Ministry of Education

National Science and Technology Commission (NASTEC)

Technical Report on Value Addition to the Natural Resources and Minerals of Sri Lanka

SCIENCE TECHNOLOGY INNOVATION

SUSTAINABLE DEVELOPMENT

IN THE ERA OF CLIMATE CHANGE

9th SRI LANKA BIENNIAL CONFERENCE ON

SCIENCE & TECHNOLOGY

2023 (BICOST IX)

23rd & 24th March 2023

Waters Edge, Battaramulla

TECHNICAL REPORT ON VALUE ADDITION TO THE NATURAL RESOURCES AND MINERALS OF SRI LANKA

Ninth Biennial Sri Lanka Conference on Science and Technology

BICOST IX

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NATIONAL SCIENCE AND TECHNOLOGY COMMISSION

ISBN 978-955-8630-30-3

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EXECUTIVE SUMMARY

Sri Lanka is blessed with several valuable minerals, which are at present mostly exported as raw materials, but which have the potential to bring in much more revenue if exported as value added products. In addition to the gems for which the country is famous, these minerals include ilmenite, rutile, zircon, and monazite (all from mineral sands), apatite (rock phosphate), graphite (plumbago), quartz, dolomite and limestone, feldspar, clay (montmorillonite), and even sea salt. Each of these minerals is in a different state of readiness for value addition, depending on factors such as available technology and market conditions.

This report was prepared after consultation with a committee consisting of a cross section of stakeholders, including researchers from both academia and research institutions (ITI and SLINTEC) working in the minerals field, and representatives of the Ministry of Industries, the Geological Survey and Mines Bureau, and the Central Environmental Authority.

Although several measures have been taken in the past to promote value addition (or inhibit export of non-value added products), Sri Lanka has not yet finalized a comprehensive policy on value addition to minerals, and even the definition of value addition used in the country is not aligned with that in other countries. A much needed step is to redefine the term value addition (to include beneficiation), to finalize the National Minerals Policy which is currently under development, and to streamline the regulations and procedures dealing with commercialization, guaranteeing medium to long term access to raw materials to potential investors, in order to attract overseas partners.

Manufacturing value-added products from minerals, *e.g.*, single superphosphate (SSP) from apatite or titanium dioxide from ilmenite or rutile, requires the support of a basic chemical industry, and crucially, a local supply of sulphuric acid. Developing the existing chemical industry and establishing a plant to produce sulphuric acid have been given a high priority in the recommendations of this report.

With a supply of sulphuric acid assured and a large local demand for SSP as fertilizer from local agriculture (~ 200,000 tonnes per annum), high priority is also assigned to setting up a plant to manufacture SSP from apatite (Eppawela rock phosphate).

Sri Lanka is the only commercial producer of high purity vein graphite (most countries produce flake graphite). Value addition to Sri Lankan graphite is well on the way to commercialization, with the establishment of Ceylon Graphene Technologies Ltd. as a partnership between the LOLC Group and SLINTEC. However, production of graphene would absorb only a small percentage of the total production of graphite. Research into products which would take advantage of the properties and high purity of vein graphite would increase the value of Sri Lankan graphite. Research is already being done on potential applications, such as lubricants and battery electrodes. Such research should be promoted and funded.

The mineral sands found along the East coast of Sri Lanka constitute one of our potentially most valuable resources. The major component of this is ilmenite (~ 70%), which is an important target for value addition. Value addition of ilmenite, as well as other minerals such

as zircon, rutile, monazite, etc., starts with beneficiation. The next stage of value addition would be conversion to pigment grade titanium dioxide, for which there is a small, steady local demand from the paint industry, of about 5000 metric tonnes per annum. SLINTEC has developed technology to convert ilmenite into TiO_2, and "off the shelf" commercial technologies are also available elsewhere. A local supply of sulphuric acid would be needed to make this economically feasible. However, before this next step into value addition can be taken, a number of ancillary problems, listed in the report, would need to be overcome.

Sri Lanka also produces very high quality vein quartz. While this is sold in powder form, the tailings are a waste stream. There is potential to convert these into items such as ornamental products and engineering stone, a relatively low-tech value addition that could increase the value from USD 420 to USD 1500 per tonne.

Other minerals to be considered for value addition include monazite, dolomite, and limestone, as well as sea salt. The production of chlorine and caustic soda (sodium hydroxide), as well as hydrochloric acid and sodium hypochlorite, from sea salt is an industry operated by Paranthan Chemicals, which fell into disuse during the civil war. There are now plans to revive it, which, together with sulphuric acid, would provide the country with a basic chemical industry. Limestone is used in the manufacture of Portland cement, and sufficient quantities are available to increase cement production using local cement from the current 15% to around 30%, which would save foreign currency. Dolomite is used as a fertilizer and has several other applications as additives and fillers in numerous industries. Research is also needed to see whether locally available monazite would be a viable source of rare earth elements, for which there is tremendous demand internationally in the electronics industry. Overall, much research still needs to be done to explore these and other avenues of value addition to our minerals.

