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**BUSINESS PLAN FOR GRAPHITE MINING & PROCESSING PLANT
PROJECT OF 2,000 TPD ORE INPUT**

IN RUANGWA DISTRICT

LINDI REGION, TANZANIA

EXECUTIVE SUMMARY

Grafica Resources Ltd (GRL) a company was incorporated under Companies Act 2002 on 12th December, 2001 with 100% shares allotted to foreign investors (Brela Extract attached along with the application). It is a registered company in the United Republic of Tanzania.

Grafica Resources Limited (GRL) owned Block ML-5, vide mining license number ML-499/2013, is situated in the Nambilanje ward in the Ruangwa District, Lindi Region of the United Republic of Tanzania, northeast of the hamlet of Mtondo. The location is roughly 260 km north of Mtwara town and 620 km from Dar es Salaam.

ML - 499/2013 dated 16th August 2013 was granted to Grafica Resources and further renewed for 10 years in 2023 by Ministry of Energy and Minerals (MEM) now Ministry of Minerals, Tanzania to begin the commercial mining of Gold. While carrying out the exploration for gold during 2009-2010 the presence of graphite was also reported, but during that time it was not feasible to export ore of such grade because of the high transportation and logistics costs. However, during the continued survey for gold, reasonably good resources for graphite were discovered. Further on 21st October 2014, another report was submitted to MEM for addition of Graphite in its Mining License, further to which it was 'Authorization to Add Another Mineral' was granted to GRL on December 2014.

Further to which Grafica had commenced to acquire land for the proposed plant in and near its Mining License area in 2015. The company had paid compensation to the stakeholders of the land in the year 2016. All the land acquisition exercises were done as per the rules and all the formalities with regards to this were completed from our side. The company also had paid advances to the EPCM contractor in 2016 that shall Engineer, Procure, Commission and Manage the Graphite Beneficiation Plant on the site for ML 499 in expectation the land derivative rights shall be allotted to the company soon and after that it can commence construction of its plant. It is expected to receive the title deed soon from the ministry. The company has done lot of development including site clearances for the plant and mine site, construction of warehouse, water borewells, pits and ores have also been dug out etc.

This report describes the status of the geological, engineering and economic studies of the Ruangwa Graphite Project. The discussions contained herein reflect the best judgment of Grafica, based on the present state of knowledge with respect to the Ruangwa property deposit within Mining License no. ML - 499.

The detailed exploration in ML-5 led to the discovery of a graphite deposit that can be mined and has a mine life of more than 60 years. During the course of mining operation, it is anticipated that some areas might be exposed which might increase the resources in this ML block and the mine life.

Detailed survey for Graphite ore and mining was performed in this ML including trenching, pitting and drilling for Graphite. Large quantities of samples were sent to numerous laboratories in other nations, including Canada, Germany, India, China, and South Africa, which confirmed the availability of graphite ores of reasonably excellent grades. A total of 10,055 m trenches were dug in ML 5 in which 2837 m were done in CSB block and 4,451 m diamond drilling was conducted in ML 5.

Therefore, the company intends to develop and is shovel ready for an open pit mine in Central Sub Block (CSB) of ML-5 within 156 hectares along with setting up of Graphite Processing and Beneficiation Plant Facility having a capacity of 0.6 million ton per annum that shall take raw graphite ore from ML-5. The company is also open to take raw graphite ore from other deposits around the area. The beneficiation plant shall process 2,000 TPD (0.6 million TPA of Ore) which shall produce 43,200 tons per annum of finished graphite flakes of 85 – 95% carbon content with 85-90% recovery rate. The target ore mining shall be to maintain 8% C content at 90% recovery producing 43,200 TPA finished graphite flakes are considered for this feasibility.

This beneficiation plant shall be setup on land which is purchased by the company that is located next to Block ML-5. It is also noted that in some areas, gold is also present in meagre quantities in the mining area. In the future plans, a gold extraction plant shall be set up in the area. This would bring additional revenue to the company.

Graphite Ore Processing and Beneficiation Plant

The plant will combine the grinding, flotation, drying and packing components. The technique of concentration process is designed in such a way to separate the maximum graphite flakes with different seize. The pilot plant processing resulted to generate 95% GC concentration with 90% recovery using 4 cum water for per ton of ore.

To accommodate rejects/tailings if height of Tailing Storage Facility (TSF) is to be raised by 5 m then in 5th year there will be requirement of 137.8 hectors. A common TSD is proposed to construct towards west of the plant location which will be sufficient for 20 years at 0.6 million ton per year ore processing.

Power to be supplied by TANESCO for 5 MW connected load in initial period. Diesel Generators are recommended to generate necessary 8 MW power for plant, work shop and colony as there are no electricity in the nearby area.

Earlier it was decided to set up an alluvial gold plant, but after the discovery of a significant graphite ore body in the mining license area, GRL now desires to mine and process both graphite first and gold (in later phase). To begin with, a graphite beneficiation plant shall be setup first.

For the electricity, GRL is also in discussion with TANESCO about extending the electrification of the National Grid to the plant site. However, in the feasibility study

report which is being submitted to MEM, the Diesel Generator is being mentioned. But this carries a significant running cost. If the government gives support to supply direct electric line connected with the National grid, then the operating costs would reduce and will give additional boosts to the company and surrounding villages and communities.

The project at its full production will employ approx. 125 persons on site for ML – 5. Creation of job opportunities for locals and with the payments of royalties, taxes, and numerous other statutory payments accordance with the law, the proposed project at Block ML - 5 will significantly improve the social and economic conditions of the surrounding communities in the Ruangwa area as well as Tanzania at larger extent and will indirectly help in increase in living standards, improved infrastructure, increase in indirect employment and technical development of people.

Since the beginning, the company has harmonious relationship with the nearby villagers and the community. From time to time, Grafica is supporting the community in providing basic infrastructure like borewell, donation in nearby schools, donation in kind during the time of excessive rains in the Mtondo village etc.

Through the delivery of local goods, inputs, and supplies to the mine and its workforce, the Ruangwa Graphite Project's US\$ 46 million overall infusion for Central Graphite Processing Plant ML-5 into the economy would stimulate several secondary economic activities in the Ruangwa District, Lindi Region, and Tanzania as a whole.

This project will directly/indirectly entail creation of allied services and will be a valuable addition to the existing export portfolio of the country. Export of the graphite concentrate will provide direct inflow of foreign exchange to the Tanzania.

Currently, the Mtwara-Ruangwa highway, which is roughly 260 kilometres from the mining site, is the only way to reach this Block ML-5. Another route that may be used to go to this is Mtwara-Mandawa via Rutamba, which is even shorter at only 153 kilometres. However, due to the poor state of the road, big trucks are now unable to access this. Being an industrial material, graphite is always shipped in large quantities.

Therefore the logistics costs have a major impact on the export price; hence, a shorter, faster and better route will prove beneficial. If the government supports the construction of this Mtwara-Mandawa route for heavy roadways infrastructure, it will lower product costs and enhance exports.

Although Graphite has been discovered in large quantities in nearby countries in which few of them have already started exported graphite flakes in large quantities. This will lead to a competition as the buyers are limited in this industry and have more choices which may lead to competitive pricing strategy in sale prices of graphite flakes in future. Also, China is still world's largest and cheapest graphite producer and have significant graphite resources which ultimately will be the biggest competitor. Although Tanzania graphite is better quality graphite compared with others which is an advantage.

CHAPTER-1: INTRODUCTION

1.1 COMPANY PROFILE

Grafica Resources Ltd (GRL) a company was incorporated under Companies Act 2002 on 12th December, 2001 with 100% shares allotted to foreign investors (Brela Extract attached along with the application). It is a registered company in the United Republic of Tanzania.

Exploration undertaken in the area has identified sufficient mineralization for a potential medium scale gold mine in the area. While carrying out exploration for Gold in the PL area good deposit of graphite in Block ML-5 (ML499-2013) and other areas were located. Therefore the detailed exploration for Graphite was carried out in ML-5 and that resulted in locating the mineable deposit of graphite with mine life of 60 years. Further exploration shall be continued which is expected to add more reserves in this ML block increasing in mine life.

Therefore, Company intends to develop an open pit mine in Central Sub Block of ML-5 Block within 156 hectares along with setting up a graphite beneficiation plant with a capacity of 0.6 million ton per annum that shall also take raw graphite ore from ML-5 (ML 499). The company is also open to process graphite ore from nearby areas other than this ML block. This beneficiation plant shall be setup on land which is purchased by the company that is located next to Block ML-5. The company has paid compensation to the stakeholders of the land and now after long await, it is expected to receive title deed for the land soon.

The Government of Tanzania has granted Mining License to GRL in Block ML-5 vide Mining License No.-499/2013, on 16th August, 2013 and further renewed for 10 years in 2023, signed by the Honorable Minister of Energy and Minerals, Government of Tanzania. Further the company has allotted two more mining license vide no. ML 689/2023 and ML 690/2023 where the plant and tailing storage facility shall be established within these mining licenses.

For the convenience for exploration and exploitation the ML-5 Block, Ruangwa Properties is divided into three sub blocks as detailed below.

1. North Sub Block (NSB)
2. Central Sub Block (CSB)
3. South Sub Block (SSB)

Detailed exploration has been completed in CSB, therefore for mining, processing plant, production, market price of graphite and to determine economical viability, Feasibility Report is prepared pertaining to the CSB of ML-5 Block. The capacity of processing plant is 0.6 million ton of ore per annum and that will be supplied CSB Block of ML-5 at the rate of 0.6 million.

To test the grades of graphite ores the samples were sent to various labs in different countries including Canada, Germany, India and South Africa which confirmed the availability of reasonably

good grades of ores. The graphite project in Ruangwa Property is economically viable and ready to mine therefore the mine plan is prepared according to the Mining Act -2010, Government of Tanzania.

