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Exploiting Mineral Resources for Economic Prosperity

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Sri Lanka has an abundance of high-quality mineral deposits which have not been efficiently utilized for economic development of the country. While some have not been exploited to their full potential, others are sold at a pittance to overseas buyers. Our industrial policies have never entailed using mineral resources for economic development.

Exploitation of mineral resources without the concomitant development of a chemical industry is meaningless; neither is possible without the other. At present, we do not have a single chemical industry in Sri Lanka going by its true definition of chemicals reacting to give a product. The only exception is petroleum refining at Sapugaskanda Refinery where chemical reactions take place during the cracking process. Actually, we have gone on the reverse gear on chemical industry. During the time when the Paranthan chemical factory was functioning, it had manufactured caustic soda for the soap industry and even manufactured hydrochloric acid and chlorine for a brief period of time. The fundamental requirements for chemical industry are the manufacture of an acid and a base. One of the common indicators of industrial development of a country is the number of sulphuric acid plants which it has in operation.

Phosphate minerals

Eppawela rock phosphate deposit discovered in 1971 is considered as one of the best phosphate deposits in the world because of its high phosphorus content (38-42% as P_2O_5). Since its discovery, the ore is only utilized in the supply of powdered rock phosphate for plantation crops. However, it is not suitable for short term crops such as rice and vegetables because of its low solubility. Around 100,000 tons of soluble phosphate fertilizer in the form of triple super phosphate is imported annually to Sri Lanka at a price of about Rs. 60,000 per ton.

We have an abundance of high-quality minerals which can be exploited if there is a chemical industry in Sri Lanka which will supply the basic chemicals required for such exploitation. A case in point is the utilisation of our Eppawela phosphate deposit to produce superphosphate fertiliser. If we manufacture sulphuric acid locally, then it is possible to produce single superphosphate from apatite which can then be used to fulfill our demand for phosphate fertiliser. This process involves simple mixing of powdered rock phosphate with sulphuric acid. The acid diluted to about 90% is added to finely powdered apatite rock and mixed using paddles. The mixture is allowed to stand for a period of 2-6 weeks, a process called curing. It involves no liquid effluent and hence has a minimal adverse impact to the environment. This method does not require a complex technology and can be carried out even in a clay pot on a small scale.

$$Ca_3(PO_4)_2(s) + 2H_2SO_4(aq) \rightarrow Ca(H_2PO_4)_2(s) + 2CaSO_4(s)$$

The mixture obtained here is generally sold as single superphosphate (SSP) and it has the additional advantage of providing sulphur to the soil in the form of $CaSO_4$. This is a definite advantage over triple superphosphate, which has no sulphur component, given that many soils of Sri Lanka are sulphur deficient. Sulphuric acid is the cheapest mineral acid and the production process of sulphuric acid is economically viable. However, this industry has not yet commenced in Sri Lanka and as a result we continue to import superphosphate fertilisers from other countries. Moreover, utilizing Eppawela phosphate in fertilizer, has more favorable environmental impacts, since it contains very low levels of heavy metals compared to the levels in imported TSP which contains unacceptable amounts of cadmium and arsenic. High analysis fertilisers such as triple superphosphate and diammonium hydrogen phosphate are not suitable for Sri Lanka considering the high cost of equipment and environmental damage caused by phosphogypsum.

What is attractive is that the entire cost of commissioning an SSP plant can be recovered in about 3 years while providing the phosphate fertiliser at half the current price. Meanwhile, Sri Lanka imports around one hundred thousand tonnes of triple superphosphate yearly, spending a massive amount of money. The fertiliser subsidy the Government has to incur per year is around Rs. 5 billion while a complete SSP factory along with a sulphuric acid plant can be commissioned for about Rs. 5 billion.

Mineral sands

Beach deposit of mineral sands at Pulmoddai is considered as one of the best sand deposits in the world with about 60-70% mineral content. The main constituents are ilmenite (75-80%), rutile (8-12%), zircon (8-10%), magnetite (2-3%) and smaller amounts of monazite, garnet, sillimanite and quartz. These are separated and sold in raw form ever since the mineral sands corporation came into existence in the 1960s.

Sri Lanka is currently exporting ilmenite in the raw form at a price of about $ 150 a ton while importing about 100,000 tons of titanium dioxide (purified form of ilmenite) at a price of $ 2250 a ton. TiO_2 is widely used as a white pigment in paints, plastics, and other industries. It is widely used as an optical brightener and making photocopy paper involves the use of titanium dioxide.

