



UNITED REPUBLIC OF TANZANIA
MINISTRY OF ENERGY AND MINERALS

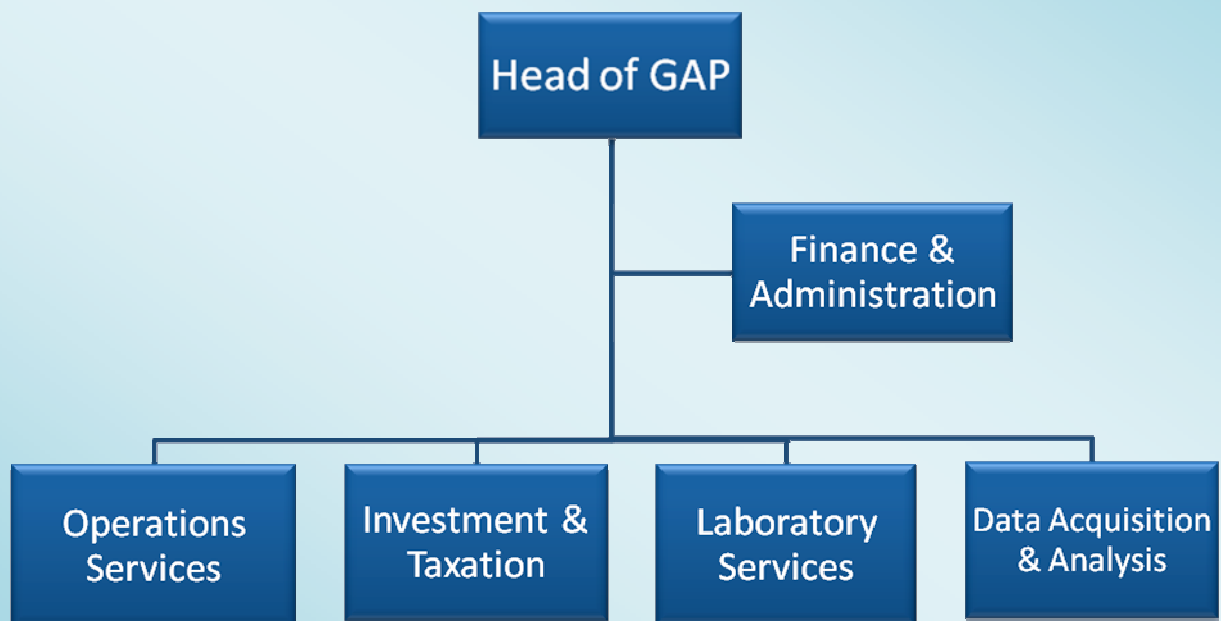
GOLD AUDIT PROGRAM



OPERATIONS GUIDEBOOK
2007

**THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF ENERGY AND MINERALS**

GAP ORGANISATION CHART



Contact Details:

Plot 1129 Chole Road,
Masaki, Kinondoni
P. O. Box 23400
DAR ES SALAAM
TANZANIA

Tel: +255 22 2601819
+255 22 2602109
Fax: +255 22 2601326
Email: info@memgap.go.tz
www.memgap.go.tz

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1. BACKGROUND INFORMATION

The Government of the United Republic of Tanzania through the Bank of Tanzania engaged M/S Alex Stewart (Assayers) Government Business Corporation (ASAGBC) through a two-year contract signed on 14th June, 2003 to undertake gold auditing of the major gold mines in the country. The contract was extended for another period of two years ending 13th June, 2007.

The Commissioner for Minerals, as the In-Charge of the Mining Sector appointed ASAGBC as Authorised Officers under Section 16 (5) of the Mining Act, 1998 as reflected by Government Notice No. 260 of 22nd August 2003 and amendment Notice No. 299 of 30th September 2005.

