000 t.p.y. rutile 7000 - 8000 t.p.y. zircon)	25
Existing plant at book value (31-12-80)	117
Earthmoving equipment (new)	5
	312

31-01-81
KL:GA

E X P E N S E S

		M ₨
Salaries, O.T., E.P.F. & Bonus	870 employes x 13200 ₨ each	11.5
Contract stevedoring		.6
Employees Loans		.3
Fuel	D7-6gph, Main Dryer-18 gph, Zircon Dryer-7gph, Rutile 3gph. Loaders, Trucks, Vehicles etc. :- 4 g.p.h., Floating craft - 2.5 g/hr Say 45 gph x 7000 hrs x 27 ₨/gal	8.5
Lubricants		.1
Repairs, Maintenance - Consumables	Plant	6.0
" " "	Head Office	.
" " "	Floating Craft	2.8
Electricity (Existing Plant	- 500 K.W x 7500 hrs x 55 ₨/K.W hr	2.1
(Projected Plant	-1200 K.W x 7000 hrs x 55 ₨/K.W.hr	4.6
(Sundry		.1
Postage, Telephone, Telex		.5
Sales Promotion		.4
Sundry Expenses	- rent, rates, printing & stationery, entertainment, insurance, legal, licence fees, lorry running expenses, bank charges, staff welfare, analysis fees, royalties etc.	1.0
Research & Survey - to dilineate reserves		2.5
		41.0
Add contingency 15%		6.2
Add depreciation - 312 m ₨ ÷ 13 years		24.0
	Total :-	71.2

31-01-81
KL:GA

Appendix 11

MONTHLY RAINFALL - PULMODDAI

MONTH	1975 INCH	1975 R.DAYS	1976 INCH	1976 R.DAYS	1977 INCH	1977 R.DAYS	1978 INCH	1978 R.DAYS	1979 INCH	1979 R.DAYS	1980 INCH	1980 R.DAYS
JANUARY	2.[illegible]1	06	0.49	06	0.83	04	0.68	04	0.58	04	-	-
FEBRUARY	0.20	03	0.02	01	5.21	05	-	-	0.70	04	-	-
MARCH	2.78	03	0.73	03	1.21	06	2.69	03	0.71	01	-	-
APRIL	0.33	03	2.16	08	1.01	06	3.46	05	-	-	4.81	07
MAY	2.26	04	0.31	02	3.04	05	0.49	03	3.59	05	1.35	05
JUNE	0.09	02	4.75	05	0.67	04	0.05	01	2.56	04	0.07	01
JULY	0.36	04	0.04	01	2.77	05	2.73	03	1.54	02	1.88	04
AUGUST	4.24	06	4.37	08	0.06	01	0.23	01	1.32	02	0.07	01
SEPTEMBER	1.49	07	5.92	10	9.62	12	2.41	08	9.52	18	0.66	03
OCTOBER	4.38	10	7.35	11	14.54	20	15.26	17	15.93	17	3.24	5
NOVEMBER	14.56	21	12.80	24	17.03	21	16.13	13	15.80	24		
DECEMBER	9.39	16	14.94	20	13.02	13	10.50	16	19.59	17		
TOTAL	42.69	90	51.83	99	68.81	102	52.63	74	72.19	93		

Appendix 12a

Pig Iron. The molten iron tapped from the blast furnace is called *pig iron or cast iron.* The composition of this alloy will be about as follows:

Fe	90–95%	Si	0.7–3.5%
C	3.5–4.5%	S	0.02–0.12%
Mn	0.5–0.8%	P	0.10–0.90%

The particular composition desired is obtained by proper selection of the ores and by regulation of the furnace temperature; the manganese and silicon content is largely determined by the temperature, and this also has some effect on the sulfur content; low-phosphorus iron can be secured only by using low-phosphorus ores. The amount of silicon and other metalloids will affect the solubility of carbon in the molten iron.

Iron and slag collect continuously in the crucible and are tapped at intervals. Commonly, the iron is tapped four or five times every 24 hours, and for a 1000-ton furnace this means that 200 to 250 tons of pig iron ("hot metal") are tapped at each cast.