The process of making pigment grade titanium dioxide involves digestion of ilmenite with concentrated sulphuric acid to obtain titanyl sulphate.

$$FeTiO_3 + 2H_2SO_4 \rightarrow TiOSO_4 + FeSO_4 + 2H_2O$$

The titanyl sulphate is next hydrolysed to give titanium dioxide.

$$TiOSO_4 + H_2O \rightarrow TiO_2 + H_2SO_4$$

A research carried out at the Sabaragamuwa university describes a patented low temperature process to synthesise nano TiO_2 involving diluted hydrochloric acid.

Even titanium metal can be extracted from ilmenite or rutile. Here, rutile is heated with coke and chlorine at about 1000 ^{0}C.

$$TiO_2 + C + Cl_2 \rightarrow TiCl_4 + 2CO$$

Rutile contains iron impurities, which results in a ferric chloride impurity being formed during this reaction. TiCl4 can be separated by fractional distillation and then reduced to titanium metal by using Mg.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

Titanium metal has many industrial and medical uses. It is used to produce Ti alloys which are commonly used for the wings and engine parts in airplanes. Titanium is one of the most biocompatible metals and its density is similar to that of the human bone and hence it is extensively used in orthopaedic implants such as hip balls, sockets and rods. It is also used in heart stents and dental implants.

Another valuable mineral sand deposit containing monazite is found in the coastline at Beruwela. A large offshore deposit was also discovered off the coast of Beruwela through an ocean survey. Monazite is an anhydrous phosphate of rare earths with a variable percentage of thoria (ThO_2). In the past, we had a small processing plant at Katukurunda for processing monazite to separate the rare earth phosphates found in this type of sand. This operation was abandoned after 1977. However, with the increasing demand for the rare earths today we are losing a valuable opportunity by shutting down this plant. Typically, the lanthanides in monazite consists of about 45–48% cerium, ~24% lanthanum, ~17% neodymium, ~5% praseodymium, and minor quantities of samarium, gadolinium, and yttrium. There is a high demand for rare earths because they are used in television screens, mobile phones, sensors, camera lenses, light emitting diodes, scanners, X-ray tubes, MRI contrast agents, etc. In addition, they are necessary for the permanent magnets industry and in many defence related industries. China has the monopoly in supplying rare earths to the entire world and any embargo on them will have serious repercussions to the entire electronics industry. It's high time to react for this demand and try to use our resources to get maximum economic benefits. The processes for the separation of the rare earths involves either sulphuric acid or sodium hydroxide. Digestion with concentrated sulphuric acid separates thorium as an insoluble phosphate while the rare earths go into the solution as a mixture of their sulphates. Further separation of rare earths is complicated with several solvent extraction steps and ion-exchange chromatography. However, value addition to monazite through acid digestion and selling the rare earth mixture has economic advantages compared to selling raw monazite.

Thorianite

Few scientists are aware that thorianite, an extremely pure form of thorium oxide was exported from Sri Lanka during the early 1900's from shallow dug pits at Nelluwa in the Galle district. Marie Curie's fundamental work on radioactivity was based on thorianite from Sri Lanka (Ceylon). Some other discoveries using our thorianite are; the Radioactive Decay Law, discovery of polonium and radon. The Sri Lankan origin of thorianite is clearly mentioned in her published research papers.

Quartz

High quality quartz is found at various locations around the country, including Galaha, Embilipitiya and Naula. The mined rock has been exported without any value addition for a long time. This rock can be processed as powders, and selling classified powders is more profitable than selling the raw form. Quartz from Sri Lanka has very high purity often exceeding 99.5%. It is one of the main raw materials used to produce silicon wafers used in the semiconductor industry. Silicon production involves the reduction of quartz (silica) at a temperature of around 1700 ^{0}C in an electric arc furnace. Silicon production from quartz is not practical in Sri Lanka owing to technological complexity and high electricity requirement. However, there are many other smaller industries which can be started with quartz as the raw material, such as manufacturing water glass (sodium silicate), quartz lenses and other quartz glass items which involves simple melting and reforming of quartz.

Graphite

There are several other minerals for which value addition can be carried out in Sri Lanka. The best quality graphite with a purity of about 99% have always come from Sri Lanka and only about 5% of the total graphite mined in Sri Lanka is used for local industries. In the past, Sri Lanka produced pencils using local graphite but now even the pencils are imported. Also, the Ceylon Ceramics corporation at one time had a small crucible factory at Hal-oya near Peradeniya where graphite was used to make crucibles for the foundry industry. We export almost all the graphite mined from the pits but import the finished products containing graphite, such as carbon brushes for motors, graphite greases and electrodes for dry batteries. The anodes of most batteries are made of graphite, and in lithium-ion batteries, approximately twice as graphite is used as lithium carbonate. The battery of a Nissan leaf car contains as much as 40 kg of graphite. There is increasing use of graphite in lithium batteries due to increased demand for laptops, CD players, mobile phones and power tools.