One of the strengths of the Sri Lankan minerals industry is the high quality and purity of locally available minerals. This could be used as a marketing tool, perhaps as a way of obtaining better prices, but doing so needs scientifically valid data acceptable internationally. Such data could emanate from one or more accredited laboratories, fully equipped and expertly staffed, to obviate the need to send samples overseas for testing. Such laboratories, if set up, could serve other purposes as well, and could be established within the existing institutes such as the ITI or SLINTEC, leveraging their existing equipment and expertise. The establishment of such a support facility is the final recommendation of this report.

INTRODUCTION

Even without taking in to account the hitherto unproven offshore reserves of petroleum or natural gas in the Mannar basin, Sri Lanka is blessed with considerable natural resources, in the form of several key minerals, such as ilmenite, apatite, and graphite. Since historic times, Sri Lanka has been a source of high quality gemstones, and the excellence of its iron and steel industry since the Anuradhapura period has been well documented,[1] though largely forgotten. However, in modern times, industries based on value addition to these resources have been slow to develop. Many of these substances have simply been exported as raw materials or ores, to supply industries in other countries.

During the last 20 years or so, considerable research has been carried out by Sri Lankan scientists into these mineral resources. Some of this research has been summarized by Prof. Gamini Rajapakse in a recent review article.[2] Despite the relatively small amount of money spent on research and development in Sri Lanka (around 0.11% of GDP in recent years), a fair amount of research into value addition has been carried out in Sri Lankan institutions in recent times, and several technologies developed at institutions such as SLINTEC. However, progress towards commercialization has been slow.

Statistics show that in recent decades, the mining and manufacturing sector has contributed a fairly consistent 26 - 29% of the country's GDP,[3] of which the mineral sector contributes about 2%. In and of itself, this figure is comparable to that of a developed nation. However, with regard to exports that could boost earnings of foreign exchange, Sri Lanka has remained low on the value addition chain. While part of the reason for this is the slow progress in R&D due to the low priority given to funding (gross domestic expenditure on research and development (GERD) is over 1% of GDP in many developing countries; in countries focused on rapid technological advancement, such as South Korea, Finland, and Israel, it approaches 4%), other factors are also playing a major role. These include

- The near absence of venture capital.
- Skilled manpower shortages at many levels, including researchers (full-time equivalent) per capita.
- Communication between the researchers and industry is inadequate and not enough industry driven research is carried out.
- Regulatory barriers to establishing new industries, compared to competing nations, making it difficult to attract not only foreign direct investment, but even local investment, and giving rise to corruption.
- An averseness to risk-taking on the part of both the financial sector and the industry.
- The failure of the government to promote selected industries, as well as R&D in thrust areas, with suitable incentives, such as the now removed 300% tax deduction on R&D expenditure..
- Perceived difficulties of breaking into well-established markets.
- The non-availability of key locally sourced chemicals, such as sulphuric acid, caustic soda, chlorine, and hydrochloric acid, which are essential for certain manufacturing processes to be cost-effective.
- Inadequacy of facilities/funding to scale up research results to the pilot plant level.

Countries which have developed rapidly via R&D, innovation, commercialization of technologies, and high-technology exports, have created an "ecosystem" in which universities, research institutions, industries (including industrial R&D facilities), and government bureaucracies work seamlessly together. Thus far, Sri Lanka as a nation has failed to do that, though a few bright spots exist. Creating such a system is the challenge we face. Value addition to mineral resources would be just one step in this process.

METHODOLOGY

In preparing this report, a committee was assembled composed of representatives from a number of relevant institutions and government entities. These include

- The Sri Lanka Institute of Nanotechnology (SLINTEC)
- The Industrial Technology Institute (ITI)
- The University of Peradeniya
- The Open University of Sri Lanka
- The Ministry of Industries
- The Geological Survey and Mines Bureau (GSMB)
- The Central Environmental Authority (CEA)
- The National Science and Technology Commission (NASTEC)

The committee had a number of meetings to obtain the views of its members and to collect data, including relevant information from the institutions they represented. Information collected included

- Available technologies,
- Technologies undergoing research and development,
- Market prices of minerals / raw materials,
- Prices (where available) of products at different stages of value addition,
- Availability of required inputs,
- Other relevant information, such as waste disposal/environmental issues and barriers to investment.

Based on these and the expert opinions of the participants with respect to feasibility, market demand, barriers to progress, etc., a set of key projects was identified and prioritized. These could be further categorized as short to medium term, and medium to long term. Together they constitute a path for a significant contribution to national development through value addition to Sri Lanka's mineral resources.

RESULTS AND ANALYSIS

Overview and Policy Implications

The proposed National Mineral Policy, which has not yet been finalized, defines the term "value addition" as follows: "*Value addition" refers to any process, such as selective mining, beneficiation, processing, and product development, as well as identifying market opportunities that increase the value of a mineral relative to its pit-head value in bulky form.* Beneficiation, which can involve crushing, grinding, or gravity, magnetic, or flotation separation, refers to processes which result in a more concentrated and usable form of the ore, as well as a waste stream. Under the current definition used in Sri Lanka, beneficiation does not come under the definition of value addition, but in many other countries it does. **This report will consider beneficiation to be value addition.**

According to the Geological Survey and Mines Bureau, the true competitive advantage of Sri Lankan mineral resources is their quality. The high quality and purity of many Sri Lankan minerals has been stressed by a number of sources. To take advantage of this for marketing purposes, scientific data from chemical analysis is required. A long felt need, therefore, is an accredited laboratory, fully equipped with instrumentation capable of obtaining analytical data of a standard that would be acceptable in the international marketplace. Setting up such a laboratory or laboratories, at SLINTEC and/or the ITI is included in the recommendations. The location would make use of advanced instrumentation and facilities already in place at those institutions.

