THE UNITED REPUBLIC OF TANZANIA
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TANZANIA MINERALS AUDIT AGENCY (TMAA)

A Study on Viability to Construct a Copper Concentrate Smelter in Tanzania

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EXECUTIVE SUMMARY

Bulyanhulu and Buzwagi Gold Mines are two unique gold mines in Tanzania due to the fact that gold and silver are found embedded in pyrite and chalcopyrite. Two processing methods are mainly employed to recover gold and silver from the ore, which are gravity and froth flotation. Gravity method produces gold bars while froth flotation method produces Copper Concentrate. Bulyanhulu Gold Mine (BGM) commenced production in April 2001 with a minimum mine life of 24 years while Buzwagi Gold Mine (BZGM) commenced production in May 2009 with a minimum mine life of 10 years.

BGM produces and exports abroad between 25,000 and 50,000 tonnes of Copper Concentrate annually for smelting and refining to recover gold, silver and copper. On the other hand, BZGM produces about 10,000 tonnes of Copper Concentrate per annum. However, other possible by-products (if any) are not declared by the miner.

This study has revealed that most of the Copper Concentrate producers in the world similar to that produced in Tanzania do not have their own smelters, but rather they export their concentrates mainly to China and Japan for smelting and refining. The study has also revealed that most of the constructed Copper Concentrate smelters in the world have feed capacities greater than 150,000 tonnes per year and their total construction costs exceed USD 500 million.

The study has also revealed that most of the imported Copper Concentrate by the world's leading copper smelters contains relatively higher quantities of payable minerals than that supplied by BGM and BZGM.

For example, Copper Concentrate supplied by Escondida (the largest Copper mine in the world) has the following composition: Copper - 36%, Gold – 0.0002%, Silver 0.0045%, Iron - 20%, Sulphur - 32% and Mercury - 1%. On the other hand, the average composition of Copper Concentrate supplied by BGM and BZGM to China and Japan is as follows: copper – 15%, gold – 0.02%, and silver – 0.02%.

This study was mainly focused on the determination of the viability of constructing a copper smelter in Tanzania so as to be used to process Copper Concentrate produced by BGM, BZGM and that to be produced by other mines in future. The following are the findings and conclusions:

1. A commercially viable Copper Concentrate smelter requires a feedstock of not less than 150,000 tonnes per year. At full capacity, BGM and BZGM can produce 60,000 tonnes of Copper Concentrate annually, which would only account for 40% of the capacity of a viable copper smelter. Additionally, there is currently no commercial-scale proven technology, which is suitable for small scale Copper Concentrate smelting of less than 100,000 tonnes per year, but this matter continues to be investigated.

2. In order to construct a viable smelter in Tanzania, it would require importing 60% of Copper Concentrate to feed the smelter, or Tanzania would have to increase its own production of Copper Concentrate through the development of new mine(s) of similar production technology to that of BGM and BZGM. However, there are currently no known copper sulphide deposits in Tanzania, which could add significantly to the Copper Concentrate requirements to feed the smelter to be constructed.

3. If a Copper Concentrate smelter was to be built relying on imported Copper Concentrate as the primary feedstock to meet smelter minimum annual requirement, then such a smelter would find itself competing against the world leading Copper Concentrate smelting merchant market on a price basis and probably attempting to win market share in the higher growth copper markets of the Far East.

4. A Copper Concentrate smelter of a feedstock of not less than 150,000 tonnes per year would cost between USD 500 million and USD 800 million to construct complete with sulphuric acid plant for purification of fugitive gases emitted from the smelter furnace. This is a substantial investment project. Most planned new Copper Concentrate smelters in the world are in non-free market economies and are heavily supported by local governments directly or indirectly through tariffs.

5. Cost and availability of reliable supply of electricity is a key to deciding to erect a copper smelter. However, electricity is currently quite expensive in Tanzania and the existing capacity does not meet the requirements to run a large copper smelter. For example, electrical energy requirement at Toyo Smelter in Japan is to the tune of 1.53MWh per dry metric ton of Copper Concentrate.

The study concludes therefore that it is currently not feasible for a copper concentrate smelter to be constructed in the country to smelt and refine Copper Concentrate produced by BGM and BZGM.