ASAGBC was engaged to undertake the following major tasks:

- i. To conduct a survey of the current practices and procedures; and current Government regulations of the gold mining industry in Tanzania and give recommendations for improvement;
- ii. Auditing of quality and quantity of produced and exported gold-containing products (Doré Bullion, Matte, Slag and Copper Concentrate) for the purpose of determining its values and royalty due;
- iii. Auditing of capital investment expenditure and operating costs for the purpose of tax assessments; and
- iv. Auditing of environmental budget and expenditure for the purpose of assessment of mine closure plan.

The major gold mines in which the auditor was engaged to undertake the auditing are Geita Gold Mine (owned by Anglo Gold Ashanti Limited); North Mara Gold Mine (owned by Barrick Gold Corporation); Golden Pride Mine (owned by a joint venture of Resolute Tanzania Ltd and Mabangu Mining Limited); Bulyanhulu Gold Mine (owned by Barrick Gold Corporation); Buhemba Gold Mine (owned by Meremeta Limited); and Tulawaka Gold Mine (owned by Barrick Gold Corporation and operated by Pangea Minerals Limited).

On 10th of May, 2007 the Government through the Bank of Tanzania informed ASAGBC its intention not to renew the contract between the two parties for another term. However, on 10th of June, 2007 the Government extended the contract for three months (up to 10th of August, 2007) to ensure smooth handover of the laboratory and reports produced by ASAGBC during the audit exercise.

On 15th of August, 2007 the Cabinet discussed Cabinet Paper No. 50/2007 presented by the Minister for Energy and Minerals and approved the formation of a Special Unit under the Minerals Division to take over the activities previously undertaken by ASAGBC. In implementing the decision made by the Cabinet, the Ministry of Energy and Minerals formed a Unit called Gold Audit Program (GAP) under the Commissioner for Minerals and recruited 25 employees formerly employed by ASAGBC and relocated 2 staff from the Minerals Division and 2 staff from the Geological Survey of Tanzania to strengthen the Unit.

The functions of GAP are the following:

1. Auditing of quality and quantity of produced and exported gold-containing products (Doré Bullion, Matte, Slag and Copper Concentrate) for the purpose of determining its values and royalty due. The audit is aimed at ensuring that declarations of the mining companies are thorough and correct (not misstated either willfully or by mistake);
2. Auditing of capital investment and operation expenditures for the purpose of tax assessments. The audit is aimed at preventing missing or erroneous declarations of capital and operation expenditures, whether by mistake or by willful act;
3. Auditing of environmental budget and expenditure for the purpose of assessment of compliance to the mine closure plan. This audit is aimed at verifying environmental expenditures declared by mining companies and to determine whether mining companies are fulfilling their obligations to provide sufficient funds for environmental conservation, reclamation and rehabilitation during the mine life and after closure of the mine; and
4. Reviewing ASAGBC audit findings for each audited major gold mine, discussing the same with respective mines and carrying out revised tax computations after taking into account the resolved and unresolved findings.

The mines currently being audited by GAP are: Bulyanhulu Gold Mine (BGM), Golden Pride Mine (GPM), Geita Gold Mine (GGM), North Mara Gold Mine (NMGM), and Tulawaka Gold Mine (TGM).

The gold auditing program is comprised of five areas:

- (i) The auditing of quantity and quality of exportable gold-containing products (Doré Bullion, Matte, Slag and Copper Concentrate), to provide the government with a precise account of gold exports, for the purpose of confirming the amount of revenue generated from the exported mineral products and royalty due. The audit of mineral products relies on the witnessing of production, weighing, sampling, packing and exportation of the products, and analysis of the collected mineral samples at the GAP laboratory.
- (ii) The analysis of historical documentation on gold production, exports and past payments of royalty. This involves the forensic analysis of documentation available at the Ministry of Energy and Minerals and from the mining companies.
- (iii) The audit of the mines' capital investments to assess the actual amount of the investment and to determine if the amortization and depreciation declared by the mining companies are correct and do not improperly reduce the profit line and so reduce the amount of tax due to the Government.
- (iv) The audit of operating costs to assess if the deductions claimed by mining companies were actually incurred and correspond to legitimate operational expenses, as these affect the taxable profit of the mining companies. The audit of operating costs requires the examination of engineering controls in the processing plant, the examination of accounting data and mine processing records.
- (v) The audit of environmental budget and expenditure to determine whether the mining companies are fulfilling their financial obligations to provide sufficient funds for future reclamation and rehabilitation. The audit also involves verification of significant environmental costs.