Seven minerals to which value addition is possible have been identified by Prof. Rajapakse.[2] They are graphite, quartz, ilmenite, apatite, dolomite, clays, and feldspar. Other minerals for possible investigation include monazite, zircon, and rutile, all of which are found, together with ilmenite, in the mineral sands at Pulmoddai and elsewhere. It has been suggested that value addition to the point of developing new products (*e.g.*, the conversion of ilmenite or rutile into pigment grade titanium dioxide) is not practicable in the world marketplace, where supply chains are set up such that technology is seldom transferred to the "periphery," and value added products are controlled by the major multi-national companies in the "centre." **Thus, beneficiation, the first stage of value addition, should be the immediate goal for many minerals in Sri Lanka.** And this approach is strongly recommended, as it sacrifices nothing.

At the same time, if we never explore the next stage of value addition, Sri Lanka will forever remain a "developing" country, low on the value addition chain. Therefore, the Government should explore ways of technology transfer through foreign direct investment or partnerships with foreign corporations, with the necessary safeguards and compromises to ensure that national interests are protected and foreign currency continues to flow into the country. At the same time, suitable investment should be made in application oriented research, to develop our own intellectual property having commercial value. In this regard, many advances have already been made by Sri Lankan scientists in SLINTEC, the ITI, and elsewhere. These initiatives need to be expanded, not only with a view to developing new technology, but also the human resources and expertise that will be needed.

Guaranteed availability of raw materials is another important issue from the point of view of an investor. Since the mineral rights are owned by the government, any private investor (foreign or domestic) or even a public-private partnership, would have to be assured of a continuing supply of the raw material, as well as the right to export any products after initial beneficiation, subject of course to regulations regarding repatriating earnings in foreign currency. A significant barrier to the development of mineral resources has been the somewhat counter-productive 2012 Cabinet paper, which set minimum levels of value addition for various minerals before export could be permitted, but then created exceptions for certain companies, such as Lanka Mineral Sands, effectively creating a monopoly, removing incentives for investing in value addition, and inhibiting other companies from participation.

In summary, in order to embark on a series of value addition projects, a comprehensive National Minerals Policy would need to be established, which would cover all the points discussed above. Since private sector investment, either foreign or local, would be needed to establish the manufacturing facilities, the policy would have to cover the following points as well:

- Procedures for selecting the investor. In most cases there would be room for only one investor to make enough profit for the investment to be worthwhile, so selection must be done carefully and certain criteria would have to be met. Foreign investors would probably come through the Board of Investment (BoI), which would have to be involved in the Policy.
- Regardless of whether the investor was foreign or local, there would have to be regulations to ensure the repatriation of revenue in foreign currency to Sri Lanka. There should be a mechanism to monitor remittances.
- The investor should, in addition to providing employment for skilled labour, hire technical and scientific manpower locally.
- The technology brought in by an overseas investor should be sufficiently high-tech and environmentally sound (low water/energy intensive, less polluting etc.). Import of outdated/environmentally unsound technologies should be prohibited.
- Environmental impact assessment process should be speeded up to minimize unnecessary delays in the approval process, while safeguarding the Sri Lankan natural resources that are unique and have intrinsic value.
- The State, which owns the mineral resources, should commit to giving medium to long term access to raw materials to the investor, in order that the return on investment (ROI) is adequate to attract investment.
- Royalties should be reasonable, consistent, and based on pit-head values.

Sulphuric Acid

Value addition to many of these minerals, as well as many other industrial processes, requires a small but vibrant chemical industry. Unfortunately, the Sri Lankan chemical industry has not recovered its full capacity since the end of the civil war in 2009. In particular, the Paranthan Chemicals Co. is only now beginning to recover the manufacturing capabilities it lost during the war. A key chemical that would be needed for certain types of value addition to ilmenite, graphite, and apatite, as well as other processes, is sulphuric acid. The availability of inexpensive, locally produced sulphuric acid would make many chemical processes feasible. This report recommends that the highest priority should be given to the establishment of a sulphuric acid manufacturing facility, as an essential ingredient in a number of value addition technologies. A single investor should be selected, local or overseas, to ensure economies of scale, and the location should be selected with access to the key raw material, sulphur, in mind as well as availability of water. Sulphur may either be imported or obtained as a by-product of petroleum refining (if done on a sufficiently large scale), so Trincomalee may be a suitable location for the plant.

Apatite

Eppawela rock phosphate consists of the mineral apatite, a relatively insoluble form of phosphate. While phosphate has many uses, the most important one for our purposes is in agriculture, where more soluble forms of phosphate are essential fertilizers. A proposal has already been made to convert apatite into single superphosphate (SSP), a soluble form of phosphate, which can be used in Sri Lankan agriculture. This product has the potential to save USD 35,000,000 per annum in import costs, based on a report written in 2020 (Lanka Phosphate Ltd.), which estimated the local market at 200,000 tonnes per annum.