1.0 REPORT OBJECTIVES

The main objectives of this report are as follows:

1. To provide historical background and statistics of Copper Concentrate production and export at BGM and BZGM; and

2. To study and provide a professional opinion on the viability of constructing a smelter in Tanzania so as to process Copper Concentrate produced at BGM and BZGM.

2.0 METHODOLOGY

1. In order to arrive at the findings and recommendations of this report, a comprehensive literature review was undertaken as well as data collection and analysis. Information contained in this report has been gathered from sources believed to be reliable. However, the use of information that has been sourced from the internet is strictly your own responsibility.

2. BGM and BZGM, which are the only mines currently producing and exporting Copper Concentrate were visited to witness production, loading of the concentrates into containers, sampling and sealing of loaded containers ready for transportation to China or Japan for smelting and refining.

3. A study tour to Toyo and Saganoseki Copper Concentrate smelters in Japan was conducted in order to learn the transactions of Copper Concentrate exported by BGM and BZGM to Japan and familiarise with technology involved in processing Copper Concentrate. The tour was also aimed at understanding investment cost involved in the construction of such smelter, their capacities and major operating expenses.

3.0 BACKGROUND INFORMATION

3.1 Bulyanhulu Gold Mine

The Bulyanhulu Gold Mine, owned by Barrick Gold Corporation is located 45km south of Lake Victoria or 65 km north of Kahama town in northern Tanzania. The geology of BGM area consists of mafic volcanic flows overlain by a series of

pyroclastics and ash tuffs. Argillite is present at the contact between the mafic and felsic rocks.

The gold, silver and copper mineralization on the property occurs in mineralized reefs or quartz veins localized along steeply dipping northwest striking structures, generally localized in the argillite units. The rock in which economic minerals are found is universally called 'ore'. BGM ore is a complex ore consisting of chalcopyrite, chalcocite, bornite and pyrite. Gold and silver are found embedded in pyrite and chalcopyrite.

3.2 Buzwagi Gold Mine

Buzwagi Gold Mine (BZGM) is located in the Kahama District - Shinyanga Region. The mine is 6 km southeast of the town of Kahama. BZGM is wholly owned by Pangea Mineral Ltd, which is a subsidiary of Barrick Gold Corporation.

Mineralization at BZGM occurs in shear zones within host rocks. Gold mineralization occurs in association with sulphides (pyrite) and quartz, and as free grains while copper mineralization occurs as primary sulphides (chalcopyrite).

3.3 Processing Method

Three mineral processing methods are mainly employed at BGM and BZGM to recover gold from the ore, which are gravity, froth flotation and carbon-in-leach (CIL). Copper Concentrate at BGM and BZGM is recovered through froth flotation process, accounting for approximately 60% of the gold produced. Gravity and CIL recovery accounts for the remaining 40%. The production of gold bars and Copper Concentrate at BGM and BZGM started in April, 2001 and May, 2009 respectively.

Copper Concentrate comprises of the following major products: copper (average assay 15%), gold (average assay 0.02%) and silver (average assay 0.02%), copper being in higher concentration than the rest, hence the product named Copper Concentrate.

4.0 CURRENT PRACTICE

The nature of gold ore determines the process to be used to extract gold. Ores extracted at BGM and BZGM are sulphide in nature whereby gold is locked in complex compounds with copper and silver, which cannot be separated from the waste rock by Carbon-In-Leach/Carbon-In-Pulp (CIL/CIP) method; hence require froth floatation technology for economic recovery of gold and silver.

Froth floatation technology results in the production of Copper Concentrate as part of its gold processing. On the other hand, Geita Gold Mine, North Mara Gold Mine, Golden Pride Mine and Tulawaka Gold Mine have oxide ore type which requires CIL/CIP process in gold recovery.

Currently, BGM and BZGM produce about 60,000 tonnes of Copper Concentrate per annum. Copper Concentrate produced in Tanzania is normally exported either to Marc Rich Investment (China), Sumitomo Metal Mining Co. Ltd (Japan), Pan Pacific Co. Ltd (Japan), or Aurubis AG (Germany) for smelting and refining. Copper Concentrate from Tanzania is blended with concentrate from other countries before undergoing smelting and refining. Products obtained after refining are copper, gold and silver as reported by BGM and BZGM. However, there are other common by-products such as Platinum Group Metals (PGMs), sulphuric acid, nickel sulphate, crude nickel sulphate, selenium, tellurium, copper sulphate, iron, lead, zinc and slag. These products are normally beneficial to smelter owners.