1.1.1 General

Name of company	: Grafica Resources Limited (GRL)
Registered Office	: PGL House, Plot no. 481, Garden Road, Mikocheni-A, PO Box-105014, Dar Es Salaam, Tanzania
Phone and E mail address	: +255 788 350 575, info@grafica.co
Status	: Private Limited Company
Mineral Occurring in the area	: Graphite and associated Gold
Period for mining License	: Ten years

1.1.2 Project at glance to produce 43,200 ton of concentrated graphite using 0.6 mt ore.

Promoters	Grafica Resources Limited has businesses focused on Mining and Exploration for Precious Metals and Graphite in Tanzania.
Project	Graphite ore dressing and beneficiation plant to process 2,000 TPD (0.6 Million TPA of Ore) which shall produce 43,200 TPA of finished graphite flakes of 90 - 95% carbon content with 90% recovery.
Plant location	The locating co-ordinates of the proposed plant are: <ul style="list-style-type: none"> • Latitude : N 9°45' 40.64" • Longitude: E 39°5' 28.40" The considered plant site is around 170 Km West of Lindi, around 260 Km North West of Mtwara and around 400 Km South of Dar es Salam.
Markets	China, Europe, Korea, Japan, America
Water requirement	8,000 m ³ /day and which shall be met through dedicated 15 nos. of boreholes around Plant Periphery.
Envisaged raw material cost	Main Raw Material shall be Graphite Ore and its recurring cost to the plant shall be Approximately USD 4/t. This mining operation shall be awarded to an experienced mining contractor.
Maximum power demand & source	Total installed load for initial Phase of the projects is approximately 5MW. It shall be met through 06 numbers G2 grade, Diesel Generators of 1000KW / 400V 50Hz capacity each.
Suggested manpower	The manpower requirement for plant operation is approximately 125 persons.

Storages Capacities	Item	Days
	ROM Graphite	30
	Crushed Graphite Ore	2
	Kerosene	7
	Gas (LNG/LPG)	7
	Packed Bags	60
	Diesel	7
Project implementation	An implementation period of 12 months from the date of receiving all the permissions/approvals.	
Investment Cost	Investment cost estimates are based upon the negotiated plant and machinery order received from a reputed plant machinery supplier.	
	Item	Amount (In Mio USD)
		Phase I
	Mine and Site Development	3.74
	Building & Infrastructure	11.88
	Process Plant (including EPCM)	12.06
	Miscellaneous Fixed Assets	3.47
	Electrical Infrastructure	4.14
	Pre-Operative Expenses	4.50
	Working Capital Requirement	6.00
	Total Investment Cost	45.79
Financial Indicators	Item	Value
	IRR on Investment (%)	23.88%
	Pay Back Period	4 - 5 Years
Conclusion	Based on the performance indicators, it is concluded that the project is Financially Viable.	

1.2 PROPERTY DESCRIPTION, LOCATION & ACCESSIBILITY

The Central Sub Block is located within Block ML- 5 is situated within the villages of Nanjaru, Nambilanje, Mtondo and Mkalanga, falling under the jurisdiction of the Nambilanje ward in Ruangwa District, Lindi Region of the United Republic of Tanzania. The Ruangwa property is approximately 170 kilometers west of Lindi and 260 km west of Mtwara. It is accessible by 135 km tarmac road from Lindi town connecting all weather road via Ruangwa township (head quarter of Ruangwa District) and about 35 km seasonal road North east of Ruangwa township. The property may also be accessed by a shorter route from Dar-es-Salaam via Kitumbini - Mandawa settlement approximately 100 km north of Lindi town for approximately 400 km from Dar-es-salaam. The route, however, is not passable during the rainy season.

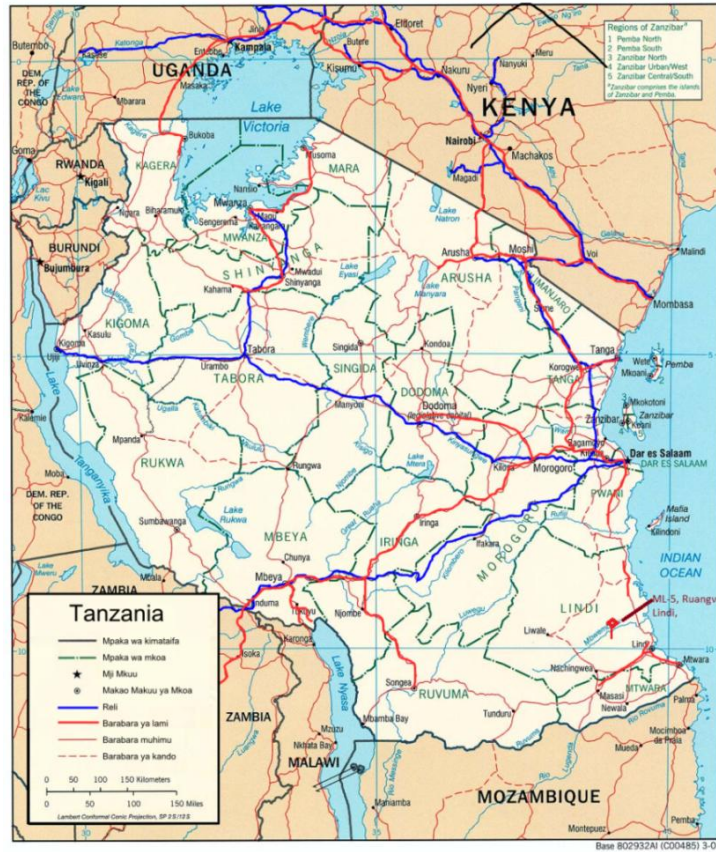
Lindi Region is one of the three regions forming Southern Zone of United Republic of Tanzania, the other regions being Mtwara and Ruvuma. The Mtwara and Ruvuma regions border northern Mozambique and eastern Malawi.

The main road from Dar-es-Salaam to the southern regions passes through the Coastal, Lindi, Mtwara and Ruvuma regions. The road connects to northern Mozambique and eastern Malawi via the Mtwara and Ruvuma regions. Recently funding from external donors and the central government have significantly improved the road from Dar-es- Salaam to the Lindi and Mtwara regions from gravel to tarmac level, covering a total distance of about 700 Kilometers, including the construction of 1 Km long bridge across the Rufiji River.

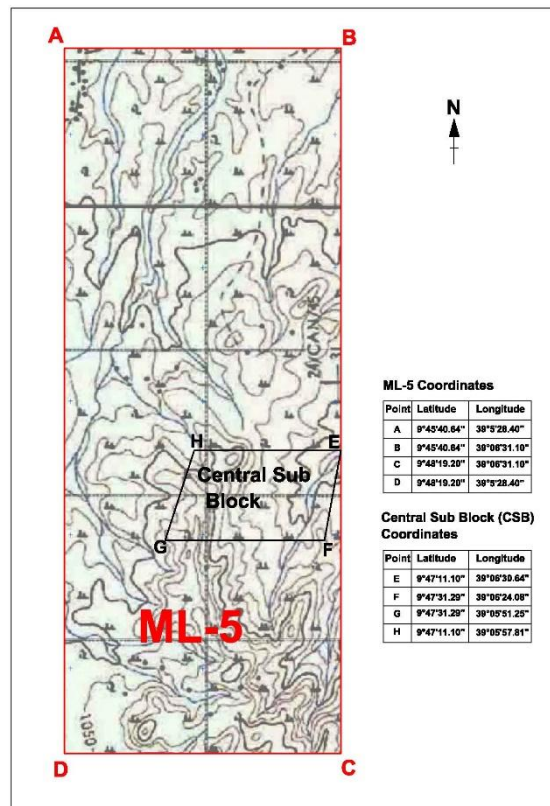
The Lindi Region is served by 4 airstrips, in Lindi, Nachingwea, Liwale and Kilwa Masoko. These gravel strips are capable of supporting small to medium size planes only. There is no commercial air service to the region.

Although the electric power grid is reaching in most areas of Tanzania, but it does not extend to the area of the Ruangwa property, however power is available at Ruangwa, the District head quarter.

Within the area, several mobile telephone networks (Vodacom, Airtel, Zantel, Tigo and TTCL) and internet communication is available in local internet cafes in Ruangwa or mobile internets.



Location of ML-5 with respect to Dar es Salaam, Lindi and Mtwara.



Boundaries of Central Sub Block within Block ML - 5 in Ruangwa property

1.3 TOPOGRAPHY

The topography of the area ranges between 212m to 356m and is relatively moderately rugged to the central, west and the southwest, and flat to the eastern part. In the ML - 5 block NNE-SSW trending ridges are located in the middle of the area, which are sloping towards west and east. Many of the rivers and streams which are flowing to the North and East directions are seasonally dry. The main Mbwemkuru River, which is about 6 km north of ML-5, remains dry during dry season, however water is available at 0.5 to 1.0 m depth, therefore water availability for all aspects of the exploration and development program, will not be a problem. River Lindadwe originate from this area as it acts as water divide. The area is densely vegetated with thick bushes along the rivers and streams valleys. Drainages show dendritic combine with trellis pattern indicating the imprints of structure and active slopes.