This document assigns a high priority to value addition to apatite, via conversion to SSP, because of its impact on Sri Lankan agriculture. It should be noted that sulphuric acid is a required input for this process, so the location of the plant should be close to the sulphuric acid plant. Other inputs (for a plant capable of producing 700 tonnes of SSP per day) include land (about 20 ha) and water (1750 cubic metres per day).

Mineral Sands

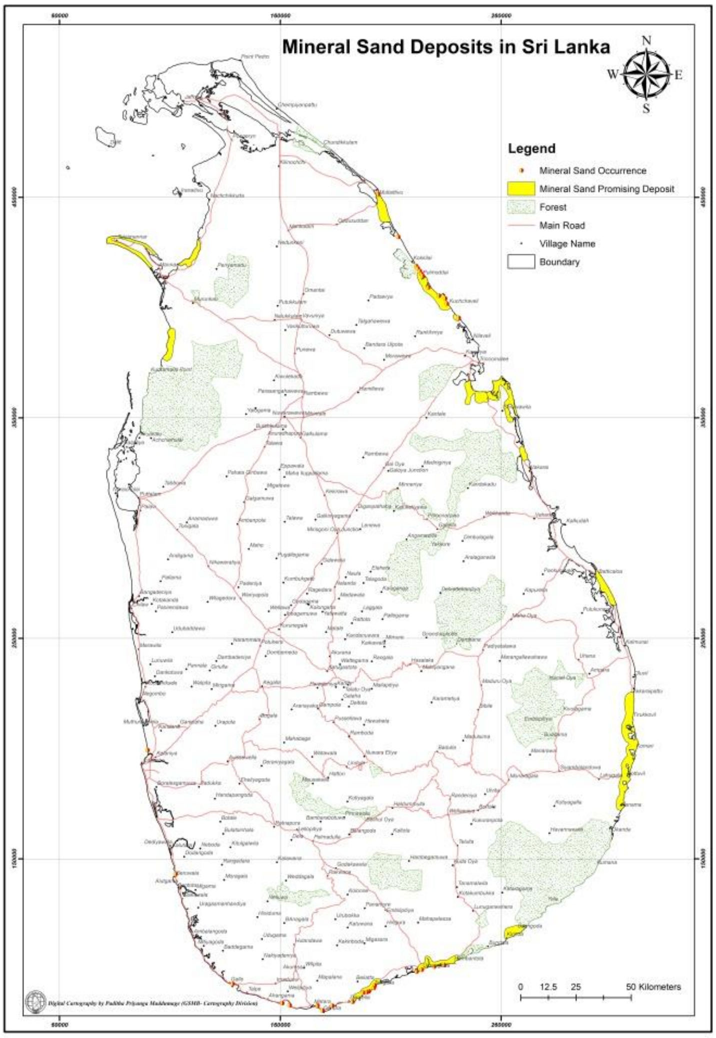
The principal minerals found in the mineral sands of the east coast of Sri Lanka are ilmenite (70 - 72%), rutile (8%), zircon (8 - 10%), and monazite (0.3%). Separation of the sand into these components is the first step in value addition. Currently, Lanka Mineral Sands Ltd., the state-owned company licensed to mine this product, has an annual production of 90,000 tons of ilmenite (50% TiO_2), 4000 tonnes of hi-titanium ilmenite (61% TiO_2), 9000 tonnes of rutile (95% TiO_2), 5500 tonnes of zircon (65% ZrO_2), and 100 tonnes of monazite.[*] These are sold by a special procedure approved by the Cabinet.

The first step in value addition to these raw materials is beneficiation (concentration to an approximately 90% level), especially with regard to ilmenite, and this needs to be followed up. The extent of value addition can be understood if we compare the benchmark prices per tonne of raw local ilmenite and rutile, given in Table 1 below.[4] For comparison purposes, the price of pigment grade TiO_2, which can vary considerably, is also included.