The Blow. The molten metal is poured into the converter while it is turned down so that the tuyères are not covered by the molten metal. Scrap steel is added if necessary to cool the metal, the air is turned on, and the converter is turned to the upright position.

First Stage. During the first stage of the operation there is no flame at the converter mouth; during this period the silicon and manganese are being oxidized. The cold air striking the molten metal oxides the iron to FeO, and this in turn immediately reacts with the silicon and manganese.

$$2Fe + O_2 \rightarrow 2FeO; \qquad \Delta H = -128{,}000 \text{ Cal}$$

$$2FeO + Si \rightarrow 2Fe + SiO_2; \qquad \Delta H = -70{,}200 \text{ Cal}$$

$$FeO + Mn \rightarrow Fe + MnO; \qquad \Delta H = -26{,}800 \text{ Cal}$$

These exothermic reactions provide most of the heat for the operation and raise the temperature of the bath considerably during this first stage. The SiO_2, MnO, and some FeO combine to form the slag. The metalloid content of the pig iron is important because it determines the nature of the slag formed and the amount of heat generated.

Second Stage. After most of the manganese and silicon are gone, the carbon begins to burn:

$$2C + O_2 \rightarrow 2CO; \qquad \Delta H = -52{,}500 \text{ Cal}$$

The CO escaping from the bath burns to CO_2 at the converter mouth and gives rise to a long flame (Fig. 12); when this flame drops, the blow is over, the converter is turned down, and the metal poured into the ladle. The heat evolved during the second stage is just about enough to maintain the bath temperature.

Control. The entire blow will last for only 15 minutes or so, and at the end of that time practically all the carbon, manganese, and silicon will be gone. Since the operation is so rapid, it is essential that the blow be stopped at just the proper instant, and that the finishing temperature be held within certain limits. Formerly the end point was judged by the visual appearance of the flame, but today the photocell or electric eye is used to give a more precise determination of the end point.

Deoxidizing. Ferromanganese or some other deoxidizer is added to the blown metal to remove the residual oxygen remaining in the metal. Usually a part of the deoxidizer is added directly to the converter, and the rest is added in the ladle. For certain grades of steel the metal is allowed to stand for a while in the ladle to permit the slag and oxides to rise to the surface. After the deoxidation is

Appendix 12 b.

Expected Composition of Raw Iron from Electro Smelting Operation

based on Test Smelting at Zaporozhie, 1976.

	C	S	P	Si	Ti	Mn
Sulphate Slag	2.36	0.14	0.25	0.11	0.05	0.06
Chloride Slag	2.55	0.06	0.15	0.06	0.02	0.04