Questions are being asked as to why Copper Concentrate producers in Tanzania are not building their own smelters in the country. BGM's response is as follows[1]:

1. Analysts have proven that a Copper Concentrate smelter requires a feedstock of not less than 150,000 tonnes of Copper Concentrate annually to make it economically viable;

2. A copper smelter of this size would cost between USD 450 million and USD 600 million to construct, together with a sulphuric acid plant for purification of fugitive gases emitted from the smelter furnace;

3. At full capacity, BGM's production ranges between 25,000 and 50,000 tonnes of Copper Concentrate a year over the life of the mine, which would only account for 16% to 33% of the capacity of a viable copper smelter;

[1] *BGM Information Pack, October 2003*

4. In order to construct a viable smelter in Tanzania, it would require to import 67% to 84% of Copper Concentrate to feed the smelter, or Tanzania would have to increase its own production of Copper Concentrate through the development of more mines, and of similar production technology;

5. In addition, one of the key components in deciding to erect a smelter is the cost and availability of power. Electricity is relatively expensive in Tanzania and the existing capacity does not meet the requirements of a large copper smelter.

BGM therefore, insisted that it is uneconomical to construct their own smelter as per reasons provided above.

4.1 Statistics of Copper Concentrate Production in Tanzania

Table 1 summarizes gold, copper and silver quantity from the Copper Concentrate produced by BGM and BZGM for the year 2009 and 2010.

Table 1: Exported Gold, Copper and Silver Quantity from Copper Concentrate Produced by BGM and BZGM (2004 – 2009)

Year	Gold (toz)	Copper (lb)	Silver (toz)
2004	140,321	6,745,295	157,581
2005	172,023	7,995,187	181,930
2006	213,767	8,700,357	198,133
2007	138,502	7,010,414	146,089
2008	118,196	5,680,103	125,163
2009	160,595	7,093,375	164,307
2010	228,336	10,050,391	219,792