2. PROCEDURES FOR THE AUDITING OF QUALITY AND QUANTITY OF GOLD-BEARING MATERIALS AT GAP

2.1 Auditing of Doré Bullion

Doré Bullion is an impure alloy of gold or silver produced at a mine, normally weighing between 8Kg and 25Kg each, containing between 60% and 90% fine gold, with a balance of silver and other materials. All five major gold mines subjected to the audit program produce Doré Bullion.

The cycle of Doré Bullion production involves the following 18 generic steps:

1. Pouring of Doré Bullion at the gold room
2. Drawing of sample for mine assay and GAP assay
3. Recording of Doré ingot weight and secure storage
4. Release of sample for mine assay (*almost daily*)
5. Release of sample for GAP assay (*fortnightly or monthly*)
6. Mine assay result output
7. Export documentation preparation (*provisional invoice and provisional royalty payment*)
8. Export of Doré Bullion
9. GAP assay result output

10. GAP comparison with mine assays output (*in case the respective mines provide GAP with mine assay results on time*)

11. Provisional royalty reconciliation (*mine assay Vs GAP assay*)

12. Exported Doré Bullion arrives at refinery

13. Refinery smelts Doré Bullion ingots in lots

14. Refinery assay result issued and conveyed to mine

15. GAP obtains refinery assay results (*provided by mine*)

16. GAP undertakes final reconciliation for royalty computation based on results of assays by GAP, refinery and mine

17. Mine pays final royalty liability or raises credit note with respect to the same, and

18. Reconciliation on shipment complete

2.1.1 Transaction Time

The above described sequence contains the eighteen generic steps, from production, through sales, and the final royalty computation process. There is a time lag between the successive steps called transaction time. For that reason, at the end of each month there are some outstanding items of information other than production and mine assay results that are yet to be received by GAP and consequently, not reported. Transaction time varies from mine to mine and is influenced by factors such as production and export schedules, bureaucratic delays, logistics inefficiency, distances and mode of transportation, Refinery throughput processes and schedules etc. Doré Bullion and Doré Matté shipments are air freighted while Copper Concentrate shipments are bulk and are transported by road and rail then shipped by sea. The transaction time and final

reconciliation for Copper Concentrate may take up to five months from the date of export for reasons described above.

The following methodology for the auditing of the production and exports of Doré Bullion has been already implemented in all the mines subject to the audit program. The purpose of this area of audit is to ensure that:

- every gold-bearing ingot produced at the major gold mines is accounted for;
- the gold and silver contents of each ingot are correctly assayed.

The procedures for the auditing of the production and export of Doré Bullion are as follows:

2.1.2 Witnessing of production activities

Gold room is the final stage of gold production. Here gold in solution form is converted to solid form by electro-winning method. The gold sludge deposited in electro-winning cell is removed, filtered and dried, weighed, fluxed and smelted into a doré bar (see Figure 1).

- The GAP Auditor is always present in the gold room whenever there are production activities. His/her main duties include witnessing and recording weights of wet and dry calcine from electro-winning cells and/or gravity concentrates prior to smelting.
- The GAP Auditor witnesses the smelting, pouring, sampling, stamping and weighing of doré bars. The gold room supervisor takes two samples of each doré bar and one of them is given to the GAP Auditor. The GAP Auditor records the ownership, date, serial number and weights of each doré bar. There are three major sampling methods which are used by mining companies, which are dip sampling (mostly applied at NMGM), vacuum tube sampling (applied at GGM and GPM) and drill sampling (applied at TGM and BGM).