1.4 CLIMATE

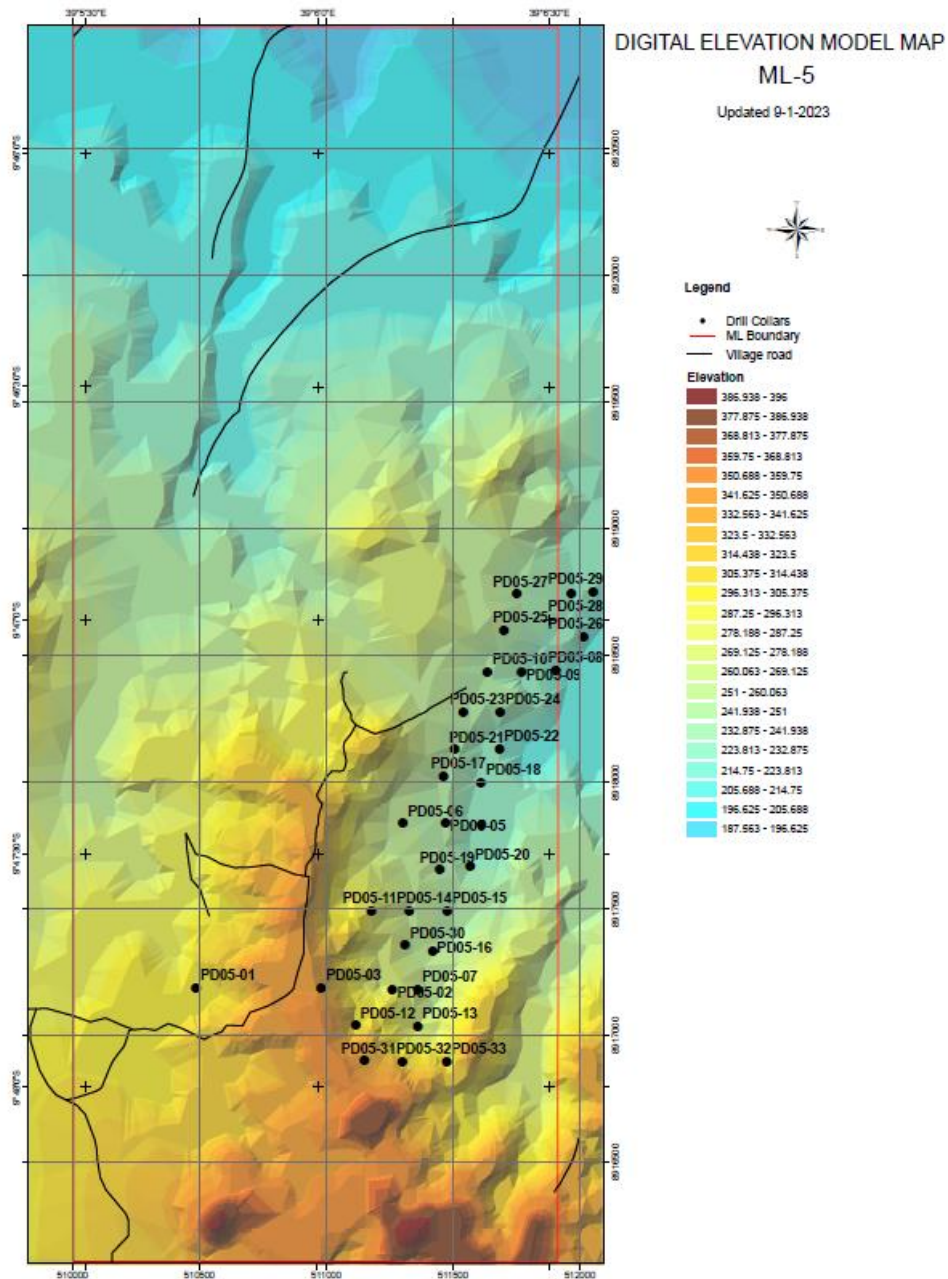
There are four main climatic zones that can affect the whole of Tanzania: the coastal area where conditions are tropical; the Central Plateau, which is hot and dry; the semi-temperate highland areas; and the high moist lake regions.

The climate of Ruangwa District is more-or-less uniform throughout the year. Temperature ranges from 10^o to 40^o however a daily average of 24^oC in the dry season to a daily average of 34^oC in the rainy season, with an annual average of 26^oC.

The District enjoys monsoon winds from the northeast from June to October, and south-east wind from November to May of each year. It rains from mid-November to May, with most parts of the District receiving between 800 mm and 1200 mm per year. The slopes of the Rondo Mountains get more rain than other parts of the District, with over 1000 mm/year. In general, rainfall decreases from east to west. There are two rainy seasons in the North, from November to January and from March to May.

1.5 VEGETATION

The area is covered by trees and bushes. The most predominant natural vegetation is Miombo wood land. Common vegetative species include those of *ranchystigea*, *dalbegia*, and *Pteracarpus*. Other common vegetative species include *Bamboo*, *Miombo*, *Mikongo*, *mibuyus*, *miyale*, *misufi*, *Mipingo*, *miungain* the highlands and species like cashew-nut trees, simsim, mango trees, which are cultivated in the lowlands.



Three Dimensional topographical DTM map of the ML-5, Ruangwa, Tanzania

1.6 GRAPHITE’S USES AND MARKET SCENERIO

This chapter covers aspects of world graphite market scenario, its various usage and estimated achievable sales volumes for graphite flakes produced by the proposed graphite beneficiation plant of Grafica Resources Limited (GRL).

NATURAL GRAPHITE

Graphite is the natural mineral of carbon “C” occurring as soft shining grey to black coloured mineral. It is a native element found in metamorphic and igneous rocks. Graphite is a mineral of extremes. It is extremely soft, cleaves with very light pressure, and has a very low specific gravity. In contrast, it is extremely resistant to heat and nearly inert in contact with almost any other

material. These extreme properties give it a wide range of uses in metallurgy and manufacturing. The crystalline graphite occurs as flakes whereas amorphous graphite occurs in fine granular form. The pure crystalline graphite shows sub metallic silver luster.

1.7.2 Uses of Natural Graphite

Under the present scenario natural graphite is used in many industries depending on the size of the flakes of graphite, carbon content and other impurities. Natural graphite is used mostly for manufacturing refractories, lithium ion batteries, steelmaking, nuclear power plants, brake lining, foundry facings, pencils, lubricants and industrial products like graphite foil, sheet etc.

Graphene, which occurs naturally in graphite, has unique physical properties and might be one of the strongest substances known. There are a number of applications where the major developments are expected. Research related to economical extraction of graphene from graphite on industrial scale is being done.

The various uses of natural graphite are given below:

Refractories: Refractories are ceramic materials designed to withstand the very high temperatures (in excess of 1,000°F [538°C]) encountered in modern manufacturing. They are more heat-resistant than metals and are used to line the hot surfaces found inside many industrial processes.

Refractories come in shapes and sizes and are basically produced in two categories in terms of form type: brick and monolithic. Bricks and shapes are the more traditional form of refractories and historically have accounted for the majority of refractory production.

- Natural graphite is a key ingredient used as an additive in many types of specialized refractories like Magnesia-Carbon (MGO) bricks. Graphite content of typical bricks ranges from 4 – 35 % natural flake graphite. Graphite carbon contained in the refractory is an active reducing agent of the iron oxides. Iron & steel industry currently uses approximately 70% of all refractories produced. Other industries include cement, non-ferrous industry and glass industry.
- Crucibles are used for transfer of molten steel from furnace. Furnace crucibles are designed to withstand the highest temperatures encountered in the metal casting works. The crucible should essentially be made of materials with a much higher melting point than that of the materials to be melted. The crucible materials should also have good strength even when extremely hot.

Graphite crucibles with good thermal conductivity and high temperature resistance are designed to melt metals such as gold, silver, copper, aluminum, and platinum, and graphite can withstand temperatures up to 1600°C.

- Alumina-graphite shapes are used as continuous casting ware, such as nozzles and troughs, to convey the molten steel from ladle to mould, and carbon magnesite bricks line steel converters and electric-arc furnaces to withstand extreme temperatures. Graphite blocks are also used in parts of blast furnace linings where the high thermal conductivity of the graphite is critical. High-purity monolithic are often used as a continuous furnace lining instead of carbon-magnesite bricks.

Batteries: Growing market in electric vehicles, mobile phones, smartphones and tablets, has led to staggering growth in the use of graphite in batteries. Big electronic device screens need big batteries to power them, for practical purposes lithium ion or lithium polymer batteries, in which graphite is a key component.

1.9 OVERALL FUTURE DEMAND FOR GRAPHITE FLAKES

As elaborated in the preceding sections the demand for graphite flakes is likely to undergo a sea change from the current levels on the back of existing as well as new applications. Thus, based on the same the total future global demand for graphite flakes is given below:

Table 1.5: Total World Graphite Flake Demand for all Applications

Year	Existing Applications	Electric Cars	Giga Factories	Total
2018	0.617	0.32	0.79	1.73
2019	0.648	0.33	0.97	1.95
2020	0.681	0.34	1.19	2.21
2021	0.711	0.38	1.46	2.55
2022	0.751	0.47	1.78	3.00
2023	0.79	0.59	2.37	3.75
2024	0.829	0.96	2.62	4.41
2025	0.872	1.32	2.90	5.09
CAGR	5.07%	22.44%	20.42%	16.67%

Source: www.statista.com, Bloomberg NEF, Benchmark Mineral Intelligence, Total Battery Consulting, Inc.

1.10 ACHIEVABLE SALES VOLUMES FOR GRL

The demand for graphite flakes is envisaged to grow at a very healthy rate in next 4-5 years owing to the shift in the applications of graphite. Electric cars as well as the new Giga factories would fuel this demand growth in the coming years.

As detailed in section 1.6, the future demand for graphite flakes is envisaged to grow from 2.55 million tons in 2021 to 5.09 million tons in 2025 at CAGR of around 25% pa. More than 65% of this demand is likely to come from the new applications like electric cars and Giga factories and the rest is expected from the normal applications of graphite.

GRL is setting up a graphite beneficiation plant of graphite flake production capacity of 43,200 TPA of finished graphite flakes in the initial phase. Based on the envisaged time period of 12 months for construction of the plant (after the placement of main plant & machinery order to the equipment supplier).

GRL has developed and acquired in-house expertise and technology to understand various stages of beneficiation to retain and increase the maximum output of large flake graphite and to deliver

value added products. Further, based on the test samples of graphite flakes produced by **GRL** it is seen that the produce from **GRL's** captive graphite mines is of high quality with 6.5 to 7.5 % carbon content.

Thus, considering the fact that the total production capacity of **GRL** is likely to only 2% of the total graphite flake demand, **GRL** should not encounter any bottlenecks in selling its entire produce to the potential customers.

Table-1.6 Potential users of GRL natural graphite.

Sr No	Type of Graphite	Potential Uses
1	Natural Graphite	1.Refractories 2. Brake Lining 3. Lubricants 4. Carbon Brushes 5. Crucible
2	Spherical Graphite	Lithium Ion Batteries
3	Other Graphite	1. Gaskets 2. Seals 3. Foils 4. Heat Sinks 5. Fire tops 6. Hot Tops

GRL team has met nearly most of the graphite consumers in China, Europe and USA and have briefed them about quality of product, supported by test results.

By and large all users have shown their keenness and it is assured that they shall buy bulk quantity and are looking for long term supply as our quality is better than the existing suppliers.

