Economic Feasibility of Copper Extraction from Seruwila Copper Magnetite Deposit

Abinav R, Chamara HAKM, Dinojan J, Sampath HKT
Dr.Dissanayake DMDOK
Department of Earth Resources Engineering, University of Moratuwa
. Corresponding author; email: dmdok@earth.mrt.ac.lk

Abstract: Sri Lanka is endowed with a variety of industrial minerals such as graphite, quartz, mica, brick and tile clay, ball clay, kaolin, dolomite, calcite, feldspar, miocene limestone, mineral sands (Ilmenite, Rutile , Garnet and Zircon), apatite (phosphate rock), silica sand, magnetite and also gem minerals. Contribution to the GDP from mining and quarrying industries including gems is within the range of 1.8-2% over the last two decades. However, Government has banned export of minerals used for ceramic, construction and agricultural industries considering the limited availability of such mineral resources in Sri Lanka. Some export limitations were also imposed for other export minerals as well without value addition. However, high energy cost for processing is a drawback to value addition of industrial minerals. Considering the above fact and the country's needs, this research was carried out to evaluate economic viability of manufacturing of copper metal from Seruwila Copper magnetite. A detailed literature survey has been done initially and field investigations were carried out to collect ore samples. The chemical analysis revealed that average copper concentration of the surface sample collected in Arippu area was 1.1%. Copper concentration of finely-ground ore samples could be increased up to 15-20% using a Potassium Amyl Xanthate in a laboratory scale flotation cell. Concentrated copper sample taken from froth flotation was dissolved in concentrated hydrochloric acid and the filtered solution was used for copper electrowinning. Extraction of copper was directly related to the applied current density. However, current density varies with other factors mainly the distance between electrodes, temperature, pH, concentration of electrolyte, area of the electrode, stirring speed and applied potential etc. Conducting several trial runs for laboratory made copper sulphate solution by varying a single parameter at a time, the optimum parameters for electrowinning were identified. Unit cost for electrowinning of copper metal was calculated by applying identified optimum current density and other parameter values to actual chalcopyrite solution and average cost of copper extraction was calculated as Rs.101.7/kg considering the average electrical tariff for industrial application in Sri Lanka is to Rs.15/kwh.

Keywords: Electrowining, Current density, Flotatio

Dr.Dissanayake DMDOK
B.Sc.Eng.(Hons)(Moratuwa),Ph.D.(SNU), C.Eng., M.I.E.(S.L.)
Senior Lecturer, Department of Earth Resources Engineering, University of Moratuwa.
Malith HAKM, Dinojan J, Abinav R, Sampath HKT, *Final year undergraduate students in the Department of Earth Resources Engineering, University of Moratuwa.*

1. Introduction

Sri Lanka is gifted with a variety of industrial minerals such as graphite, quartz, mica, brick and tile clay, ball clay, kaolin, dolomite, calcite, feldspar, Miocene limestone, mineral sand (Ilmenite, Rutile, Garnet and Zircon), apatite (phosphate Rock), silica sand, magnetite, gem minerals. Geological Survey and Mines Bureau of Sri Lanka confirms that mining and quarrying industries including gems have contributed an average of 1.8-2% to the GDP over the last two decades.

Considering the limited availability of industrial mineral resources in Sri Lanka, Government has banned export of minerals used in ceramic, construction and agriculture industries in raw form and further, export limitations were imposed for some other export minerals as well without any value addition. However, high energy cost for processing, high investment cost, lack of technology, and environment issues and number of unforeseen other reasons are main drawbacks to invest in value addition of industrial minerals.

Therefore, considering above facts and the needs of the country, this research was carried out and focussing on the economic feasibility of manufacturing of copper metal from Seruwila copper magnetite deposit.

1.1 Seruwila Copper Magnetite ore Deposit

The Seruwila Copper-Magnetite deposit is one of the massive copper magnetite deposits found in Sri Lanka. The deposit was discovered by the Geological Survey Department in 1971.The deposit contains Magnetite associated with primary copper minerals such as Chalcopyrite ($CuFeS_2$) and minor amounts of Bornite (Cu_2FeS_4). The mineralised area was divided into 3 areas, namely, Block 'C', Arippu and Kollankulam. The part of the ore deposit in the Arippu region itself has an estimated 2.75 million tons of metallic iron and 0.69 million tons of metallic copper, the grade being in the region of 1-3%.

More than 70% of the world primary copper minerals originate from sulphides pyrometallurgical smelting as well as electrometallurgical processes which are greatly used in copper extraction today. However, froth flotation, physical concentration processes may cause reduction of smelting as well as electrometallurgical cost.