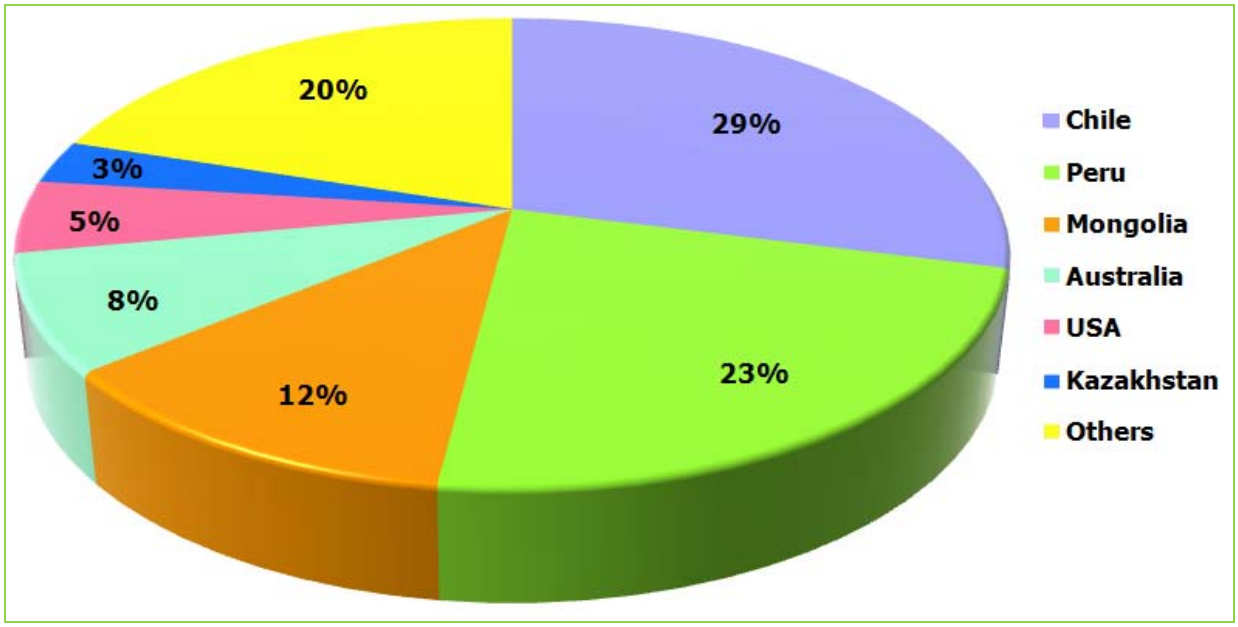
5.0 OBSERVATIONS

Copper Concentrate is produced in other mines processing copper sulphide ores world-wide. Detailed information from literature review has revealed that there are nearly 400 copper mines, 150 copper smelters and 170 copper refineries world-wide. Most of the Copper Concentrate producers export their products to China, Japan and India for treatment and refinery. The main Copper Concentrate producers include Chile, Canada, Australia and Argentina. Chile is supplying more than 29% of the China's Copper Concentrate market and 36% of the Japan's Copper Concentrate market (Figures 1, 2 and 3).

Figure 1: Major International Trade Flows of Copper Ores and Concentrates

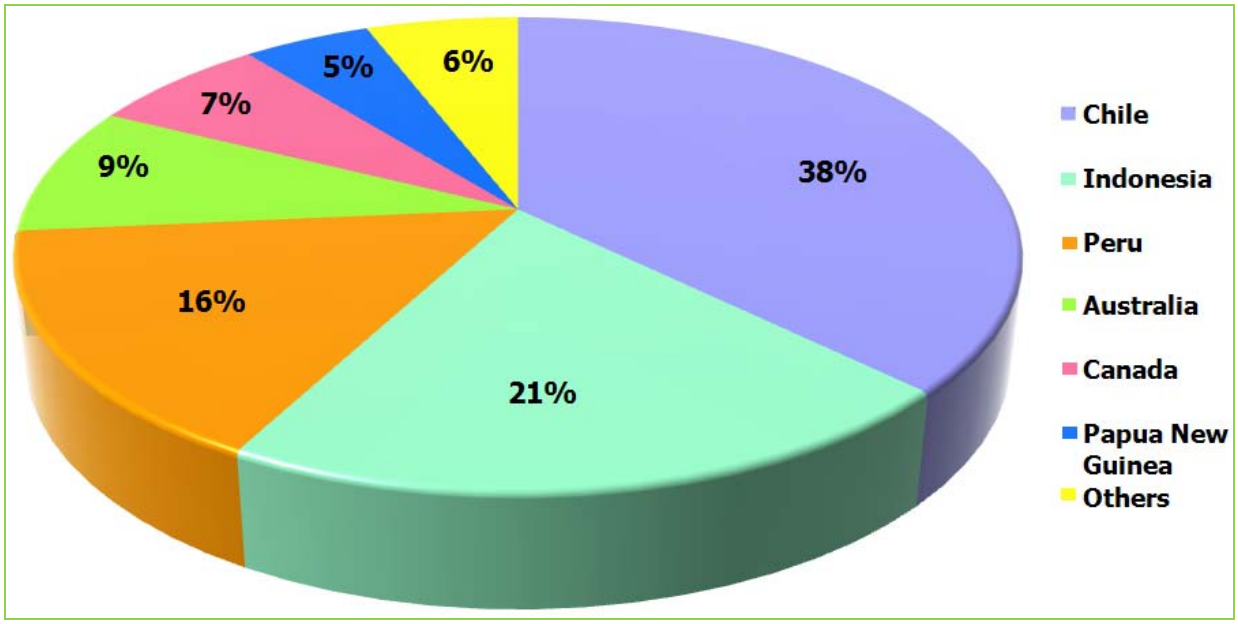
Source: International Copper Study Group

Figure 2: China's Copper Concentrate Imports, 2007



Source: www.chinamining.org

Figure 3: Japan's Copper Concentrate Imports, 2009



Source: Pan Pacific Co. Ltd

5.1 Copper Concentrate Smelter Capacities and Building Costs

The cost of constructing a Copper Concentrate smelter depends on two major factors namely the processing method to be employed and the feedstock required for a specified period. Pyrometallurgy and hydrometallurgy are methods used in treating Copper Concentrate. The later is a new technology and not widely used in treating ore.