[*] lankamineralsands.com/products/

Table 1: Benchmark prices of TiO_2

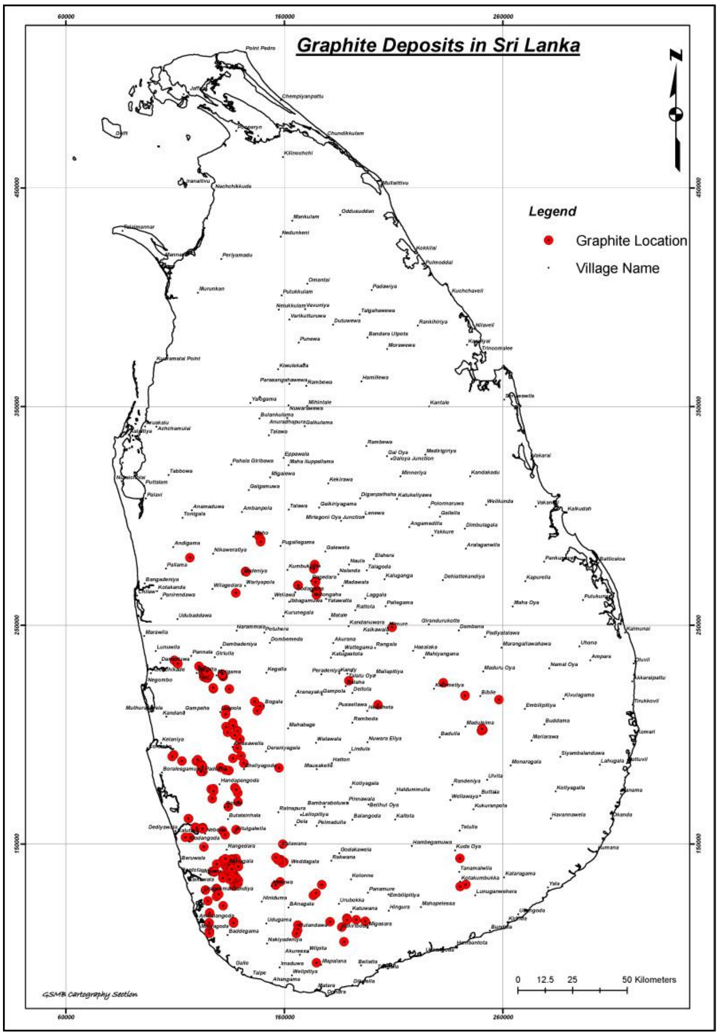
Product	TiO_2 Content (purity)	Benchmark Price (USD / tonne)
Ilmenite	48 - 50%	327
Rutile	95 - 97%	2027
TiO_2	pigment grade	2400 - 3400 (variable)



Conversion of ilmenite into pure TiO_2 has been discussed in Sri Lanka over many years. Technology for this conversion, using a sulphate process that requires an input of sulphuric acid, has been developed by SLINTEC, and taken to the pilot plant scale. However, many barriers exist to commercialization. These have been discussed in a 2018 report by SLINTEC,[5] which includes a detailed analysis of the global supply chain situation. They include the absence (up to now) of a local supply of sulphuric acid, the small size of the local market for TiO_2 (ca. 5000 tons per annum in the paint industry), the fact that the global market is dominated by large international companies which have the advantage of economies of scale, the problem of waste disposal or, alternatively, finding applications and markets for the ferro-gypsum or iron oxide by-products, and the high cost of power in Sri Lanka. These issues would have to be addressed before a decision could be made to proceed with the next step of value addition, conversion to TiO_2.

Monazite, a relatively minor component of mineral sands, also has potential for value addition, as it is a source of rare earth elements such as cerium, lanthanum, neodymium, praseodymium, samarium, dysprosium, and gadolinium, as well as the radioactive element thorium, which is being developed in India as a nuclear fuel. The rare earths are in high demand, being essential components of the electronics industry, with the world market being dominated by China. Sri Lankan monazite has been shown to contain significant amounts of cerium, lanthanum, and neodymium, so that further research can be recommended to determine its potential for export as a source of rare earths, after concentrating them via fractionation. Currently, monazite is produced in such small quantities that export occurs at irregular intervals. Because of its high content of radioactive thorium, stringent safety precautions should be taken when concentrating it.

Graphite



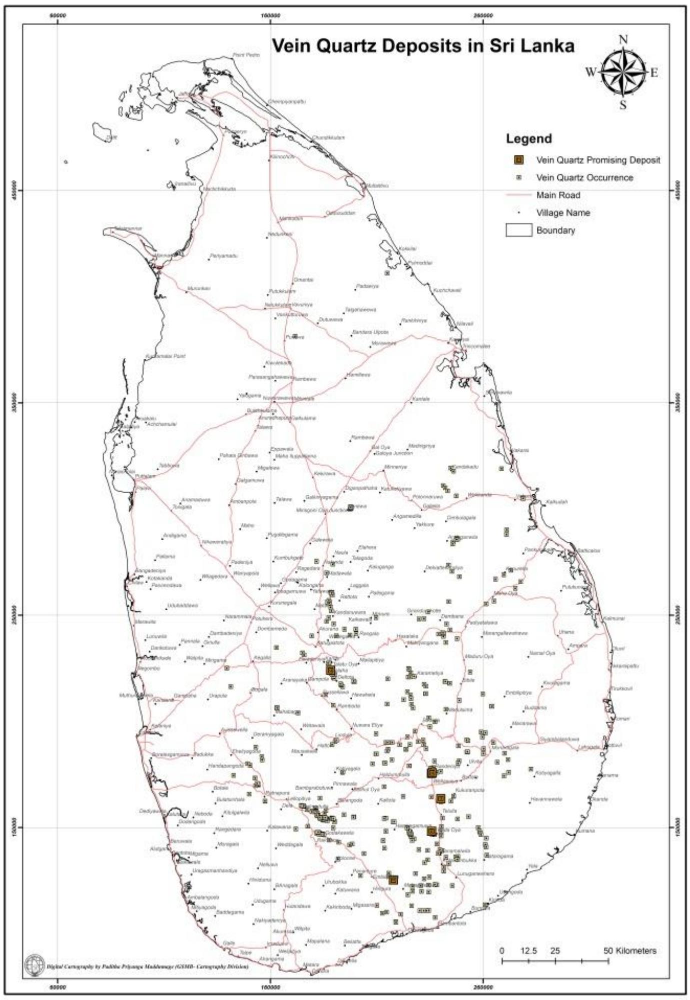
Sri Lanka produces a high-purity variety of graphite known as vein graphite, and is the only supplier of vein graphite in the world. Other sources supply flake graphite, and most technological applications are intended for this variety. Graphite has many value added applications, such as lubricants, vehicle brakes, battery electrodes, fillers in the rubber industry, etc., many of which are already in production locally. Currently some of the mined graphite is exported to India for separation into individual powder fractions and brought back to Sri Lanka for further value addition for export. The private sector should be encouraged to invest in relevant technology to undertake the intermediate processing locally, thereby saving significant amount of foreign exchange.