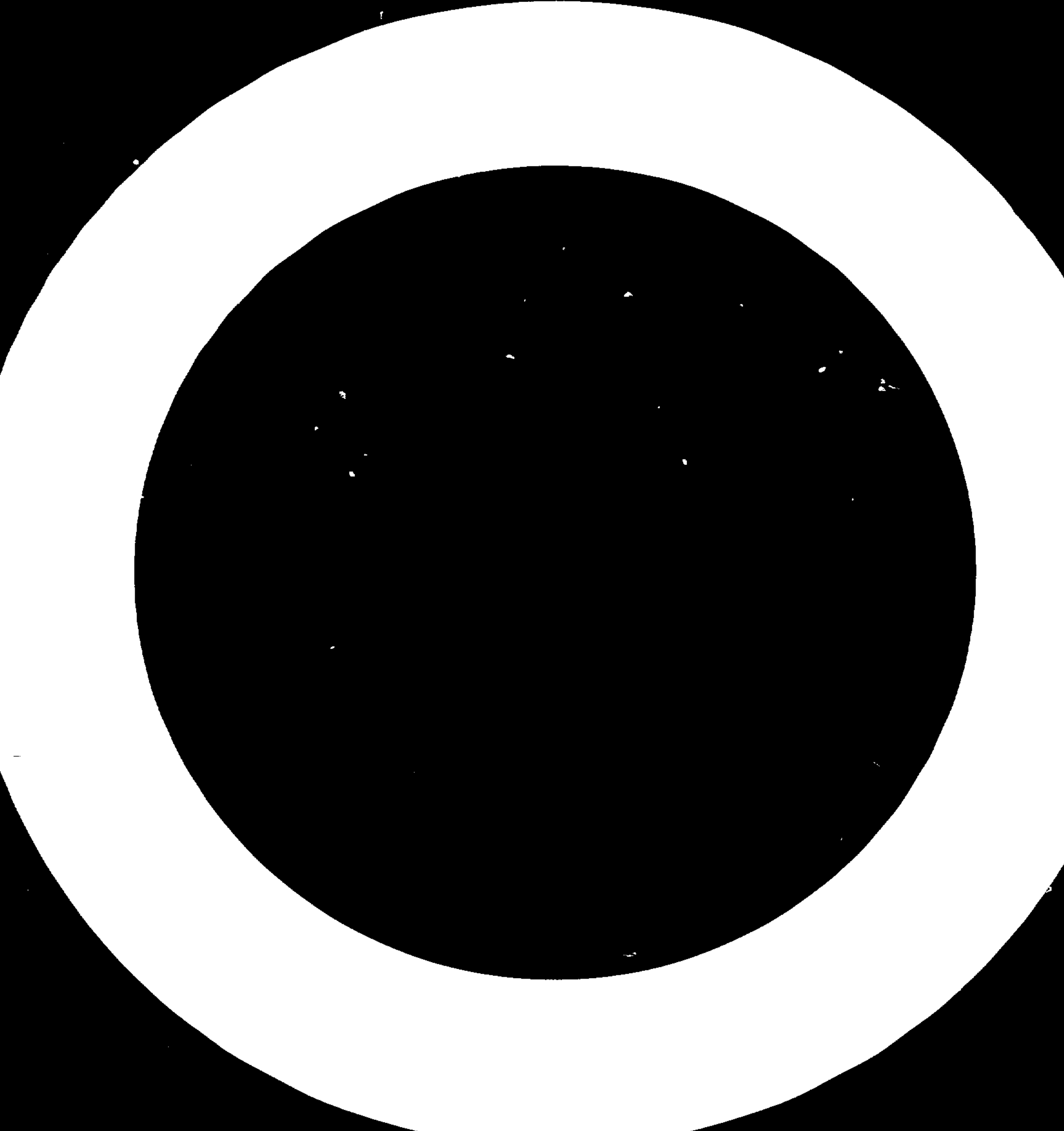
Appendix 13

typical Ilmenit e Assays

	TiO_2	Fe_2O_3	FeO	Cr_2O_3	V_2O_5	ZrO_2	SiO_2	MnO	MgO	CaO	Al_2O_3	Comments
CMSC Dry. mill				0.18								
CMSC Ilm. Mill	53.6	22.2	20.2	0.08	.20	.40	0.92	0.80	0.90	0.15	0.70	
Australian east coast	47.2	17.0	23.9	4.3		0.1	0.2		2.1		3.70	little sale
Capel Wa primary	54.8	16.5	24.0	0.03	.12	.2	1.1	1.3	..18	.01	.75	Sulphate feed
Capel WA secondary	59.3	15.0	18.0	0.08	.12	.4	1.2	1.2	.18	.01	1.2	Chloride feed
Eneabba WA	59.9	29.0	5.4	0.16	.16	.8	1.2	1.1	.26	.01	.6	partially altered
Yoganup WA	59.0	31.6	4.5	0.05	.18		.36	1.3				" "
Yoganup fully altered	83.5	8.4	0.0									fully altered to leucoxene
Finland, Kemira	45.2	8.8	38.7	0.005	0.26	?	2.0	.65	1.3	0.6	2.0	sulphate feed
USSR "Lemna"	57.9	32.3	5.1	0.03	0.18		4.2	.43	.46		.41	
"Irsha"	51.7	13.9	29.4	0.03	0.14		4.2	.70	.48		.40	
Norway Titania A/S	44.6	11.5	34.7	0.07	0.18		2.65	.29	4.6	0.2	.68	sulphate feed hard rock
India 'Q' GradeQuilon	60.6	24.2	9.3	0.12	.15	0.9			.9		.96	losing to market
MK Grade	54.2	14.2	26.6	0.07	.16	0.8		.4	1.03		1.25	
Ratnagiri	51.9	20.9	23.7	?	?		1.86	.4			.37	
Malaysia	57.7	16.8	18.5	0.04	.02		1.3	3.4	0.1	.4	1.0	

typical Ilmenite Assays (contd)