As per the marketing plan, **GRL**, proposes to export Graphite Flakes from its plant in Tanzania primarily to the markets of China, Europe, Korea, Japan and the Americas.

GRL Team has met nearly all major graphite users in China, Europe and USA and has briefed them about quality of the product, supported by test results. By and large all users have shown their keenness.

The applications of graphite are slated to witness sea change in the coming years with focus primarily on the electric cars and energy storage system. This phenomenon which would result in exponential growth in the graphite demand. Based on the demand of graphite for existing applications, electric Cars and Giga factories, the future demand for graphite flakes is like to reach around 5.09 million tonnes by 2025. **GRL** which is setting up a 43,200 TPA graphite beneficiation plant in Tanzania is slated to benefit from the accelerated growth in the world's graphite demand. The major markets for graphite are China, Europe and the US. The basket FOB price, likely to be commanded by GRL is around **USD 700/t**.

CHAPTER -2 : EXPLORATION AND RESOURCES

The following exploration work has been carried out in Central Sub Block of ML-5, to determine the three-dimension geometry of the ore body and for the estimation of reserves of different categories along with the weighted average.

2.1 GEOLOGICAL MAPPING

- a) Regional geological mapping on 1:20,000 scale
- b) Structural and tectonic study of the area on the basis of satellite imageries on 1:30,000 scale
- c) Large scale mapping on 1:5,000 scale
- d) Large scale mapping of CSB using Total Station exclusively for graphite mineralization on 1:2,000 scale
- e) Topographical survey on 1:2,000 scale using Total Station.

2.2 TRENCHING

In CSB, 4 trenches with cumulative length of 2837.44m has been excavated across the strike to understand the sub soil lithology, structure and nature of mineralization (Table-3.1). Besides this, panel and channel samples were collected from these trenches to delineate the thickness and grade of mineralized graphite zone.

2.2.1 Planning Of Trenches

In CSB to understand the nature of mineralization and its continuity along and across strike the scout trenches were planned at around 300 m interval (Trench – 23 & 24) as mostly area is covered by soil, especially graphite schist which is the host rock. Trenches Tr-26, 27, 28, 29, 30, 31, 32, 33, 34 and 35 were excavated in the western part of the ML-5 and that have not shown good results, therefore at present concentration of exploration remain in the eastern part of the area.

The assay value of samples of Tr–23 & 24 indicated very good results. As the results were encouraging in filling Tr-39 & 40 were taken up. These all gave positive results establishing about 600m strike length and cumulative maximum 300m width on the surface.

Later, further extension of trenches were done in the above Trench–23, 24, & 40 towards the eastern part of the deposit to find additional lodes and possibility of the extension of the width from 300 m to even more on surface.

Till now, this exercise is also successful as there is continuity in the east part of the CSB. This would definitely increase the reserve of this mining block significantly. This shall be confirmed in the later phase, after systematic sampling in this area.

2.2.2 Trenching

Further detailed exploration is in progress towards eastern most part of the CSB of ML-5 as the good quality graphite is observed in the scout trenches, which are carried out recently.

These trenches has exposed good grade of graphite zone and further sampling and detailed exploration is in progress. This is supposed to enhance the resources with good grade of Graphite Carbon.

2.3 DRILLING

To understand the sub surface geology, grade variation of ore body and to determine the three dimensional geometry of the ore body of graphite mineralization, sub surface exploration by Diamond core drilling was carried out. In all, 9 boreholes were drilled with a cumulative length of 1204.10m.

2.3.1 Borehole

Boreholes were planned to intersect the ore zones at two to three levels to determine the resources up to 150 m vertical depth from the lowest RL of ore zone point in that section. The detailed study of four sections along four trenches was carried out and that include sampling, assay, calculation of lode zone at 3% GC cut off and attitude of ore zone. On this basis the boreholes were planned along these sections to intersect lodes at 25.0 m vertical depth to 75.0 vertical depths. On the basis of good assay results of channel samples collected from Trench-23, three boreholes PD05-4, 5 and 6 were planned along trench Tr-23 to test the depth continuity of lode determined in the trenches. These indicated very encouraging results, therefore planning was done along other trenches to test the depth continuity of lode (at different depth up to 100 m vertical depth) and this is detailed below.

1. On Tr-23 boreholes are PD05- 4, 5 and 6
2. On Tr-24 boreholes are PD05- 21 and 22
3. On Tr-39 boreholes are PD05- 20 and 19
4. On Tr- 40 boreholes are PD05- 17 and 18

2.4 CORE SIZE AND CORE RECOVERY:

The drilling was carried out using NQ and HQ diamond bits by coring methods. The recovered core sizes are 62 mm and 72 mm from NQ and HQ bits respectively. Mostly surface diamond bits with 40-60/60-80 psi were used for drilling. Since the rocks are mostly soft, therefore the bits have given good performance. Only 10% to 20% were medium hard to hard rocks.

Core recovery was good in all the boreholes. Core recovery varies between 60 % and 70% in weathered zone (depth up to 15 to 20 m) whereas overall average is 93.18%. In the ore zone, the core recovery is more than 97% and considering mechanical losses for all practical purpose it is considered 100% for all calculation purpose.

Borehole survey was not carried out due to non-availability in the nearby area. However, boreholes are not much deep and the average depth of 9 boreholes is 133.80m, therefore not much deviation in angle and azimuth are anticipated.

2.5 CORE LOGGING

The cores of 9 boreholes with 1204.1m were logged with the details of lithology, mineralization, % core recovery, % and RQD and structure angle with core axis. The logging of boreholes was recorded in separate register for each borehole. However, run wise core recovery and RQD are recorded separately for all the boreholes. The details of lithological variations were recorded in the register and each minor lithounits cannot be plotted while preparing the geological sections, therefore the simplified summarized lithologs and other details of boreholes are considered.

2.6 SAMPLING

All the Trench samples and core samples were analyzed for graphite carbon, however some cores were also analyzed for gold and 32/ 64 elements. In a few and bulk samples moisture, volatile matter; LOI, carbon and ash contents were determine to understand the usability of graphite carbon in the different Industries and its property for its concentration.

Table – 4.3 Details of boreholes drilled in ML-5, Ruangwa, Lindi.

GRAFICA RESOURCES LTD.- ML-5 Area, Diamond Drilled Boreholes Data (For Graphite)						
Hole ID	Coordinates			Drilling Angle	Azm	Meters Drilled
	East	North	RL			E.O.H (m)
PD05-04	511612.62	8917832.70	224.0	65.0	285	116.60
PD05-05	511470.73	8917837.92	245.5	65.0	285	152.60
PD05-06	511305.21	8917835.25	265.35	65.0	285	149.60
PD05-17	511461.65	8918024.05	246.98	65.0	285	120.10
PD05-18	511610.36	8917997.36	233.58	65.0	285	119.10
PD05-19	511446.26	8917652.75	246.87	60.0	285	161.10
PD05-20	511567.00	8917667.08	240.51	60.0	285	122.60
PD05-21	511505.15	8918128.49	239.82	65.0	285	110.30
PD05-22	511683.69	8918132.01	233.34	65.0	285	152.10
				Total m		1204.10m

Total Boreholes = 9

Total meters = 1204.10

While fixing the bore holes on the ground the geological feature, mineralization lay out on the ground has been considered.

The mineralized cores were sampled keeping around 0.50m to 5.0m length for each depending upon homogeneity mineralization, lithological uniformity, core recovery, drilling run etc. However, minimum length of the sample is 0.50m whereas the maximum length is 5.0m. The longer length of the sample is taken where core recovery is more than 95% and smaller length is due to drilling run or lithological variations. The care has been taken to record accurately the length, lithology, structure, visual grade of core samples.

After determining the sample length, the core was split longitudinally into two halves by core cutting machine. The one was kept into the core box and other half was powdered (manually) to -80 and -120 mesh and reduced by coning and quartering to draw the representative sample and sent to chemical laboratory for analyses and rest are preserved.

In all total of 1361 samples were collected from the mineralized zones and analyzed for Graphite Carbon and a few were analyzed for different elements. The details of samples are as follow.

a) Grab samples	= 101
b) Channel/panel samples	= 647
c) Core samples	= 553
d) Bulk samples	= 5
e) QA/QC Check samples (Duplicate &Standard)	= 60

2.7 RESOURCES AND RESERVES

Graphite lode is determined at 3% GC cut off and lode length is calculated to be 2000 m and true width of different lodes varies from 3.99 m to 79.80 m. The mineable lodes are G, K, K1, K2, K3, Ke, Kw, Km, L, and M. The sizable resources reserves have been determined as detailed below.

2.7.1 Resource Estimation for Central Sub Block

In CSB trenches Tr- 23, 24, 39 and 40 are drilled with PD05-4, 5, 6, 17, 18, 19, 20, 21 and 22 (PI-2). On the basis of data collected from these trenches, boreholes, mapping the resource and reserves are estimated as detailed below.

Resources are estimated for different depth according to the basis of depth wise intersections in the boreholes. Up to 100 m depth, two to three intersections are available including the surface trench data. Below 100 m depth and up to 150 m vertical depth, in most of the cases, only single intersections are available that too in a few sections. The resources are estimated for different depth as below.

1. From the lowest point of the lode on surface to 50 m vertical depth. Generally average RL of 50 m vertical depth is 175 m.
2. Resource estimation between vertical depth of 50 m and 100 m i.e. up to 125m average RL.
3. Resource estimation between vertical depth of 100 m and 150 m i.e. up to 75m average RL.

4. **Bulk density** is determined by taking average of 470 samples collected from mineralized zones and non-mineralized zone and that is estimated to 2.35.

The tonnage factor of the host rocks with varying concentration of graphite carbon mineralization and other non-mineralized rocks embedded in the lode have been determined. Determination of bulk density has been carried out in three parts.

1. Determination of bulk density irrespective of mineralization (A)
2. Determination of bulk density of mineralized part and samples are taken in such a way that the overall grade of samples is equal to weighted average of the deposit i.e. around 7.5% GC (B).
3. Determination of bulk density of the lode in saprolite portion or weathered zone (C).

In all 470 samples collected from ML-5 is as described below.