Pyrometallurgy is the mostly applied process in treating copper sulphide concentrates. This type of technology is used in many countries whereby flash furnaces are installed to facilitate recovery of valuable elements from Copper Concentrate or copper ore. Table 2 highlights processing capacities and initial investment costs of a few smelters installed in Africa, Asia and America between 1996 and 2006.

Table 2: Examples of Copper Smelter Capacities and Building Costs

Company/Country	Year	Feed Capacity (tpa)	Initial Building Cost (USD)
PT Smelting/ Indonesia (1)	1996	660,000	500,000,000
Stillwater Mining Co./ USA (2)	2002	30,000	370,000,000
Mopani Copper Mines/ Zambia (3)	2006	850,000	705,000,000

Sources:

1. *http://www.smelting.co.id/aboutus.htm*
2. *http://www.mining-technology.com/projects/stillwater*
3. *http://www.miningreview.com/archive/mra_1_2006/pdf/PG%2020-23.pdf*

Note that, the amount of Copper Concentrate treated by Stillwater Mining Co. of USA is relatively low compared to that of the other two smelters listed in Table 2 because Stillwater's concentrate contains Platinum Group Metals from which the company relies on.

In a nutshell, this study has revealed that most of the Copper Concentrate smelters installed worldwide have feed capacities greater than 150,000 tonnes per year and their total construction cost exceed USD 500 Million.

5.2 Copper Concentrate Smelters Worldwide and their Owners

China and Japan are not only the world's leading Copper Concentrate importers and smelters, but also major consumers of the refined copper for industrial applications. China is the leading copper consumer in the world followed by Japan. They both import copper in form of copper ore and Copper Concentrate from major copper/gold mines producing Copper Concentrates around the world.

Table 3 summarizes smelters widely recognised in the world for processing Copper Concentrates similar to that produced at BGM and BZGM. Copper Concentrate from these two mines is normally shipped to Marc Rich Investment (China), Sumitomo Metal Mining Co. Ltd (Japan), Pan Pacific Co. Ltd (Japan), and Aurubis AG (Germany).

Table 3: Some of the World's Largest Copper Concentrate Smelters and Owners

Country	Smelter	Owners
Chile	Altonorte smelter	Noranda Inc. Of Toronto, Ontario, Canada
Chile	Calestones smelter	Corporación Nacional del Cobre de Chile (CODELCO) of Santiago, Chile
Brazil	Camacari smelter	Paranapanema Group of Rio de Janiero, Brazil
Chile	Chagres smelter	Anglo American plc of Johannesburg, South Afric
Chile	Chuquicamata smelter	Corporación Nacional del Cobre de Chile (CODELCO) of Santiago, Chile
Kazakhstan	Dzhezkazgan smelter	Government of Kazakhstan and Samsung Heavy Industries Co., Ltd. of Seoul, Republic of Korea
USA	Garfield smelter	Rio Tinto plc of London, United Kingdom
Poland	Glogow I & II smelters	KGHM Polska Miedź S.A. of Lubin, Poland
China	Guixi smelter	Jiangxi Copper Corporation of Guixi City, China
USA	Hayden smelter	Grupo Mexico S.A. de C.V. of Colonia Roma Sur, Mexico
Spain	Huelva smelter	Freeport-McMoRan Copper & Gold Inc. of New Orleans, Louisiana USA
Peru	Ilo smelter	Cerro Trading Company Inc. [a subsidiary of the Marmon Group of Chicago, Illinois] (14.2 percent),