Conversion of graphite into products such as carbon nanotubes, graphene, and graphene oxide has become an important source of value addition, and much research has been done in Sri Lanka by the ITI and SLINTEC. These processes also require sulphuric acid. SLINTEC has joined with LOLC to form a company called Ceylon Graphene Technologies (Pvt) Ltd., to commercialize the results of this research. Considerable progress has thus been made with respect to value addition to graphite, which can therefore be considered a partial success story. However, only a small percentage of the graphite produced (< 10%) can be used in this process, and the gains from commercialization remain to be determined. Other value-added products need to be investigated, and much research still remains to be done. Furthermore, the mining technology currently in use is outdated and needs to be upgraded, to avoid contaminating the graphite. There is a room to expand the productivity of the existing mines as well.

Quartz

Like many other Sri Lankan mineral resources, the vein quartz (silicon dioxide) found in Sri Lanka is of very high purity. It is currently sold in powdered form at about USD 420 per tonne. The minable reserves have been estimated by the GSMB at 2.7 million tonnes. A possible low-tech value addition is to make use of the tailings from mining, currently a waste material, to manufacture products such as engineered stone (USD 1500 per tonne) and ornamental objects. Tailings can be reduced from current 40% to about 20% by using an optical sorter, and this should be implemented by the quartz mining industry, as a way of increasing productivity. As with graphite, considerable potential remains for value addition, and focused research in this area is recommended.

Dolomite and Limestone



Dolomite, a 1:1 mixture of calcium and magnesium carbonates, is an abundant mineral in Sri Lanka, and already has a number of applications. Dolomite is used in the ceramic and glass industries, as a fertilizer, in the construction industry, in animal feed, and as a filler in the cosmetics, plastics and PVC, rubber, and paint industries. Considerable potential for value addition exists in the pharmaceutical industry as well. Rajapakse and co-workers at Peradeniya have developed methods to separate the calcium and magnesium salts and convert them into nanoparticles for various applications. [2]

The main use of limestone (calcium carbonate) is in the construction industry, as slaked lime and as a critical raw material in the production of Portland cement. At present only about 15% of the cement used in Sri Lanka is produced locally using locally available limestone, and the GSMB has estimated that available quantities suffice to increase this to at least 30%. While this would not contribute to exports, it would save a significant amount of foreign currency, perhaps an additional USD 25 million per annum. It should also be mentioned that this limestone is currently being supplied to cement manufacturers at a very low price.

Others

Other minerals to which value addition is possible include sea salt, feldspar, and clay (montmorillonite). The conversion of salt (sodium chloride) to chlorine and caustic soda (sodium hydroxide) by electrolysis is the subject of a current proposal by Paranthan Chemicals, which essentially revives an industry that fell into disuse during the civil war. The availability of chlorine, hydrochloric acid, sodium hydroxide and sodium hypochlorite, and ancillary products such as bleaching powder would be a boost the country's chemical industry, and even in the absence of an export market, would help conserve foreign currency. However, other simple approaches to value addition in the salt industry itself may be possible, such as Pure Vacuum Dried (PVD) salt. Also, the concentrated liquid from desalination plants could be directly used for electrolysis, as is done in India, thereby increasing efficiency.

The well-established Sri Lankan ceramics industry is based on the availability of high quality clay; unfortunately, the sources of clay are now being depleted. Further research into value addition is needed. Feldspar is currently used as a refractory material in the ceramic and glass industries, and may also be a target for value addition or research into new products.

CONCLUSIONS

Despite its history of producing high quality steel, gems, and graphite since ancient times, modern Sri Lanka has failed to develop its natural mineral resources, and therefore remains a source of raw materials rather than value-added products. Since international markets in these products are controlled by others, the longer we wait, the more difficult it will become to break into them. This report identifies a possible path to upgrading the Sri Lankan economy by making better use of these mineral resources.

In order to make full use of these opportunities, an integrated system of industry, finance, regulation, marketing, and research is needed. Sri Lanka has deficiencies in each of these areas, and such improvements and investments as have been made have been piecemeal. A carefully planned, concerted investment would need to be made in all areas to promote the success of each project. The private sector would play a key role, and existing barriers to investment should be removed. Developing a comprehensive National Minerals Policy incorporating many of the points discussed would be an important component of this.