- (A) From 'A' zone = 222 samples were collected and average density is =2.65
- (B) From 'B' zone =148 samples were collected and average density is =2.31
- (C) From 'C' zone =100 samples were collected and average density is =2.08

Thus determined the average bulk density is 2.35, therefore for all the calculation purpose 2.35 is taken as tonnage factor.

2.7.2 Resource Classification

- A. Distance criteria to establish the measured, indicated and inferred mineral resource categories in ore bodies are given below.
 - i) Strike length influence considered either side of sample/ intersection (Fig.-4.4)

Measured Category	= up to 75 m
Indicated Category	= Beyond 75 m, 50m
Inferred Category	= Beyond 125 m, maximum up to 100 m.
 - ii) Dip length influence considering either side of sample/ Intersection (Fig.-4.5)

Measured Category	= Up to 50 m.
Indicated Category	= Beyond 50 m, 25 m.
Inferred Category	= Beyond 75 m, up to given RL.
- B. Resource classification was done qualitatively by inspection of the sample intercepts in relation to continuity of the ore zones.
- C. Continuity along strike is checked on the surface and by interpretation of borehole data.
- D. The dip length is estimated on the basis of intersection of boreholes, which are drilled for two to three levels.
- E. Lode correlation was carried out along strike and dip length.

2.7.3 Resource Statement

The resources are estimated for Measured, Indicated and inferred category according to above described depth wise.

The resources determine on JORC basis for CSB in ML-5 are tabulated in Table-4.8. Besides this some more samples were collected from gap area and analyzed from earlier drill holes and trenches and positive results were received.

Table-4.8 Depth and category wise details of resources of CSB Graphite deposit, Ruangwa, Lindi.

Category	Resources ton	Grade	Resources ton	Grade	Resources ton	Grade
	Vertical depth 0 to 50 m	% GC	Vertical depth 50 to 100 m	% GC	Total	% GC
Measured	26,664,536	8.16	13,114,923	7.29	39,779,459	7.87

Over all total Resource up to 100 m vertical depth = 39,779,459 ton with 7.87% GC

2.7.4 Reserves Estimation

The lodes of ML-5 graphite deposit are exposed on the surface and dip of lode and hill slope are in the same direction i.e. towards east, therefore this makes an ideal condition for open cast mining. Therefore the deposit will be mine by open cast mining method up to a vertical depth of 100 m vertical depth. Therefore reserves are estimated up to a vertical depth of 100 m from surface.

Conversion of the open pit resources into mineable reserve or Proved category reserves (JORC) is carried out by applying a 90% mining recovery factor and 5% dilution with a nil metal content. Here the graphite lodes contacts are easily recognizable with the naked eye therefore only 5% dilution factor is considered. Besides this the lode with less than 0.1% resources are not considered for reserve estimation. Here only measured category resources are considered for the conversion into reserve of Proved category of reserve for CSB, north block and south blocks are determined for only up to 100 m vertical depth in ML-5 area. The resources converted to reserve are tabulated in Table-4.9.

Table-4.9 Details of category, tonnage and grade of reserves of, ML-5 Graphite Deposit, Ruangwa, Lindi.

Resources of ML-5							
Sr.no.	Category	Depth 0-50m		Depth 50-100m		Total	GC%
	Proved	81,505,839	8.09	34,167,208	7.93	115,673,047	8.04

***Though due to dilution reserve quantity increased but here it is kept actual and dilution in the grade is considered and calculated. Total reserve of Proved category in ML 5 is 115,673,047 ton with 8.04% say 7.50 %GC (grade after dilution by 5%).**

CHAPTER - 3: MINE PLAN

The Central Sub Block contains the total Proved reserve of 39,779,459 ton with 7.50% GC up to the 100m vertical depth from the surface. In CSB, graphite lodes are 650m long and almost 440m wide on surface. Since CSB contain sufficient reserves of graphite with good grade and topography is favorable for open cast mining, therefore for first five years mining has been planned and that is detailed below.

3.1 PROPOSED OPEN CAST MINING METHOD

The company has a program to mine around 0.6 million ton of Graphite ore to produce 43,200 TPA of 85-95% graphite flakes at 90% recovery in ML-5.

Mining will be carried out by mechanized open cast mining method forming 6 m high and 10 to 15 m wide benches. In these sub blocks the dip of ore and hill slope is in the same direction i.e. towards east, therefore the mining will be easy. The dip of ore body varies from 25⁰ to 40⁰ with an average of 30⁰. Therefore eastern slope of mine will be at 30⁰ averages. The hanging wall sloping towards west will be kept at 45⁰ inclinations as the non-mineralized rocks are gneiss, marble and schist. The benches and haul roads will be at gradient not exceeding 1:10. The benches will be joined by 10 m wide ramps at 1:10 gradient. 2.7m³ shovel, 25 ton rear dumpers, 15 cm diameter wagon drill Bulldozers, 20 ton Motor grader, Tyre handler, 5 ton Fork-lift, 10 m³ capacity water sprinkler, 20 KL Diesel tanks etc. will be deployed.

Details of year wise Production plan of CSB, ML-5, Ruangwa.

Sr. No	Year	Central Sub Block in million ton	Total in million ton
1	Ist	0.6	0.6
2	IInd	0.6	0.6
3	IIIrd	0.6	0.6
4	IVth	0.6	0.6
5	Vth	0.6	0.6
	Total	3.00	3.00

3.2 PROPOSED RATE OF PRODUCTION

The exploration has established Proved reserves of 39,779,459 ton with 7.50% GC up to the 100m vertical depth from the surface. Here slope of hills and dip of ore body is almost same. However surface elevation varies from 350m RL to 210m RL, therefore 100 m vertical depth RL also changes. Here resources are determined up to 150 m vertical depth and reserves up to 100 m vertical depth, from the lowest RL where the ore is exposed on the surface. Further exploration is going on to determine the reserve up to vertical depth of 150 m. Besides this detailed exploration is continuing in South and North Sub Blocks, which will enhance the reserve. Per year mining of 0.6 million ton of

ore will produce 43,200 ton of 85-95% GC at 90% recovery. Subsequently, as per demand, production will be raised by mining in other blocks.

3.3 OPEN CAST MINING

During first five years, open cast mining will be carried out by mechanized method, deploying heavy earth moving machinery like 2.7 m³ capacity shovels having digging height of 6 meters, 25 ton dumpers and 150 mm diameter hole Drills. The ore zone up to the vertical depth of 10 m is highly weathered and soft, therefore up to that level the blasting will not be required. This has been also experienced while doing trenching and pitting in the area. The graphite schist, containing main ore zones, is soft therefore mild blasting will be required.

The benches will be of 6 meters height and 10 to 15 meters wide and will be connected by ramps having gradient of 1:10. Number of benches to be formed in the hanging wall and footwall will be 10 in number.

3.4 CONTRACTUAL MINING

Grafica Resources Limited Company is planning to go for contractual mining at Central Sub Block of ML-5 Block and to set up a central graphite processing plant with a capacity of 0.60 million ton ore processing to produce 43,200 tons of 85-95% GC concentration. To feed GC will be mined at CSB of ML-5. It is planned to mine the ore on contract basis and market survey indicated that there are mining companies who are available to mine the ore at the rate of USD \$4-8/per ton.

CHAPTER - 4: MINING AND PROCESSING SCHEDULE

Scheduling of the mining operation at site has taken into account the following main factors:

- (i) The climatic conditions of Ruangwa area, in which three months of December, January and February are wet months. During this time, minimal open pit mine activities will be taking place.
- (ii) Provision of time for major and minor services and maintenance of the mining equipment and the processing plant machinery. Out of 360 days of the year, sixty (60) days has been scheduled for major and minor maintenance of the processing plant machinery, public holidays and inconvenience that may arise. The remaining 300 days has been scheduled to run the wet section of the processing plant for 24-hours continuous operation based on three shifts of 8 hours each day.
- (iii) The mining will be operated for two and one shift of 10 hours (working hours 8) from Monday to Sundays. Processing plant shall be operated in 3 shifts. The 12 days of public holidays per year will be compensated during the three months of closure of the mine due to wet weather condition. The three months of rain have been taken out of schedules for mine production. The total number of working days for the mine is therefore limited to 300 days. Capacity of the mining equipment therefore will be sized to ensure enough stockpile is available to enable the processing plant consume 2,000 tons/day.

Total tonnage to be mined will be 0.6 million ton per annum.

- ◇ Total material to be mined (Ore + Waste) will be: 3.0 mt in 5 years.
- ◇ The Plant is designed for 8.0% GC ore and 600,000 ton per annum, therefore, ore blending (From CSB of ML-5) will be required after mining and before feeding to the Plant. Two full time Mining Geologist shall be appointed to supervise the mining operation and selection and checking of grades.
- ◇ Different pits shall be developed to produce 8.0% GC after blending the ore from different places in the mine. These shall be blended before feeding to the plant.
- ◇ Mine Foreman shall ensure timely production of each pits

4.1 PRODUCTION SUPERVISION

A mine foreman at mine of each sub block will be employed to control equipment and machinery, and to ensure that high productivity is maintained. They will work in close liaison with the senior management to ensure that field preparations are in place as required as regards roads, dumping areas, other access, stockpile sites, drainage arrangements, etc. Mine Foreman (MF) will ensure that the materials marked out in the alluvial as a result of the grade control exercise are accurately mined and delivered to the correct destination. They will work under the Mining Engineer.

4.2 CONSTRUCTION

A medium sized bulldozer will be necessary for road construction/upgrading and maintenance dump and stockpile and general mine site cleanup duties. For road maintenance, on both mining haul roads and those linking it with the main outlets, a motor grader will be required. Where road lengths are short, economies can be achieved by using a towed grader.

A towed water browser will also be necessary to maintain roads and working areas and to allay dust. To be effective a volume capacity of at least 10,000 liters is required.

4.3 WATER SYSTEMS

Make-up water will be pumped from underground aquifers using boreholes and submersible pumps. Borehole water will be supplied to the fire water tank and to the plant (floatation), and thereafter, following treatment, into the potable water tank. Potable water will be used at the camp site and will be supplied to the safety showers and emergency eyewash stations situated in the plant.