	TiO_2	Fe_2O_3	FeO	Cr_2O_3	V_2O_5	ZrO_2	SiO_2	MnO	MgO	CaO	Al_2O_3	Comments
South Africa, Umgababa	50.5	9.2	38.2	0.20	.12							
Isipingo	46.6	9.1	39.5	0.10	2.8							
New Zealand Westport	46.5	3.2	37.6	0.03	0.03		4.1	1.7	1.2	1.4	2.8	not mined yet
Canada Lake Allard	34.3	25.2	27.5	0.10	0.27		4.3	.16	3.1	0.9	3.5	Sorel slag feed
USA ASARCO Lakehurst NJ	60.2	29.3	3.6	0.14	0.09							
Trail Ridge Florida	64.8	26.0	4.8	0.07	0.12			10.35	.35		1.5	
Titanium Enterprises Green Cove Springs	60.3	26.3	5.6	0.22	0.14							
N.L. Industries												
Adirondack NY "61"	44.4	4.4	36.7	.01	.24		3.2	.35	0.8	1.0	.19)	hard rock sulphate feed
Adirondack NY "62"	44.5	5.8	38.0	?	.14		2.5	.50	2.1	0.6	1.79)	
Brazil "Nuchelon" Co. min	55.4	28.6	6.6	.05	.17							
max	58.9	38.6		1.15	.45							



Appendix 14 Typical Product Analysis (Chemical @ Screen)@Guaramtees

ILMENITE

1) Chemical Analysis

Chemical Analysis	Percentages
TiO_2	54.58
Fe_2O_3	23.15
FeO	18.11
SiO_2	1.51
ZrO_2	0.02
Al_2O_3	1.18
MnO	0.37
Cr_2O_3	0.07
V_2O_5	0.09
MgO	0.85
CaO	0.08
P_2O_5	Traces ($\angle$ 0.1%)
Total	100.01

2) Screen Analysis (BSS)

+	60	0.30%
+	72	0.32%
+	100	12.72%
+	150	40.82%
+	200	33.82%
-	200	11.90%

Usual Guarantees:

TiO_2	53% Minimum
Moisture	Less than 2 per cent

RUTILE:

1) Chemical Analysis		2) Screen Analysis	
TiO_2	96.4%	+ 36	NIL
Fe_2O_3	.80%	+ 60	NIL
SiO_2	.38%	+ 100	9.7%
ZrO_2	.74%	+ 150	47.0%
Al_2O_3	.16%	+ 200	40.0%
S	NIL	+ 240	3.0%
P Less than .001%		- 240	.3%
		LOSS	-
		TOTAL	100.0%

Usual Guarantees

TiO_2 95%

Under present conditions, it is possible to offer a recognized "Standard" grade of rutile i.e. 95% TiO_2 minimum
1.0% ZrO_2 maximum
1.0% $Fc2O_3$ maximum

STANDARD GRADE ZIRCON

1) Chemical Analysis	Percentage
ZrO	66.3
SiO	32.6
Fe_2O_3	0.10
TiO_2	0.23
Al_2O_3	0.25

2) Screen Analysis (BSS)	Percentage
+ 100	0.1
+ 150	8.4
+ 200	60.8
+ 240	25.6
- 240	5.1
	100.00

<u>Usual Guarantees</u>

ZrO_2	65% Minimum

Again under present conditions, it is possible to offer a recognized "standard" grade of zercon, i.e.

ZrO_2	65% minimum
TiO_2	0.3% maximum
Fe_2O_3	0.1% maximum

Appendix 15

Rates of Exchange per US$1

Year	Sri Lanka Rupees Av.	Sri Lanka Rupees 30th June	Australian $
'72	6.40	6.13	.893
'73	6.40	15.6/£S	.85
'74	6.50	"	
'75	7.00		.754 (devalued)
'76	8.50	8.68	.809 (30=6=76)
'77	8.88	7.28	.92
'78	15.50	15.72	.871
'79	15.55	15.63	.891
'80	17.10		.86
'81	19.00		.87
'81 Oct	21.10		.87