2. Methodology

2.1 Size reduction

In this research study, investment cost for detailed mineral exploration and mining processes have not been considered. Technical feasibility of laboratory

scale physical mineral processing techniques and electrometallurgical processes were only considered to evaluate the economic feasibility.
Size reduction of samples collected from Arippu area was done up to 63 µm size before subjected to froth flotation by means of laboratory scale Jaw Crusher and Tema mill.

2.2 Froth Floatation

As the copper grade in the ore is very low, it has to be concentrated before taking further steps. One of the most effective physical methods of concentrating low grade ore is froth floatation, by which copper minerals are made to become selectively attached to air bubbles rising through an agues pulp of ground ore.
Selectivity of flotation is carried out by the use of reagents, which make the copper minerals hydrophobic (air avid) while the gangue minerals are left water avid. The floated minerals are held in a stable froth on top of the flotation cell from where they are removed as the concentrate. Typical copper concentrate contains 20-30% copper.

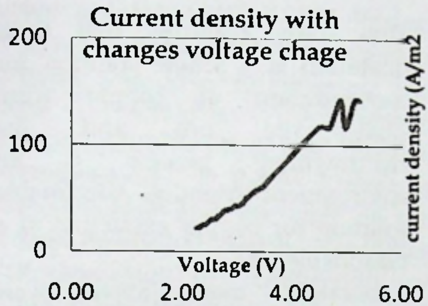
2.3 Liquation

Floated minerals accumulated on top of the flotation cell were removed and mixed with concentrated hydrochloric acid to make the electrolyte solution reach a known suitable concentration. This solution was used for copper electrowinning.

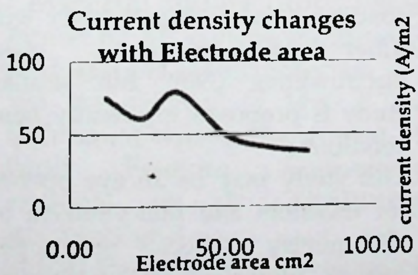
2.4 Electrowinning

In the electrowinning process, a current is passed through an inert anode and an electrolytic solution containing the copper metal ions so that the copper metal is extracted as it is deposited in an electroplating process onto the cathode.
Extraction of copper was directly related to the applied current density and also some other factors such as distance between electrodes, temperature, pH, concentration of electrolyte, area of the electrode, stirring speed and the applied potential. Increasing current density may increase the metal deposition as well as rate of escaping hydrogen and oxygen gases from electrodes and also increase the solution temperature and ion migration as well. This may cause a decrease in system efficiency. Therefore, optimum current density and optimum values of other variables also found for maximum efficiency for a laboratory made known copper sulphate solution. Unit cost for manufacturing of copper metal was calculated by applying above parameters for actual chalcopyrite solution.

3. Result



Laboratory analysis reveals that Chalcopyrite sample collected in Arippu area has 45-50 % of iron and significant amount Manganese (about 1%) and 2-2,3% Copper which is considerable amount compare with other counties. Copper concentration of finely-ground Chalcopyrite powder could be increased to 18-21% from Froth Flotation with Potassium Amyl Xanthate as a collector.



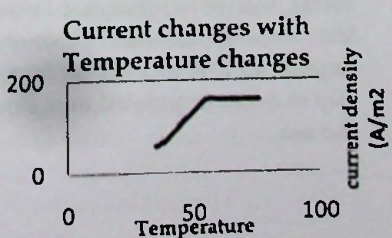
Froth concentrate was readily dissolved with concentrated Hydrocloric Acid.

Optimum current density and current density variation with variable parameters are shown in the graphs.

4. Discussion

Copper is man's oldest metal, dating back to more than 10,000 years. A copper pendant discovered in what is now northern Iraq has been dated to about 8,700 B.C. Copper is vital to the health of humans, animals and plants and an essential part of the human diet. Copper-rich foods include dried beans, almonds, broccoli, chocolate, garlic, soybeans, peas, whole wheat products, and seafood.

The Seruwila copper–magnetite deposit discovered by the Geological Survey Department (GSD), (present GSMB) in 1971 is the first base metal found in Sri Lanka. However the ancient chronicle Mahavamsa records that during the reign of King Dutugamunu (161-137 BC) copper was found at Seruwila and used to build the Ruwanveli Dagaba. The old trenches seen in the area with magnetite (iron ore) thrown out is strong evidence that copper minerals were collected by the ancient miners who knew the art of smelting to obtain the metal. These historical evidences indicate Sri Lanka has the technology for iron and copper smelting.