The fire water system will comprise of a tank, diesel-powered centrifugal pump with jockey pump and a network of fire water piping. Raw water, used for pump seals and process water makeup, will be supplied from the streams connected to the Mbwemkuru River. Pumps situated at the river will deliver water to the 100,000-m³ capacity water storage area.

Water collected in the tailings impoundment area will be pumped to the process water storage tank in the plant. Tailings overflow and raw water makeup will also feed the process water system. Process water will be distributed by pump from the storm water management pond and from the water storage dam.

4.4 PROJECT IMPLEMENTATION SCHEDULE

The graphite ore mining and beneficiation plant proposed at site near ML-5 Plant includes several permits including mining license renewal, land acquisition and getting derivative rights, vegetation clearance from forest department, ground water extraction permit from ministry of water, transmission line from TANESCO, Tailing Storage Facility permits etc. These are the several permits which are critical to the project implementation and schedule. Therefore a schedule is planned accordingly which shall start after the mining license renewal. Tentatively it will take 12 months to setup the plant and commence the mining operations.

CHAPTER - 5: ORE BENEFICIATION PLANT

5.1 DETAILS OF PLANT

The proposed plant in stages will be of capacity 0.60 million ton per annum in 5th year. Feed grade of ore: 8.0% Graphite carbon at 90% recovery producing 43,200 TPA finished graphite flakes.

- Recovery rate: 90%
- Final concentration: 85-95%

5.2 PLANT COMPONENT

5.2.1 Crushing Unit

This should have the following crushing systems

- a) Raw ore bin – This shall be made in civil
- b) Vibrating feeder
- c) Primary Jaw crusher
- d) Secondary Jaw crusher
- e) Cone crusher

5.2.2 Milling Unit

It comprises two parts

- a) Ball Mill
- b) Spiral Classifier

5.2.3 Beneficiation Unit

It is to concentrate the 7.50 % graphite ore to 85-95% graphite carbon by churning the graphite with water. It works at three stages.

- a) Rougher and Scavenger
- b) Re-rougher and Re-scavenger
- c) 11 Stage Flotation

5.2.4 Tailing disposal

There are two methods of tailing disposal

- a) Wet System: Tailing discharge is sent in wet form i.e. with water where the tailings are sent to tailing dams from where the water is again recollected. This system is adopted.
- b) Dry System: Tailing discharge is sent in dry form forming the cake. This system is not adopted as it is not economical

5.2.5 Concentrate De-watering and Drying Unit

The concentrates from floatation cells are dried in two stages which are then sent for packaging.

- a) Peeler Centrifuge: Here the concentrate moistures reduced from 70% moisture content to 22% moisture
- b) Dryer: The concentrate containing 22% moisture will be burned in the dryer at 700 degrees which will reduce the moisture to 1-2%.

5.2.6 Packaging and Warehousing

- a) Screening: The material will be screened into different sizes
- b) Packaging: The product will be packed in different bags of sizes from 25 kg to 1000 kg bags.
- c) Warehousing: These bags will be arranged in the big warehouses as per different specifications of the client.

5.3 OPERATION OF THE PLANT

5.3.1 Stock Yard

The raw material of different grades of ores shall be transported from the mine pits to the stock yard by dump trucks. These shall be stock piled before the raw ore bins and stock piles shall be made according to the grades of ores. This stock yard shall have capacity to store around 360,000 tons which shall store ores from ML-5. A wheel loader shall be placed here which shall collect the ores from the pile, blend them in the dump truck and shall be further fed into raw ore bin. Ore blending shall be done to make an average of 7.50% GC.

A slope of 200 m length of 3.2° gradient shall be made till the top of the raw ore bin.

5.3.2 Raw ore bin

A Raw ore bin shall be constructed in civil with RCC structure which shall have the capacity to hold 1000 Tons of ore in it. The ore shall be dumped by the trucks on the rail grid which is of 7 m x 7 m having beams spacing 350 mm x 350 mm grids. This is placed so that the big rock boulders of over 350 mm should not pass from the grid. In case there are big boulders, then a rock breaker, placed near the raw ore bin shall break it into small pieces.

The rail grid is in placed on the top and the material is stored in the middle of the raw ore bin. The ore bin is designed as a sturdy RCC structure having one side vertical edge and another side having a slope of 50° to give the natural push to the ores stored in.

Below the bin, a Vibrating feeder of capacity 200 Tons per hour (TPH) is placed which shall take feed from the bin and supply the ore to the primary crusher.

5.3.3 Crushing Unit

The main purpose of the crushing plant is to crush the rock boulders into small 6 mm pieces and feed to the ball mill. This entire plant is connected with belt conveyors.

Primary Jaw Crusher

The capacity of the primary jaw crusher is 192 TPH. The raw ore input size is 350 mm. output size will be from 75 to 200 mm. The dimension of the crusher will be 2400 (L) x 2300 (w) x 2400mm.

Double Deck Vibrating Screen

The primarily crushed ore directly fed on to the double deck vibrating screen, having the capacity 780 TPH and the spacing in the screen/deck will be 200x 200 mm. This material is conveyed through conveyor belt in a closed loop. The under size (<200 mm) of the double deck screen is directly fed on to the conveyor no.3 and transported in to the fine ore bunker in a closed loop.

Secondary Jaw Crusher

The oversized (>200 mm) material pass on to the secondary jaw crusher having the capacity will be 120TPH. The input and output size of the ore in secondary jaw crusher is 250mm and 90 mm respectively. The output size of the secondary jaw crusher is 90 mm, is directly fed on to the conveyor no.2 in a closed loop and directly pass on to the cone crusher through conveyor belt.

Cone Crusher

The output from secondary jaw crusher 20-90 mm is directly fed into the cone crusher which has the capacity of 130TPH. The output size of the cone crusher is 6-30mm is fed on to the conveyor no. 1 and conveyed to the double deck vibrating screen along with crushed material from the primary jaw crusher in a closed loop.

From Jaw Crusher, crushed material shall be fed to a coarse ore stockpile of 20,000T capacity. This Stockpile will have extraction openings beneath it with extraction feeders. Material from the Coarse Ore stockpile shall be extracted by virtue of gravity and extraction by apron feeders and extracted material shall be fed to Double-Deck round vibrating screen by a set of Belt Conveyors.

This double deck vibrating screen will have capacity of maximum 780 TPH with Mesh size of 20 mm x 20 mm. The under size of the double deck screen is directly fed on to the Conveyor No.3 and transported to Fine Ore Stockpile of 20,000T capacity while oversized material pass on to a Cone Crusher of 200 TPH. The output size of this Cone Crusher will be max 20 mm and output material shall again fed to feeding conveyor to Double Deck Vibrating Screen, through a return Belt Conveyor.

Cone Crusher is commonly used to crush both hard and medium hard materials, the main parts of the cone crusher are transmission device, crushing cone, bowl-shaped bearing, frame and hollow eccentric shaft.

Material from the Fine Ore stockpile shall be extracted by virtue of gravity and extraction by apron feeders and extracted material shall be fed to Mill & Beneficiation Plant by a set of Belt Conveyor.

5.3.4 Milling Unit

Milling (grinding) makes the sizes of the fine ore into microns to make the feed for flotation cells. As graphite is resistant to weathering, it may often be pre-concentrated in graphite-bearing soil, but with graphite-bearing rock, the graphite needs to be liberated.

Ball mill is the key equipment to mill the fine ores into small microns. The recovery of bigger flakes is the ultimate target of this plant along with the desired 85-95% C grade. For better recoveries of grades, the material needs to be milled more but in that case the bigger flakes are also compromised.

This plant has been carefully designed to avoid minimum breakage of the bigger flakes and achieve higher recoveries of graphite concentrate. There are number of factors which are taken care of like the optimization of the ball size, RPM of the ball mill flow rate of the material etc. Based on this optimization, ball mill is designed accordingly.

Milling unit consists of two main equipments:

a) Primary Ball Mill

It is around steel cylindrical structure mill constructed in vessel lined. Inside of this has manganese steel liners having the thickness of 40mm to 80mm and has the effective volume of 11.8 m³ with maximum load of balls is 26 ton at a time. The various sizes of the ball used inside the ball mill as a grinding medium. The wet grinding system is adopted here having the advantages of less power consumption and less dust emissions.

The purpose of this ball mill is to grind the fine ores to small fractions using big balls and high energy index.

b) Spiral Classifier

An automatic elevating apparatus is added to the discharge opening of the Ball Mill. Fine ore pulps are fed into water tank through feeding opening located in the center of settling zone. Beneath the inclined water tank is the ore pulp classification zone where ore pulps are stirred by low-speeded impellers. Fine ore particles are lifted up and then spilled out the overflow. To secure a controlled turbulence in the slurry flow for accurate size separation the proper combination of pool depth, area and spiral construction is important.

c) Secondary Ball Mill

This ball mill is for regrinding of middling's i.e. rougher concentrate, to get more complete liberation of the valuable minerals. The rougher concentrate is often subject to further grinding (usually called regrinding) to get more complete liberation of the valuable minerals. Because it is a smaller

mass than that of the original ore, less energy is needed than would be necessary if the whole ore were reground. Regrinding is often undertaken in secondary Ball Mills, designed to further reduce the energy consumed during regrinding to finer sizes.

5.3.5 Beneficiation Unit

The up gradation of the ore of 7.50% C to the finished product of 85-95% C is done in this process. Since the graphite is hydrophobic and the purpose of the beneficiation is to separate graphite from silica and other heavy minerals and gangue material, therefore milled ore is mixed with water along with other reagents and then sent to flotation cells for flotation. Graphite having lighter specific gravity than silica and other heavy minerals, also due to its hydrophobic properties, it mixes with the reagents, the impeller churns the mixed water and graphite floats on top of the cells where it is scooped away to further floatation cells. This is a continuous process and requires lot of water and flotation for better grades.