An effective chemical industry is an essential part of this system, and sulphuric acid is a key chemical in many of the developed or envisaged technologies. A sulphuric acid plant to support these technologies should be established. Revival or expansion of formerly important local industries, such as the Portland cement industry or the chlorine / sodium hydroxide industry would also boost the country's industrial capacity and save foreign currency.

Another component is the establishment of well-equipped and accredited analytical testing laboratories. Some of the facilities needed already exist at SLINTEC, the ITI, and even some of the universities, and developing and upgrading the existing laboratories at SLINTEC and the ITI would take advantage of the wealth of equipment and expertise already there.

Value addition to mineral sand could start with separation into its component minerals (already being done), beneficiation, and concentration of ores, to improve marketability and price. The feasibility of converting ilmenite (and rutile) into titanium dioxide, using already available technologies on a commercialisable scale, can be explored, but significant barriers exist, making this a long-term goal. Conversion of apatite into SSP is already technically feasible, and proposals to do so have been made and should be supported. Value addition to graphite is already a partial success story, with many value added products already being manufactured by Bogala Graphite Lanka PLC, and the establishment of Ceylon Graphene Technologies (Pvt) Ltd. to commercialize some of the technologies developed, but much more needs to be done. Research into possible applications based on the properties and high purity of Sri Lankan vein graphite is needed. Other targets for value addition include vein quartz and monazite (as a potential source of valuable rare earth elements). More research needs to be done, on the technical feasibility as well as the market for these products.

RECOMMENDATIONS

The following recommendations are made based on the foregoing analysis. Recommendation 1 is a policy recommendation, while recommendations 2 - 3 are production / commercialization related, and deal with technologies already available, backed by a local demand. Recommendations 4 - 7 are longer term, and aimed at targeted research and development, testing facilities, and export-oriented market development.

1. Issue: Removing regulatory barriers to investment

Recommendation:

A National Minerals Policy should be finalized, incorporating the points discussed on page 6 of this report. It should also amend the applicable Cabinet decision of 2012, redefining "value addition" to include beneficiation, and where appropriate, allowing reasonable competition among investors, rather than promoting a monopoly to State Owned Enterprises (SOEs).

Rationale:

The current regulations inhibit investment, particularly by overseas investors, in a situation where there may not be sufficient local (state or private) capital to commence operations. Attracting a certain amount of overseas capital is probably necessary for the success of these activities. Also, the current definition of "value addition" seems to preclude beneficiation, a step which would in fact add value. Once the policy changes were in place, value addition to a number of minerals through beneficiation, concentration, etc., could be carried out, and foreign investors attracted more easily.

2. Issue: Establishment of a sulphuric acid plant.

Recommendation:

Encourage and provide necessary inputs for the establishment of a plant to manufacture sulphuric acid, in sufficient quantities to meet all the projected needs of the country, including value addition to rock phosphate, ilmenite, and graphite. This may be implemented by any local or interested overseas investor, as a short term project. The sulphur needed as a raw material for this plant should initially be imported, but later sourced locally once the local petroleum refinery is expanded, as sulphur is a by-product of petroleum refining. Trincomalee, with a harbor and a plentiful water supply has been identified as a suitable location to set up the plant.

Rationale:

A dependable and adequate supply of sulphuric acid, locally available at minimal cost, is necessary in order to make many other proposed initiatives feasible or cost-effective. The lack of such a supply is one of the barriers to investment in such projects. This includes value addition to apatite and graphite, as well as, potentially, ilmenite and monazite.

3. Issue: Conversion of rock phosphate (apatite) to single superphosphate (SSP)

Recommendation:

Encourage and provide necessary inputs for the establishment of a plant to convert rock phosphate into SSP, in sufficient quantities to meet all the projected needs of the agriculture sector of the country. This may be implemented by any local or interested overseas investor, as a short to medium term project. A long term agreement to supply apatite to the potential investor is a must to attract investment.

Rationale

Because of its relevance to agriculture, particularly rice cultivation, this should be considered a high priority project. The technology is well understood, and once the sulphuric acid supply is available, the necessary chemical inputs would be in place. At a minimum there would be considerable savings in foreign currency.

4. Issue: Value addition to ilmenite

Recommendation

Ilmenite is the major component of mineral sands, and therefore this report recommends that ilmenite should be an important focus of value addition. In the first instance this should be done by beneficiation and concentration up to about 90%. Further value addition by converting to pigment grade titanium dioxide is a longer term prospect, even after the necessary supply of sulphuric acid is assured, because of the other issues discussed on page 6 of this report. Investigations into finding comprehensive technical and commercial solutions to these issues should continue, as well as opportunities for value addition to titanium dioxide itself.

Rationale

Ilmenite is a valuable and abundant resource, which is not contributing as much as it could to the country's economy. The proposal above, making use of simple and readily accessible technologies, would be an important step towards increasing the market price of local ilmenite. The nanochemistry of TiO_2, which has been extensively researched, offers further opportunities for value addition.

5. Issue: Value addition to graphite

Recommendation:

The establishment of Ceylon Graphene Technologies Ltd. demonstrates that value addition by conversion to graphene and graphene oxide is already underway, and other value added products are also being manufactured. However this is only a small part of total graphite production, and many initiatives to add value to vein graphite need to be taken, including upgrading mining technology, expanding production, and developing new value added products. Research into products such as electrodes for different types of batteries, lubricants, carbon nanotubes, etc., should be carried out, with a view to developing intellectual property, for which adequate funding is recommended.