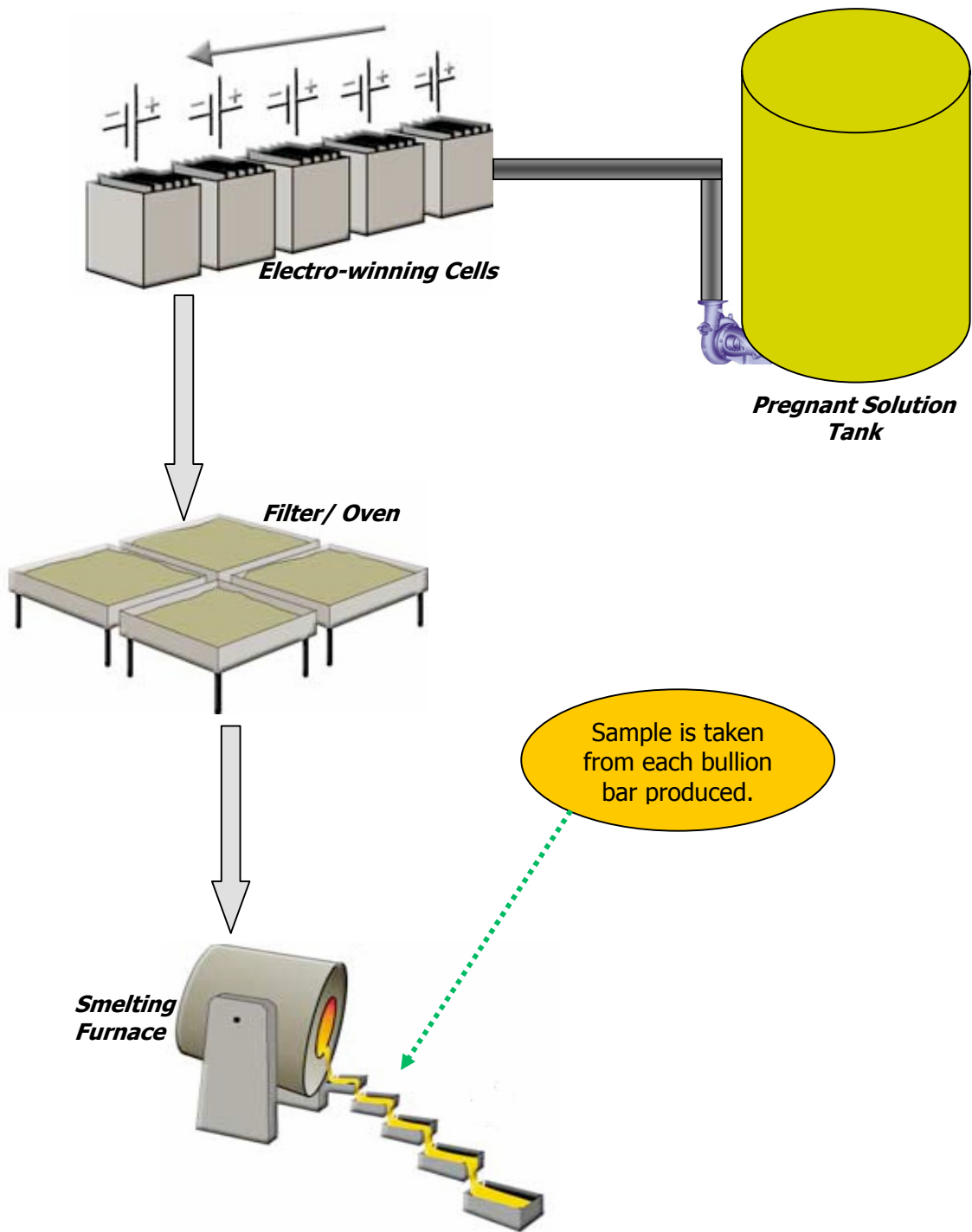


Figure 1: Flow diagram for the production and sampling of bullion bars

2.1.3 Safekeeping of samples

The GAP Auditor puts the ingot information and the sample in a bag, and seals the bag. The sealed bag is given to the gold room supervisor for safekeeping in the main vault of the gold room until the day of shipping.