1 Rougher + scavenger, 1 re-rougher + re-scavenger and 11 floatation cells shall be used to achieve 85-95% CG material. The following steps are followed after grinding to liberate the mineral particles:

The detailed flotation stages are as follows:

a) Rougher and Scavenger Cells

- The first Flotation stage is called roughing, which produces a rougher concentrate.
- The objective is to remove the maximum amount of the valuable mineral at as coarse a particle size as practical. The finer an ore is ground, the greater the energy that is required, so it makes sense to fine grind only those particles that need fine grinding.
- Complete liberation cannot be done in rougher flotation; only sufficient liberation is done to release enough gangue from the valuable mineral to get a high recovery.
- The rougher flotation step is followed by a scavenger flotation step that is applied to the rougher tailings. To recover the target minerals that was not recovered during the initial roughing stage.
- Around 80% of the ore will go into the tailings, where it is pumped by tailing pumps to the tailing dams.

b) Re-rougher and Re-scavenger Cells

- The Re rougher flotation step is followed by a scavenger flotation step that is applied to the rougher tailings and the middlings.
- The objective is to recover any of the target minerals that were not recovered during the initial roughing stage. This might be achieved by changing the flotation conditions to make them more rigorous than the initial roughing, or there might be some secondary grinding to provide further liberation.

- This is a closed loop after the rougher and before cleaner 1 cell

c) Flotation Cells

Air-Inflation cells are a large mixer and used diffuser mechanism at the bottom of the mixing tank to introduce air and provide mixing action. The counter current motion of the slurry flowing down and the air flowing up provides mixing action. The air bubbles must adhere to the desired minerals to elevate them to the surface of the slurry while wetting the other minerals and leaving them in the aqueous slurry medium.

Cleaning cells also take advantage of gravitational forces to improve separation efficiency. The collectors, frothers, and modifiers are added to separating the minerals from the slurry, later these minerals must be purified from the additives used in separation.

For froth flotation, the ground ore is mixed with water to form a slurry and the desired mineral is rendered hydrophobic by the addition of a surfactant or collector chemical. This slurry (more properly called the pulp) of hydrophobic particles and hydrophilic particles is then introduced to tanks known as flotation cells that are aerated to produce bubbles.

The hydrophobic particles attach to the air bubbles, which rise to the surface, forming froth. The froth is removed from the cell, producing a concentrate of the graphite. The reagents are introduced to the pulp to promote the formation of a stable froth on top of the flotation cell.

There are total 11 flotation cells in this unit to achieve 85-95% C grade.

d) Sand Mills

Between each flotation cells, sand is provided whose purpose is to rub the concentrate and then sent to another one. The sand mills is used here as the ceramic balls used as a medium for cleaning is the safest and gives light impact on the flakes of graphite.

5.3.6 Dewatering and drying Unit

The concentrate of 85-95% C grade is dewatered using various processes. Utmost care is taken so as no contamination of dust, breakage of flakes are done. There are 2 processes involved in this unit.

a) Peeler Centrifuge

Traditionally filter press was being used to take out the maximum water amount out of the concentrate, but it is a very untidy process and needs regular maintenance. Peeler centrifuge is used here in this plant which shall dewater the concentrate and leaves around 21-25% moisture in the concentrate. This concentrate is then further sent to rotary dryer by a screw conveyor.

b) Rotary Dryer

The wet concentrate of 85-95% C grade having moisture of 21-25% is then dried in a rotary dryer at 700° C. A Gas burner shall be used in this unit to create the flames which will blow away all the

moisture from the concentrate. After this process, the moisture level comes to 1-2%. From here the product is then sent for screening and packaging.

5.3.7 Packaging and Warehousing Unit

Screens of different flakes sizes shall be used here. The material is sent here from the dryer screened as per the sizes and then they are packed in 1 ton jumbo bags.

These bags will be sent to the warehouse where they will be kept as per different grades, sizes and as per special requirements of the customers.

A ware house shall be built to take up to 2 months of finished stock. It is planned to make a shed of about 4,050 square meters.

5.4 RUN OF MINE (ROM) ORE STOCKPILE

Ore will be stocked according to the variation of grades on the ROM pad so as to allow blending of ore. However, before the rainy season, mining operation will be done in two shifts so as to have stockpile of minimum 0.36 mt (sufficient for 90 days for plant feed). This will be worked on during the intense rainy season when access to the pit will be limited.

5.5 GRADE CONTROL AND RECOVERY ESTIMATE

The grade and beneficiation and recovery study has been carried out by NGS, ActLab, and in SGS, South Africa (Annexure-I) indicated the graphite is of medium grade and recovery of the order of 85-95%. The grade block model produced during this study will be sufficient to indicate the general areas of high and low-grade mineralization and waste within the ROM pad and pit. The dumping will be divide in three phase, low grade, medium and high grades.

Jinpeng Institute of Metallurgy Yantai, China carried out tests and that is 97.76%. However, for the purposes of estimating the operating recoveries, the test on ore has been done in India using floatation technique at three levels. The results are found satisfactory. The China Company and Plant supplier has indicated experimentally that the recovery with more (9 cycle of washing and rerunning) cycle as plant designed is 95% with 85-95% GC concentration.

5.6 PLANT OPERATION

The process plant will be operated and maintained by local suitably qualified staff, under the direction of the engineering manager, according to procedures detailed in the maintenance manuals which will be supplied with all installed equipment. A database will be developed to facilitate planned maintenance. All staff will use proper lock-out and safety procedures when working on plant equipment. In total, it is envisaged that the plant will have over 88 full time staff including specialist.

5.7 TAILINGS MANAGEMENT

Tailings are the materials left over after the process of separating the valuable fraction from the uneconomic fraction of an ore. Tailings are typically small and range from the size of a grain of sand to

a few microns. Mine tailings are usually produced from the mill in slurry form. In order to prevent the uncontrolled release of tailings material into the environment, mines usually have a disposal facility which quite often takes the form of a dam or pond. This is a convenient method of storage since tailings are often in the form of slurry when they are discharged from the concentrator. Considering that the tailings dam hosts effluents such as Kerosene, Reagents, heavy minerals, etc., its location must be carefully selected and built to avoid seepage to the ground water resources and discharges to the surrounding environment. The siting considerations for the most favorable site for construction of a tailings dam are. The details are described in section 6.3.

5.8 PLANT WORKSHOP

A plant workshop will be constructed, together with an attached engineering store area, to ensure that proper facilities are available for engineering maintenance. All critical spares will be stored in a locked lay down area and will be inspected regularly to ensure readiness and completeness. Back up spares will be provided for all critical and long delivery items. Maintenance will be assisted by qualified agents.

CHAPTER – 6: ENVIRONMENTAL MANAGEMENT PLAN

Mining activities will have definite impact on environment therefore remedial measures will be taken to eliminate the ill effect or minimize to the extent possible.

6.1 Management of Air Pollution:-

(A) DRILLING: -The major source of dust production in the mine is drilling, blasting and vehicle movement. Drilling will be done by wet drilling method by providing water injection system and also dust extractors which are fitted at the collar level to collect the dust. Dust extractors will be cleaned regularly to maintain their efficiency.

(B) BLASTING:-Continuous work on improving the powder factor will be done to produce minimum quantity of dust. Similarly, drilling pattern will be adopted which produces minimum fines.

(C) MUCKING:-After blasting, the muck will be sprayed with water so that fines become wet and will not rise during mucking.

(D) GRINDING:-Before the mineral is fed to the crusher and grinding unit, water will be sprayed to quench the dust.

(E) TRANSPORT:-The haul roads will be sprayed with water by water tankers, three to four times a day, so that the fines lying on the haul road become wet and will not be raised by movement of dumpers or trucks.

(F) MONITORING:-For monitoring the dust concentration (SPM) in the air at various points quarterly, adequate no. of High Volume Air Samplers will be procured. One for two pits and air samples will be collected at the following points:

1. Mine office
2. Each pit rest shelter
3. Colony entrance
4. Haul road entrance to each pit

Monitoring will be done quarterly.

6.2 Water Pollution Control Measures

Water is required at the mine for spraying on roads, muck and domestic use. The water sprayed on roads gets soaked on road and that on muck is in a very small quantity which wets the muck and gets evaporated within few hour of dumping in dump yard.

Domestic water will be discharged as waste in the mine office or colony. It will be treated in septic tank and soak pits to be provided in adequate numbers in office premises and in the staff colony.

6.3 Management Of Noise Pollution

The noise produced by machinery will be minimized by the following measures:-

- a) Proper maintenance of all machinery,
- b) Only trained operators will be allowed to operate,
- c) All machines will be used at optimum capacity,
- d) Plantation of trees around grinding units, haul roads will be done to minimize the noise,

- e) Monitoring will be done quarterly,
- f) Workers and operators working new D.G. Sets, Crushers and Drilling sites will be provided with ear muffs.
- g) The monitoring of noise level will be done quarterly at Mine Office, Pit Shelter and Haul road entrance to pits.

6.4 Management of Top Soil

Before drilling and blasting near the surface, the top soil layer will be scrapped and stacked on a ground level and will be used for plantation every year if suitable for the same.

6.5 Management of Land By Reclamation And Rehabilitation

The deposits of graphite is sufficient for more than 30 years period, hence reclamation of pits will be done after about 30 years by back filling with overburden from the dumping yard. However this resource is expected to increase more pertaining to further detailed exploration which shall be done on timely basis leading to increase in deposit life. The top soil stacked and available at that time will be laid over the fill to convert it into agricultural or social forestry use. In present 5 year planning the mining will be done on hill slope surface only.

6.6 Management of Dumps

The dumps will be provided with stonewalls with 2 m height all around except the haul roads to check the rolling of boulders. After the second lift is started, the slope of the first lift will be planted with shrubs for its stabilization.

6.7 Management of Flora And Fauna

The area is devoid of water body. The area falls in tropical region, which supports in the growth of vegetation. Minimum cutting will be done and from 1st year itself plantation will be done to maintain the ecosystem around the mine area. Mostly mining activity will be done during day time therefore wild animals will not be disturbed. Besides this there is no water body therefore wild animals do not come this side as water available far below the present area towards NE. In day time hare, fox and birds are seen in the area

6.8 Afforestation Program

During five years about 500 saplings of local varieties of trees will be planted every year at the following places (Table-9.6)

a) PLANTATION BEYOND 5th YEAR

Plantation will be carried out at the foot of the dump and slope every year by using local shrubs. 100 trees will be planted along the periphery, non mineralized zone and along the slope of mine which is gentle and terrace type every year.

b) POST PLANTATION CARE

Post plantation care will be an important aspect to be taken care for better survival rate of plantation. The following care will be taken:-

(I) Protection from Grazing and Fire: Fencing will be provided around the area where mass plantation has been proposed. These fencing will comprise of 1.5 m high fencing wire and at places stone wall. This will help in preventing and protecting from unauthorized entry of outside person and fire. Due care will be taken to protect plantation as well as the fencing.