Country	Smelter	Owners
		Grupo Mexico S.A. de C.V. of Colonia Roma Sur CP, DF, Mexico (54.2 percent), and Phelps Dodge Corporation of Phoenix, Arizona, (14 percent)
China	Kunming smelter	Yunnan Copper Industrial (Group) Company of Kunming, China and the Chinese Government
Chile	Las Ventanas smelter	Empresa Naćional de Minería of Santiago, Chile
USA	Miami smelter	Phelps Dodge Corp. of Phoenix, Arizona
Australia	Mount Isa smelter,	Xstrata plc of Zug, Switzerland
Mexico	Nacozari (La Caridad) smelter	Grupo Mexico S.A. de C.V. of Colonia Roma Sur CP, DF, Mexico
Japan	Naoshima smelter	Mitsubishi Materials Corporation of Tokyo, Japan
Germany	Norddeutsche Affinerie smelter	a consortium of Degussa AG of Düsseldorf, Germany; Inmet Mining Corp. of Toronto, Canada; and Xstrata plc of Zug, Switzerland
Russia	Norilsk smelter	Mining Metallurgical Company Norilsk Nickel of Moscow, Russia.
Australia	Olympic Dam smelter	WMC Resources, Ltd. of Southbank, Australia
Japan	Onahama smelter	a consortium of Dowa Mining Co. Ltd., The Furukawa Electric Company Limited, Mitsubishi Materials Corporation, and Mitsui Mining & Smelting Co. Ltd., all of Tokyo, Japan
Republic of Korea	Onsan I& II smelters	Japan Korea Joint Smelting Co., Ltd., Republic of Korea
Chile	Potrerillos smelter	Corporación Nacional del Cobre de Chile (CODELCO) of Santiago, Chile
Sweden	Ronnskar smelter	Boliden A.B. of Väsby, Sweden
Japan	Saganoseki smelter	Nippon Mining & Metals Ltd. of Tokyo, Japan
Japan	Tamano smelter	a consortium of Furukawa Electric Company Limited, Mitsui Mining & Smelting Co. Ltd., and Nittetsu Mining Co. Ltd., all of Tokyo, Japan
Japan	Toyo (Besshi)	Sumitomo Metal Mining Co. Ltd. of Tokyo, Japan
China	Yunnan	Yunnan Copper Co/ Marc Rich Investment Co.

Source: http://www.eoearth.org

5.3 Copper Concentrate Producers Worldwide

Table 4 provides a few mines in the world that produce Copper Concentrate. Some of the listed mines have their own copper smelters.

Table 4: Examples of Copper/Gold Mines Worldwide which Produce Copper Concentrate

Name of Mine	Owners	Location	Products
Palabora Copper Mine	Rio Tinto (57.7%); Anglo American (28.9%)	North Eastern South Africa	Copper Concentrate, Magnetite, Baddeleyite and Precious Metals
Aitik copper mine	Boliden (100%)	Northern Sweden	Copper Concentrate, Copper, Gold and Silver
Bingham canyon copper	Rio Tinto (100%) AS Kennecott	Utah, USA	Copper Concentrate, Molybdenum
Mount ISA Copper Mine	Xstrata plc (100%)	Mount Isa, Queensland, Australia	Copper and Copper Concentrate
KGHM Copper Mining and Smelting combine, Poland	KGHM Polska Miedz Sa (100%)	Lubin area, South West Poland	Copper, Copper Concentrates, Crude Lead, Metallic Silver, Doré Silver, Gold, Platinum, Palladium Slime, Selenium and Sulphuric Acid
Bajo de la Lumbrera Copper and gold mine	Xstrata Plc (50%), Wheaton River Minerals (37.5%)	Catamarca Province, Argentina	Copper, Copper Concentrate and Gold
Escondida Copper Mine	BHP-Billiton (57.5%), Rio Tinto (30%), Jeco Corporation (10%)	Northern Chile	Copper, Copper Concentrate, Gold and Silver
Bulyanhulu Gold Mine	Barrick Gold Corporation	Northern Tanzania	Copper Concentrate, Gold bars
Buzwagi Gold Mine	Barrick Gold Corporation	North Western Tanzania	Copper Concentrate, Gold bars

Sources:

1. *http://www.nrcan.gc.ca/mms/cmy/content/2002/25.pdf*
2. *http://www.smm.co.jp/E/metal/touyo.html*
3. *http://www.ame.com.au/Smelters%5CCu/Mount-Isa-Copper-Smelter.htm*
4. *http://www.mining-technology.com*

5.4 Copper Concentrate Products

Copper mines usually produce two types of ore: copper oxide and copper sulphide. Copper produced from copper oxide is transformed into the finished product by a process known as leaching**,** which is normally done at the mine. Copper sulphide on the other hand is firstly transformed into an intermediate product known as Copper Concentrate, which contains 15% - 60% copper that is then transformed into the finished products by smelting and refining process.