Rationale:

Graphite is a very promising material for value addition, whose production was much higher a century ago than it is now. While some new technologies are in the process of commercialisation, much more remains to be done, and research into these possibilities is still limited.

6. Issue: Value addition to other minerals

Recommendation:

Promote research and development into value addition to other minerals, with emphasis on quartz, dolomite, and monazite, with a view to initiating value addition projects in the medium term. The research should cover developing new products from quartz (including value addition to quartz tailings via engineering stone and other products), improving the productivity of quartz by recovering material from the tailings, uses of dolomite in the pharmaceutical industry, and analysing monazite for rare earth content. Value addition to zircon, rutile, and clay may also be studied further.

Rationale:

These are longer term projects, which have a lower priority than those listed previously. There is a large potential market in the international electronics industry for rare earths, and the necessary technology already exists. However, much more research needs to be done, with feasibility and market studies, before commercialisation can be successful, especially given the relatively small amounts of monazite available..

7. Issue: Establishment of an analytical laboratory to service the minerals industry.

Recommendation:

Establish one or more fully accredited and equipped analytical laboratories, capable of carrying out all necessary chemical analyses on mineral samples, as well as environmental samples and trace analyses. This should be done using the existing institutions SLINTEC and/or the ITI, leveraging instrumentation and expertise already present there. This should be considered as a short-medium term project. The State should provide funding for not only purchasing additional instrumentation, if necessary, after reviewing the facilities currently available at these institutions, but also funding for maintenance of existing instruments, some of which are aging. These labs could partner with the GSMB in completing the National Mineral Atlas initiated some time ago, providing the necessary analytical data while the GSMB estimated quantities.

Rationale:

There is a need for accredited facilities which are capable of providing internationally acceptable data regarding the quality of our mineral resources, to back up claims regarding the latter. Having the facilities in Sri Lanka would save time and money associated with sending samples abroad for analysis, as is often done today, and improve efficiency of service. This capability exists at the institutions named, but needs to be formalized and supported. Maintenance of high-end instrumentation is very expensive, and the costs cannot be recovered through provision of services. As this provides an essential service to the industry as well as the state sector, state support is vital.

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APPENDIX: COMPOSITION OF COMMITTEE ON VALUE ADDITION TO MINERALS

BICOST Committee members of 'Value addition to Natural resources and Minerals' committee

- Dr. Ranil D. Guneratne, Consultant, National Science and Technology Commission. (Chairperson of the committee)
- Dr. Azeez M. Mubarak, Sri Lanka Institute of Nanotechnology.
- Prof. Gamini Rajapakse, Senior Professor, University of Peradeniya.
- Dr. Iresha Kottegoda, Research Fellow, Industrial Technology Institute
- Dr. Lahiru Wijenayake, Senior Lecturer, Open University of Sri Lanka
- Dr. Nuwan De Silva, Senior Research Scientist, Sri Lanka Institute of Nanotechnology
- Dr. Chanaka Sandaruwan, Senior Research Scientist, Sri Lanka Institute of Nanotechnology
- Mr. Ranjith Wimalasooriya, Additional Secretary (Public Enterprises & Restructuring), Ministry of Industries.
- Mr. Nalin de Silva, Director (Mineral Surveys), Geological Survey and Mines Bureau
- Ms. Swarna Rajapakse, Assistant Director, Central Environmental Authority

BICOST 'Value addition to Natural resources and Minerals' session participants

- Mr. Wasantha Anuruddha, Principal Scientific Officer, National Science Foundation
- Ms. Udesha Bopitiya, Director, LANMIC POLYMERS (pvt) Ltd
- Dr. Sadun Dalpadadu, Director, DAMSILA Resources Pvt Ltd
- Mr. J. Dinojan, Mining & Processing Engineer, Lanka Mineral Sands Limited
- Mr. Nishantha Dissanayake, Senior Deputy Director, Board of Investment
- Mr. A. F. M. Farook, Chief operating officer, CEY Quartz MBI Pvt. Ltd
- Mr. L.R.D. Gokula, Asst. General Manager, Paranthan Chemicals Company Limited
- Ms. V.A.C. Hansani, Technical Officer, Paranthan Chemicals Company Limited
- Dr. Pathmakumara Jayasingha, Senior Lecturer, Department of Geography, University of Colombo
- Mr. Amila Jayasinghe, Chief Executive Officer, Bogala Graphite Lanka PLC
- Mr. P. K. A. S. R. Nonis, Assistant Director (Scientific Affairs), National Research Council of Sri Lanka
- Ms. S. K. Lakmini, Assistant Director, Research, Ministry of Education
- Dr. W.M.G.I. Priyadarshana, Senior Lecturer, Faculty of Technology, University of Sri Jayewardenepura
- Mr. Isharaka Perera, Managing Director, Bernard Perera Holdings
- Dr. Pradeep W. Samarasekere, Senior Lecturer, University of Kelaniya
- Ms. Dharani Wijesundara, Deputy Director (Mapping and Geo-information), Geological Survey and Mines Bureau.