(II) Watering During Dry Spell: During dry spell, water will be sprinkled using water tanker provided with 20-30m long hose pipes.

(III) MANURING: Initially, fertilizer /manure will be given to the pits before and after plantation. Thereafter manuring will be continued on reduced scale till the plant attains growth of 2 to 3 m height. Provision of utilizing bio-manure will also be made within the lease area.

(IV) WEEDING AND SOIL WORKING: Man power will be engaged in mulching the soil frequently along with removal of weeds.

(V) REPLACEMENT OF CAUSALITY: About 20% of saplings are unable to adjust at a new habitat and some are destroyed away by animals. It is essential to replace the causality regularly.

6.9 Protective Measures for Ground Vibration

Drilling will be done by using 155 mm diameter wagon drills on 6m X 3m X 2.5m pattern and blasting in three rows, maximum number of 60 holes will be blasted per round using delay detonators for each row to dampen vibration of row blasted first. The pattern and delay will be monitored to obtain the result that will provide minimum vibration. Since villages are far away from proposed pits, the vibration will not affect the houses.

6.10 Socio-Economic Benefits

The nearby area is covered by scanty population and they depend on agriculture and animals. The study of the buffer zone reveals that the area is moderately backward where majority of people depend on agriculture. The area will provide job to around 30 workers in first year and that will increase to 50 employed for mining work and other work earning 3 to 5 USD per day for unskilled and semi- skilled persons as against 5 to 7 USD per day. Technical and other qualified people will earn much more than the above wage.

Schools, private as well as Government, will run in the buffer zone. Market, Carpentry, Black-smithy and vehicle repair shops will come up giving indirect employment to a large number of persons. Thus, the mining will benefit directly and indirectly about 1,000 persons in the area.

The EIA carried out by Jones Philemon Mushi during 2022 indicated that there will be more positive impact and growth due to coming of mining industry in the area rather than negative impact. However, negative impact can be minimized or removed by taking proper care.

CHAPTER-7: STAFFING REQUIREMENTS

7.1 Total Personnel Requirements

7.1.1 Mining Contractor

Quotes from mining contractors indicate a total of approximately 20 - 30 workers.

7.1.2 Mine Supervisory, Process Plant and Other Personnel

GRL estimates that its workforce will amount to 125 persons, including expatriates.

These personnel will be employed in mine management, process management and operations, and administrative positions.

Including those employed by the mining contractor, the total personnel complement for the Ruangwa project, under steady-stage operating conditions, is estimated at approximately 150-200 people.

7.1.3 Construction Personnel

GRL forecasts that a peak of 150 construction management and contract people will be on site during the construction of the processing plant and project infrastructure.

7.2 Training Programs

Training and professional development programs will be installed at Ruangwa. One of the primary aims of these training programs is to employ and continuously train Tanzanian staff, with the objective of developing them into future senior managers of the Grafica Resources Limited or other Tanzanian mining organizations. Areas that will be covered by the professional training programs include:-

- Health, safety and environmental awareness training;
- Training and development of all employees;
- Operator training and multi-tasking;
- Graduate training;
- Supervisor training; and
- Blasting training.

Professional development programs will be open to all employees within the organization but will be primarily directed towards the development of national employees to higher levels of professional competence and qualification. The type of profession development programs that will be available include:

- **Practical skill advancement.** This will result in selected employees being given the opportunity to develop increased levels of skill and advancement in their existing classification or job.
- **Higher level educational development.** This will apply to employees who work in a position requiring a higher education or academic standards. Examples include geologists, surveyors, metallurgists and engineers.

Tanzanian personnel will be trained in the operation and maintenance of mining and process equipment, and in administrative functions.

CHAPTER-8: FINANCIAL APPRAISAL

8.1 Grafica Resources Limited (GRL) plans to set up a 43,200 TPA graphite beneficiation plant in Tanzania. The capital expenditure for the proposed project works out to around **USD 46 million**. The estimated project cost has been based on the requirement of fixed and non-fixed assets. The details of capital expenditure are shown in **Table 8.1**, which also indicates the mode of financing.

Table 8.1: Capital Expenditure

Item	Amount USD Mn
Land and Site Development	3.740
Building and Other Civil Structures	11.882
Plant and Machinery	12.056
Miscellaneous, Fixed Assets	3.473
Equipments for Power Distribution	4.138
Pre-Operative Expenses	4.500
Working Capital Requirement	6.000
Total	45.788

FINANCIAL ANALYSIS

S. No.	Item	Value
1.	Post-Tax IRR on total investment (%)	23.88%
2.	Pay Back Period	4 - 5 Years

Grafica Resources Limited, Tanzania						600,000 TPA Graphite Ore Input Plant					
Projected Financials of Graphite Beneficiation & Processing Plant											
ECONOMIC PARAMETERS		Grade of Finished Flake Graphite	95% C Content			2,000 TPD	Beneficiation				
		Royalty for Graphite (%)	3% + 2.9%								
Average Grade of Graphite in Ore		8.0%	Average Inflation Rate	5%	43,200 TPA Finished Graphite Flakes Production						
Average Grade of Graphite in Ore											
Graphite Recovery Rate		90%									
GRAPHITE BENEFICIATION PLANT						90%	95%	100%			
Year		Year 1	Year 2	Year 3	1	2	3	4	5	10	
Graphite Ore Mine Production (tonnes)		540,000	570,000	600,000	540,000	570,000	600,000	600,000	600,000	600,000	
Graphite Content in Ore Mined (In-situ)	Grade	8.0%			43,200	45,600	48,000	48,000	48,000	48,000	
Total Finished Graphite Flakes (95% C)		90% Recovery			38,880	41,040	43,200	43,200	43,200	43,200	
TOTAL SALES		\$703	38,880	41,040	43,200	\$27,332	\$30,294	\$33,482	\$35,157	\$36,914	
Less: Brokerage, Commission, Marketing, Advertisement etc on	5% of Sales					\$1,367	\$1,515	\$1,674	\$1,758	\$1,846	
LESS COSTS											
GRAPHITE BENEFICIATION PLANT (\$ 000)											
		Quantity - Tons per Annum			Amount in USD in Thousands ('000)						
		Year 1	Year 2	Year 3							
(A) Graphite Ore Cost	14.15%	\$4.00	540,000	570,000	600,000	\$2,160	\$2,394	\$2,646	\$2,778	\$2,917	
Cost of Ore on Finished Concentrate	\$61										
(B) ADMINISTRATION COSTS	7.79%				\$1,322	\$1,388	\$1,457	\$1,530	\$1,606	\$2,050	
Cost of Administration per ton on Finished Concentrate	\$34										
(C) PROCESSING PLANT OPERATING COSTS	58.74%				\$9,029	\$9,974	\$10,985	\$11,440	\$11,917	\$14,650	
Cost of Production per ton of Finished Concentrate	\$254										
(D) OTHER MISC COSTS	19.32%				\$3,060	\$3,327	\$3,613	\$3,794	\$3,983	\$5,084	
Cost of Misc. per ton of Finished Concentrate	\$84										
TOTAL DIRECT OPERATING COSTS (A+B+C+D)	100.00%				\$15,570	\$17,083	\$18,701	\$19,542	\$20,424	\$25,508	
	43.2 K			43.2 K TPA							
GRAPHITE BENEFICIATION PLANT											
		Year 1	Year 2	Year 3	Total						
(F) COST OF PROJECT	Amount in USD Thousand ('000)										
Land and Site Development	\$3,740	\$0	\$0	\$3,740							
Building and Other Civil Structures	\$11,882	\$0	\$0	\$11,882							
Plant and Machinery	\$12,056	\$0	\$0	\$12,056							
Miscellaneous Fixed Assets	\$3,473	\$0	\$0	\$3,473							
Equipment for Distribution of Power	\$4,138	\$0	\$0	\$4,138							
Pre-Operative Expenses	\$4,500	\$0	\$0	\$4,500							
Working Capital Requirement	\$6,000	\$0	\$0	\$6,000							
Total Capital Cost	\$45,788	\$0	\$0	\$45,788							
GRAPHITE BENEFICIATION PLANT PROFITABILITY											
Graphite Beneficiation Plant EBIT					\$10,395	\$11,697	\$13,107	\$13,856	\$14,645	\$19,250	
Total EBDIT					\$10,395	\$11,697	\$13,107	\$13,856	\$14,645	\$19,250	
Less: Depreciation					\$7,958	\$7,958	\$7,958	\$7,958	\$7,958	\$0	
Less: Interests on Working Capital Loan		Avg. Rate	6.0%		\$360	\$360	\$360	\$360	\$360	\$360	
Less: Interests on Term Loan		Avg. Rate	6.0%		\$2,387	\$2,207	\$1,727	\$1,247	\$767	\$0	
Profit Before Tax (EBT)					(\$310)	\$1,172	\$3,062	\$4,291	\$5,560	\$18,890	
Less: Taxes @ 30%		Rate	30.0%		\$0	\$352	\$919	\$1,287	\$1,668	\$5,667	
Profit After Tax					(\$310)	\$820	\$2,144	\$3,004	\$3,892	\$13,223	
Less: Government's Equity @ 16%		Rate	16.0%		\$0	\$131	\$343	\$481	\$623	\$2,116	
Net Profit					(\$310)	\$689	\$1,801	\$2,523	\$3,269	\$11,107	
Add: Depreciation					\$7,958	\$7,958	\$7,958	\$7,958	\$7,958	\$0	
Cash Profit Available for Repayment / Appropriation					\$7,648	\$8,647	\$9,758	\$10,481	\$11,227	\$11,107	
Less: Repayment of Term Loan					\$0	\$8,000	\$8,000	\$8,000	\$8,000	\$0	
Net Cash Surplus					\$7,648	\$647	\$1,758	\$2,481	\$3,227	\$11,107	