The melting point of Copper Concentrate is approximately 1080 degrees Celsius. The process output of Copper Concentrate generally includes the following products:

1. Metallic copper

2. Solid or solution by-product outputs such as:

   (a) precious metals such as gold, silver and in some cases Platinum Group Metals;

   (b) un-oxidised sulphide feed materials in the leach residue particularly sulphides of copper, iron and other base metals;

   (c) sulphide oxidation reaction products and by-products including (i) elemental sulphur from some processes (ii) sulphate sulphur as gypsum (iii) sulphate sulphur as jarosite in some cases (iv) iron oxidation products such as haematite, goethite or ferric arsenate (v) soluble metal sulphates of certain base, alkali and other metals in a bleed stream for subsequent metal recovery by processes such as lime precipitation of hydroxides, evaporation of sulphates in an evaporator or tailings dam and ion exchange; and

   (d) soluble or insoluble Se, Cd, Bi, As, Hg in the leach residue.

3. Sulphur dioxide, which is processed to produce sulphuric acid, liquid sulphur dioxide or sulphur.

Copper Concentrates by-products differ from one another depending on the geological structure of where such ore is mined. In general, Copper Concentrate consists of major and minor elements such as Cu, Au, Ag, Fe, S, As, Sb, Bi, Pb, Zn, Ni, Hg, Al_2O_3, SiO_2, CaO, MgO, Mo, Ni, Se, Te, F, Cl, Sn, Cd, Ge, Co, Mn, Cr.

5.5 Copper Reserves in Tanzania

There are many copper occurrences in Tanzania but most of them are small reserves and of low grade.

- The Old Mkwamba Mine located at Mpanda District is known for producing about 2 million tonnes of ore between 1950 and 1961, averaging 2.4% lead, 0.6% copper, 0.00015% gold and 0.008% silver.

- The Pare copper deposit was discovered in 1955 and had 247 tonnes of ore averaging 10.18% copper.

- The Bulyanhulu Gold Mine located in Kahama District has a copper deposit with high gold values averaging 0.0015% gold, 0.52% copper and 0.00114% silver. It has a mineable resource of 13.64 million tonnes. It commenced production in 2001 with an average annual production of Copper Concentrate of 50,000 tonnes (source: Opportunities for Mineral Resource Development, 2005).

- The Buzwagi Gold Mine located in Kahama District has a copper deposit with high gold values averaging at 2.10 grams per tonne, 0.14% copper and 0.00115% silver. It has a mineable resource of 41 million tonnes. It commenced production in 2009 with an average annual production of Copper Concentrate of 10,000 tonnes.

5.6 Quality of Copper Concentrate

Copper Concentrate treatment and refining costs depends on its quality. For instance, a Copper Concentrate containing some 'impurities' such as nickel is difficult to treat and refine. For this reason, its smelting charges are higher. However, Copper Concentrates containing arsenic would be charged a bit lower because the contained impurity is advantageous to the smelter. Also concentrates with very low copper content would be deemed less profitable to the smelter and would therefore attract higher treatment or refining costs.

Literature survey has revealed that most of the imported Copper Concentrate by the world's leading copper smelters contains relatively higher quantities of copper than that supplied by BGM and BZGM. The quality and composition of BGM and BZGM Copper Concentrate is considered poor in that it contains about 15% copper, 0.02% gold and 0.02% silver on the average. That being the case, efficient smelting of their Copper Concentrate requires blending with concentrate from other producers (reference: letter from BGM dated 31st October 2007 with Ref. No. BGT/600/049/LD).

Typical Copper Concentrates imported by owners of Copper smelters contain about 26% of copper metal, 22% iron metal, 24.5% sulphur, 2.6% alumina, 0.3% calcia, 12.3% silica and 17.4% insolubles. For example, Copper Concentrate supplied by Escondida (the largest Copper mine in the world) has the following composition: Copper - 36%, Gold – 0.0002%, Silver 0.0045%, Iron - 20%, Sulphur - 32% and Mercury - 1%.

Copper Concentrate is fed into the smelter where the concentrate is melted and the copper is separated as a metallic sulphide called Matté from the gangue material that contains iron and other materials. Copper Matté is in turn oxidised to produce 98% pure copper blister which is finally refined from the electrolytic process to produce copper cathode which contains 99.99% copper and other payable minerals.