2.1.4 Packing of samples

On the day of shipping, the GAP Auditor requests the sample bags from the gold room supervisor, who gives the same to the GAP Auditor. The GAP Auditor places the sample bags in a 'security tamper proof bag', seals the bag, and labels it, addressing it to GAP office in Dar es Salaam.

2.1.5 Packing of ingots

Ingots are jointly inspected by officials from Tanzania Revenue Authority and the Minerals Department, boxed and sealed. The GAP Auditor witnesses the inspection and packing exercise.

2.1.6 Transportation

The boxes containing the ingots are given to a Security Company for transport. The Security Company takes the boxes to Julius Nyerere International Airport in Dar es Salaam by charter plane, whereby the ingots are loaded onto an international commercial flight for export under the responsibility of the Security Company. The GAP Auditor also gives the bag containing the samples to the Security Company for transport to GAP office. The Security Company delivers the bag of samples to the GAP Laboratory in Dar es Salaam.

2.1.7 Laboratory analysis

The GAP Laboratory assays the gold samples. From the assaying results, the amount of gold and silver in the ingot is determined. All the information concerning the ingot is entered into the GAP database.

2.2 Audit of Doré Matté

Doré Matté is a mixture of sulfides that forms when sulfide metal ores (copper, lead, and nickel) are smelted. Generally, this product is classified as low-grade material depending on the elemental composition of the ore and the contained ounces of its precious metals.

The only mine currently producing and exporting Doré Matté is BGM. Ores rich in sulphur such as that produced at BGM yield high value of Doré Matté when smelted (5 – 10% Au, plus Ag and other metals).

2.3 Audit of Slags

Slag is the top layer formed when Calcine, rich in gold and silver, is smelted in the crucible (see Figure 2). This layer is not considered to be a waste product as slag contains an unspecific quantity of entrained precious metals. Fluxes and reagents react and trap most of the impurities in this lighter layer. The layer is segregated from gold as it overflows into subsequently positioned moulds. Heavier molten precious metals settle at the bottom of the moulds forming the bullion while the lighter slag layer overflows to the next.

During pouring of the melt, some precious metals which might be trapped in the slag are either sold or crushed and reintroduced with fresh ore.

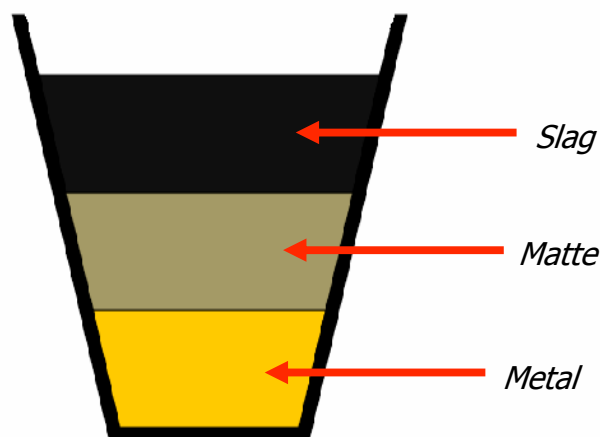


Figure 2: Metal, Matté and Slag layers in a crucible

2.4 Audit of Copper Concentrate

Bulyanhulu Gold Mine is the only one currently producing and exporting copper concentrates. Copper concentrates produced by the flotation method consist of a greenish powder comprising of the following major products: Copper (average assay 14%), Gold (average assay 200 ppm) and Silver (average assay 150 ppm).

2.4.1 Transaction Analysis for Copper Concentrate Shipments

In order to understand the copper concentrate transaction methodology of the Bulyanhulu Gold Mine, a series of financial tracking spreadsheets have been developed to highlight the complexity of the transactions of copper concentrate to the Sumitomo Metal Mining Co. Ltd (Japan), Marc Rich Investment Co. (China) and Nippon Mining & Metal Co. Ltd. (Japan). In order to follow the transaction analysis for copper concentrate shipments, all the factors and terminology used in the transaction need to be understood.