Presently, copper is used in building construction, power generation and transmission, electronic product manufacturing, and the production of industrial machinery and transportation vehicles. Copper wiring and plumbing are integral to the appliances, heating and cooling systems, and telecommunications links used every day in homes and businesses. Copper is an essential component in the motors, wiring, radiators, connectors, brakes, and bearings used in cars and trucks.

The average car contains 1.5 kilometers (0.9 mile) of copper wire, and the total amount of copper ranges from 20 kilograms (44 pounds) in small cars to 45 kilograms (99 pounds) in luxury and hybrid vehicles.

Therefore, copper has many industrial applications and has huge demand. This research study confirmed that copper can be extracted from Seruwila magnetite deposit for a reasonable cost of Rs. 101.70/ kg.

However, current world market price for one kg of copper metal is about US$ 7.23 (Rs.913. 87). This figure indicates investing in copper extraction from Seruwila Chalcopyrite is a profitable and viable industry. There is no much social and environmental issues in the mining of the Chalcopyrite deposit as it is located far from the city in a less populated area close to the sea.

5. Conclusion

This study confirms that froth floatation is a viable solution for concentration of copper from Chalcopyrite ore and the electrowining process is an environment friendly, sustainable solution for copper extraction at a reasonable cost.

Laboratory made small scale elecrowinning cell was used for this study and used with optimum conditions for each variable parameter against optimum current efficiency.

The optimum parameters were 20g/l concentration; solution temperature 55^0C- 60^0C, stirring speed 300 rpm, 2cm distance between electrodes, pH 4.2. Accordingly, the average cost for copper extraction was Rs.101.7/kg. However, these optimum conditions for each parameter will differ for industrial scale electrowining plant and similar study is proposed to identify new conditions.

This study may be an eye opener for investors and policymakers of the country to decide on copper mining. However, further studies in copper extraction are proposed for low cost and better performance.

Mining and mineral processing sector will be an important sector in our economy. Therefore, contribution to the GDP from copper extraction from Seruwila chalcopyrite deposit will be significant to the National Economy.

Acknowledgement

We are thankful to Dr. Shiromi Karunarathne, Head Department of Earth Resources Engineering and Dr. A.K.M.B. Abeysinghe Coordinator - Research Project, Department of Earth Resources Engineering and the staff of the Department of Earth Resources Engineering of University of Moratuwa for their guidance and facilitating this work. We are indebted to Dr.Kithsiri Dissanayake supervisor of this research project for his valuable guidance and involvement throughout the project period. We also thank Mr.L.P.S. Rohitha for providing valuable instructions, guidance and facilitating us during laboratory testing.

We are indeed grateful to Mr. Udaya Silva, Assistant Director of Geologiical Survey and Mines Bureau for his valuable guidance in field data and sample collection.

We are grateful to Mrs. P.T.N Pathiraja, Chemist, Department of Earth Resource Engineering assisting us in conducting laboratory tests

Special thanks are due to officers of the Martin Wicramasinghe Memorial museum and the Custom Officer of Bio Diversity Division of Sri Lanka Customs.

References

S.JAYAWARDENA, D. (1982, january 13). The Geology and Tectonic Setting of the Copper-Iron ore Prospect at Seruwila North East Sri Lanka. Srilanka.

Dr.Jayawardena, Present status and development of Minerals Resources in Sri Lanka, J Natn. Scn. coun. Sri Lanka 1984 (12)

Froth Flotation of Seruwila Chalcopyrite by Miss S.W.Yapa

Napier-Munn, B. A. (2009). *Wills' Mineral Processing Technology.* University of Queenland.

Chalcopyrite. (n.d.). Retrieved 2012, from Wikipedia:http://en.wikipedia.org/wiki/Chalcopyrite

Electrowinning. (n.d.). Retrieved 2012, from Freeport-Mcmoran Copper and Gold: http://www.fcx.com/metals/fmi/electro.html

EXTRACTION OF COPPER. (n.d.). Retrieved 2013,from CitycCollegiate: http://www.citycollegiate.com/IX_copper.htm

Froth flotation. (n.d.). Retrieved 2012, from wikipedia: http://en.wikipedia.org/wiki/Froth_flotation

Solvent Extraction. (n.d.). Retrieved 2012, from CYTEC: http://www.cytec.com/specialty-chemicals/solventextraction.htm?gclid=CKG8rbGunLYCFcUt6wodS00A7Q

SOMIKA Societe Minere du Katanga. (n.d.). Retrieved 2012, from http://www.somika.com/copper-properties-ores-minerals-lubumbashi.php