5.7 Copper Concentrate Smelting Contracts

Copper Concentrate producers may choose either to carry out smelting process of Copper Concentrate at the mine site or to sell the same to an independent smelter depending on the economic factors. The Copper Concentrate supplier is normally paid for the supplied concentrate 2-3 months following delivery, less the costs of smelting and refining.

Smelting contracts between Copper Concentrate suppliers and owners of copper smelters are normally of three types namely spot, short and long-term. A long term contract normally has a period ranging from 2 to 12 years. However, some commercial terms, including the levels of smelting and refining costs are negotiated annually by the two parties.

Short term contracts normally cover a period of less than 2 years. Spot agreements are cash purchasing agreements, of which prices are volatile since they may vary twice within the same day.

5.8 Viability of Copper Concentrate Smelter Installation in Tanzania

This study focused on the viability of installing a copper smelter in Tanzania aimed at processing Copper Concentrate produced by BGM and BZGM, and that to be produced by other mines in future. The opinion herewith is based on the technical and economic factors required for an economically viable Copper Concentrate smelter. The following are the findings and facts:

1. The study has revealed that a commercially viable Copper Concentrate smelter requires a feedstock of not less than 150,000 tonnes per year. At full capacity, BGM and BZGM production is about 60,000 tonnes of Copper Concentrate annually, which would only account for 40% of the capacity of a viable Copper Concentrate smelter.

   Currently, no commercial-scale proven technologies exist which are suitable for small scale Copper Concentrate smelting of less than 100,000 tonnes per year, but this matter continues to be investigated.

2. In order to construct a viable smelter in Tanzania, it would require importing 60% of Copper Concentrate to feed the smelter, or Tanzania would have to increase its own production of Copper Concentrate through the development of more mines, and of similar production technology. However, there are currently no known copper sulphide deposits in Tanzania, which would add significantly to the Copper Concentrate requirements to feed the smelter to be constructed.

   If a Copper Concentrate smelter was to be built relying on imported Copper Concentrate as the primary feedstock to meet smelter minimum annual requirement, then such a smelter would find itself competing against the world's leading Copper Concentrate smelting merchant market on a price basis and probably attempting to win market share in the higher growth copper markets of the Far East.

3. A Copper Concentrate smelter of a feedstock of not less than 150,000 tonnes per year would cost between USD 500 million and USD 800 million to construct complete with sulphuric acid plant for purification of fugitive gases emitted from the smelter furnace. This is substantial amount of money. Most planned new Copper Concentrate smelters in the world are in non-free market economies and are heavily supported by local governments directly or indirectly through tariffs.

4. Cost and availability of reliable supply of electricity is a key to deciding to erect a Copper Concentrate smelter. However, electricity is currently relatively expensive in Tanzania and the existing capacity does not meet the requirements to run a large Copper Concentrate smelter.

5.9 Environmental Issues with Regard to Copper Smelters

Processing of Copper Concentrate at Copper smelters provide profitable products such as gold, silver, copper and sulphuric acid but also pose potential health

hazards to the surrounding area. Common waste products and hazardous ingredients are the following:

- Depending on the composition of the Copper Concentrate, a number of heavy metals such as copper, mercury, cadmium, nickel, cobalt, zinc and so forth may be concentrated through processing and be deposited to the environment. These metals may enter into the human blood system by inhalation or by being ingested from heavy metal contaminated species (animals, fish, plants, etc).

  Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis.

- Crystalline silica, when inhaled can cause silicosis of the lung both to humans and animals;

- Carbon dioxide produced during smelting of Copper Concentrate can result into acid rain, which is harmful to plants;

- Chemicals/reagents used in smelting process can be harmful to humans especially to staff exposed to them.

- Waste products from Copper Concentrate may amount to billions of tonnes. The tailings from the concentrating operation and the slag from the smelting operation do pose a potential health hazard and may require huge expenses to protect and manage the affected areas.

6.0 CONCLUSION

The study concludes that it is currently not feasible for a Copper Concentrate smelter to be constructed in the country to smelt and refine Copper Concentrate produced by BGM and BZGM. However, investors are encouraged to explore more on possibilities of discovering copper deposits which will warrant for installation of a Copper Concentrate smelter in the Country.

TMAA will continue strengthening monitoring and auditing of Copper Concentrate production and exports activities by BGM and BZGM so as to ensure that the Government reaps maximum benefits from the product.