2.4.2 Glossary of Terms and Factors

Shipment Number: The number assigned by the seller to a consignment destined to a buyer.

Container quantity: The number of containers in a consolidated shipment to a buyer.

Gross weight: The total weight of the wet concentrate plus the container tare weight and the weight of the liner plus shoring wood.

Total payable value (Sellers): Calculated by the seller in US\$ after analysis and correcting the wet mass to a dry basis and applying a factor which is not defined by the seller. This factor reduces the total payable value by approximately 4% on each shipment. Due to lack of information, it is hereby assumed that the factor applied relates to the smelter recovery efficiency. This suggests that 4% of the payable gold is lost in the refining process.

Smelter recoveries are usually affected by two main predominant factors that compound the degree of refining difficulty:

1. The degree of impurities in the copper concentrate mass. The ore from which the copper concentrate is recovered mostly determines this. Note that the BGM ore is a complex ore consisting of Chalcopyrite, Chalcocite, Bornite and Pyrite.
2. The technical sophistication of the processes adopted to separate the impurities from the main payable components of the copper concentrate mass.

Total payable value (buyers/ refineries): Calculated by the buyer in US\$ after analysing and correcting the wet mass to a dry basis and applying a factor which is not defined by the buyer. The application of the buyer's factor again reduces the payable gold value by approximately 2.5%.

Sellers dry net weight: At BGM, the copper concentrate is produced wet and dried on vacuum screens to between 8% and 14% moisture content. The wet copper concentrate is sampled and sent to GAP laboratory where it is further dried in an electric furnace to drive off the moisture at a temperature of 105°C.

The percentage of moisture is used to correct the container net weight to a dry basis defined as a Dry Metric Ton. Although the containers used to ship the copper concentrates are lined with plastic, they are not hermetically sealed hence they can absorb or lose moisture content during the voyage.

Buyers/ Refineries dry net weight: The buyer checks the shipment on arrival at the port or smelter to ascertain the validity of the seller's assay for water content. This assay can increase or decrease depending on the ingress or egress of water during the voyage due to the thermal influence of the sun on the container and its exposure to moisture during the voyage.

Sellers Assay: The seller assays each container for its gold, silver, and copper contents. The seller could look at other component minerals present in the residual mass, which could affect the recovery process of payable metals at the smelter.

Buyers/Refineries assay: The buyer's assay is done to confirm the seller's assay; the seller witnesses this assay or subcontracts the exercise to a reputable sampling and analytical company to conduct the same on his behalf.

Sellers contained gold/silver/copper: The seller calculates the contained gold, silver and copper in each container using the calculated dry weight. The analysis of contained gold, silver and copper in the concentrate are defined in troy ounces for gold and silver and imperial pounds for copper.

Sellers Factors: The seller applies a factor to the total contained gold, silver and copper, which effectively reduces the weight. This reduced weight is called "*Payable Gold, Silver or Copper*".

The weight is reduced by approximately 4% by applying a factor of 96% to the calculated contained gold. The payable gold may in some cases be greater than the buyer's calculated saleable gold due to a positive increase in the analysis on the buyer's side.

Buyers/ Refineries contained gold/silver/copper: The buyer recalculates the contained gold after weighing the container and subtracting the tare weight. The buyer's analysis of moisture content, gold, silver, and copper is applied to calculate the contained gold, silver and copper in the concentrate.

Buyers/ Refineries Factors: The buyer applies factors, which are generally changing the weight of each commodity further, from the weight declared by the seller; this is based on reweighing, buyer's analysis, and refining recovery factor.

Generally the reduction in payable gold is in the order of 3% of the contained gold calculated from the buyer's assays and weight. Hence 97% of the calculated contained gold is payable.

Silver is paid at 90% of the contained silver; effectively 10% of the weight is not paid but is lost in the refining activity.