Advanced materials such as graphene and carbon nanotubes represent the high-end products of graphite. These have numerous applications such as in medicine for drug delivery, microchips, solar cells and batteries. In recent years, several researchers in Sri Lanka have discovered novel ways to make graphene using graphite employing more economically beneficial commercialization approaches. Graphene is considered as the thinnest, strongest and most conductive material, of both electricity and heat. Graphene batteries are light, charge easily and hold the charge longer and this can increase the travel range for electric cars. Since graphene is considered as the world's strongest material, it can be used to enhance the strength of other materials. Addition of even a trace of graphene to plastics, metals or other materials can make these materials stronger.

Iron and steel

There was a well-developed iron industry in Sri Lanka long before the British Colonial times. Archaeological evidence points out to a well organised steel industry dating back to 1200 A.D., long before Europe's first bellow driven iron manufacturing came into operation. It is believed that the famous swords of Damocles were made from steel manufactured in Sri Lanka. There is evidence for a large steel manufacturing facility in the southern slopes of the Samanalawewa area where wind tunnels were used to create the high temperatures required for the iron making process. A British archaeologist working in the Samanalawewa area in the early 1990's, actually produced iron by reconstructing such wind tunnels using iron ore available here. This work has been published in the prestigious journal Nature, and the molten slag flowing out of the furnace she built for this process appeared on the cover page of the journal. Unfortunately this steel industry died soon after the British came into power. Recently a good quality magnetite ore has been discovered off Buttala by geologists of the University of Peradeniya. This ore contains about 60 –70% iron in quite pure form and is found at the surface. Its quality is higher than that of iron ore deposits already recorded, which are found elsewhere in the country. Even by exporting this ore without value addition, considerable foreign exchange can be earned. We have ample deposits of iron ore and also limestone deposits in Sri Lanka and only coke has to be imported to manufacture iron and steel.

Limestones

There are three types of limestones in Sri Lanka: sedimentary limestones in the Jaffna and Puttalam districts, coral limestones along the south-western coast and crystalline limestones in the central highlands. Sedimentary limestones are used for the cement industry and dolomitic limestones used for glass and wall tile industries. There is a calcite deposit at Balangoda which is pure calcium carbonate. Yet, we import around 100,000 tons of precipitated calcium carbonate annually for various industries such as toothpaste, paints, plastics and drug industries. Precipitated calcium carbonate required for these industries can be made starting with this deposit of calcite. The process involves first calcining the calcite in a furnace and then slaking the lime produced to yield calcium hydroxide.

$$CaCO_3 \rightarrow CaO + CO_2$$

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Resulting milk of lime is then carbonated using carbon dioxide which is produced during the initial calcination stage.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$$

This suspension is filtered to obtain a cake which is dried and ground to give precipitated calcium carbonate. Occasionally, the calcium carbonate particles are treated with fatty acids to give enhanced surface activity.

Other minerals of economic significance

The red soils and the serpentine rocks found at Ussangoda in the Hambantota district, contain about 2-3% nickel. An electrolytic method for extracting nickel from these rocks has been reported. However, a cheaper and a more practical method is to extract the rocks with sulphuric acid to obtain nickel sulphate which can be directly used for the electroplating industry. This can be done even as a household industry since no expensive machinery is required.

Another mineral deposit of potential importance is the iron pyrites ore at Seruvila which also contains about 1% copper. This is a unique deposit because it is the only sulphur and copper containing mineral in Sri Lanka. Like other similar deposits in the world, this ore also has around 3-5 ppm of gold. This ore can be roasted to obtain iron oxide and sulphur dioxide which can be used to manufacture sulphuric acid. Copper can be separated during the metallurgical operation and the matter containing copper can be treated to recover any gold.

There is also a smaller magnesite deposit at Wellawaya and this is a useful raw material to produce magnesium oxide, which is used as a refractory material. In addition, magnesium carbonate is used as an additive in the pharmaceutical industry.

Conclusion

This account illustrates the importance of using our mineral resources for the economic development of the country. Mineral development requires the concomitant development of a chemical industry. There should be at least a sulphuric acid plant and also a caustic acid plant. A salt based chemical industry to produce sodium hydroxide can produce chlorine, hydrogen and hydrochloric acid which has many industrial uses. Research done on mineral resources by universities and the opinions of local scientists should be considered in mineral exploitation. Novel and simple methods which can even be carried out in households should be seriously considered by policy makers.

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