The copper factors are different. First, the copper analysis is reduced by one percent and the contained copper is calculated in imperial pounds and multiplied by the agreed price per pound. Then a price participation factor is applied which credits the value by an amount calculated from the following expression:

For Sumitomo Metal Mining the factor applied is US\$ 0.9 minus the actual price, times 10%. This value is credited to the total payable copper value.

For Marc Rich Investment they apply US\$ 0.8 minus the actual price, times 10%. This value is credited to the total payable copper value.

Buyer's/Refineries treatment and refining charges: Treatment charges in 2001 were US\$ 100 per dry metric ton. The rates have risen in 2003 to the level of US\$ 110 per dry metric ton. In 2004 the treatment charges were as follows: Sumitomo Metal Mining – US\$ 76 per dry metric ton; Pan Pacific Copper – US\$ 77 per dry metric ton; Marc Rich Investment – US\$ 30 per dry metric ton. In 2005 the treatment charges were renegotiated again as follows: Sumitomo Metal Mining – US\$ 115.5 per dry metric ton; Marc Rich Investment – US\$ 35 per dry metric ton. All in all, smelter charges reported by BGM during the period of 2001 to 2005 are higher than the prevailing market averages.

Transaction flow sheets: The current average transaction time of copper concentrate from the mine site to reconciliation of the outstanding Royalty of 3% of 10% of the net saleable value is five months.

2.4.3 Copper Concentrate Production and Export Auditing

2.4.3.1 Procedures

The auditing of production and exports of copper concentrate is intended to verify the amount of gold and silver contained in the copper concentrate exported. Currently, the GAP laboratory has no facilities for analysing copper contents in the concentrate. The amount of copper contained in the exported copper concentrate is reported by the seller.

In the course of auditing of production and exports of copper concentrate, the GAP Auditor is required to:

- Witness and record the loading of the copper concentrate into containers in accordance with the mine operations procedures;
- Take samples of the concentrate during the loading of the container;
- Place the sample in special electrically hermetically sealed sample bag specially designed for shipping wet concentrate samples. The sample number, container number and miner's shipment number are written on the bag with a waterproof marker pen. The records for each sample, container and shipment number are recorded on a GAP log sheet and signed off by the auditor and the concentrate-loading supervisor. The shipment number and destination is also recorded to prevent confusion if shipment numbers for different destinations coincide.

2.4.3.2 Witnessing the Weighing of Copper Concentrate

The GAP Auditor witnesses the weighing of containers fully loaded with copper concentrate. The witnessing of the weighing procedure is as follows:

- 1.** The GAP Auditor records all the information produced at each step of the weighing procedure,
- 2.** The GAP Auditor records the tare weight and the serial number of the container in the log sheet.
- 3.** The weight of the plastic liner is added to the container tare weight. Only when this has been completed can the net weight of the concentrate be established.
- 4.** After the container has been filled with the copper concentrate to the level dictated by the mine, the container is weighed. The total weight minus the container tare weight plus liner is the net weight of the concentrate. This weight is recorded as the net weight of the exported copper concentrate.

- 5.** The GAP Auditor records in the log sheet net weight of the exported copper concentrate and a representative of the mine signs the log sheet to certify its authenticity.

2.4.3.3 Sampling Procedure of the Copper Concentrate

The Auditor takes samples of the copper concentrate by observing BGM sampling procedure, referred to as SWP LB107, dated 16 Oct 2002. SWP LB107 states that the containers shall be checked and sampled in the following manner:

- (1)** Find the container lot number for the previously last sampled container from the raw data file.
- (2)** Ensure having the following equipment:
 - Hermetically sealing sample bag and electrical sealing tongs,
 - Sample Tag,
 - Cable tie,
 - Marker pen (waterproof),
 - Notebook,
 - Sample lance, and
 - Sample scraper.
- (3)** Proceed to the container loading area. Only fully loaded containers are to be sampled.
- (4)** Climb into the container.
- (5)** Take the sample from the container by making 18 spikes throughout the container in a regular pattern. Take three samples across the width and 6 rows down the length, i.e. 3 by 6 patterns. Ensure the sample spike penetrates the concentrate at a slight angle and that it penetrates to the bottom of the container. Scrape into the labeled sample bag.
- (6)** Seal bag when the sampling is completed. This is to minimize moisture loss.
- (7)** Ensure the bag is labeled with the container lot number. This is the consecutive container lot number from that determined in step 1. Also record the container serial number on the bag.
- (8)** Ensure the container lot number and serial number is recorded in your logbook.

- (9) Attach the sampling tag on the container and write the container lot number on the tag.
- (10) Take the sample to the metallurgical laboratory.
- (11) Record the container number and serial number from your log book in the appropriate raw data file.
- (12) Send sample to the GAP laboratory in Dar es Salaam, using established company procedures for shipping samples.

3. LABORATORY ANALYSIS

The GAP laboratory in Dar es Salaam analyses the samples of Dore Bullion, Dore Matte and Copper Concentrate collected from the mines. From the analysis of results and the weight in the shipment information, the amount of fine gold and silver is determined. The results of the GAP analysis, the miners and buyer's analysis are entered into the GAP database.

3.1 Sample Preparation

Orderly processing sequence of samples is specifically followed. Each sample is checked for damage, label identification and quantity.

3.2 Copper Concentrate Sample

3.2.1 Moisture Determination

- Moisture determination is done only to copper concentrate samples. The bag containing copper concentrate is opened and the sample is transferred to a tray. Sorting process is followed by using sample splitter until the required weight of 200-300g is obtained.
- The sample weight of 200-300g is then transferred to a steel bowl ready to be loaded into an oven set at 105°C and dried for 24 hours.



Figure 3: Sample loaded into an oven

- The weight of the empty steel bowl, weight of the bowl plus wet samples and weight of the bowl plus dried samples are all recorded for moisture calculation.

3.2.2 Pulverization

- The dried sample is pulverized using steel discs to get fine powder of less than 150 μ m.
- To avoid contamination of samples during pulverization, the sand is pulverized between one sample and another. The compressor is applied to remove dust from the pulverizer.
- After pulverization, samples are homogenized to get representative samples for the assay.
- From each concentrate sample of 200-300g, exactly 15.00g is weighed, mixed with flux and put into crucibles ready for fusion.

3.3 Slag Samples

- Slag samples are pulverized to get finest particles.
- Sorting and homogenization processes are followed and finally the samples are weighed (15.00g each sample), mixed with fluxes and put into crucibles ready for fusion.

3.4 Matte Samples

GAP laboratory receives matte samples of about 4g each from the mines. The exact weight of each sample is recorded and then mixed with fluxes, placed into crucibles ready for fusion.

3.5 Magnetic Samples

- The exact weight of magnetic sample is recorded
- The sample is transferred to an oven for drying, followed by pulverization and homogenization of the sample.
- Finally, exact weight of 15.00g is taken, mixed with fluxes, put into crucibles ready for fusion.

3.5.1 Flux Composition

The GAP laboratory uses the following composition of fluxes:

Type A

- Sodium Carbonate..... 11.06Kg
- Lead monoxide..... 28.76Kg
- Sodium tetra borate..... 4.43Kg
- Sand..... 4.43Kg
- Sugar..... 1.33Kg

Type B

- Potassium Nitrate..... 15g
- Sand..... 20g
- Lead monoxide..... 30g

Type A flux is the homogenized mixture of the five components above. During the fusion process, each sample is mixed with 113g of Type A flux and the three individual components of Type B flux. A total of 178g of fluxes are consumed by each sample.

3.6 Fusion and Cupellation

3.6.1 Fusion

- Fusion is carried out on samples of magnetic, matte, concentrate and slag. Bullion samples do not undergo fusion process.
- In the fusion step of the assay, a known quantity of concentrate, slag, magnetic or matte sample is put in a crucible, mixed with Type A and B fluxes and heated for 90 minutes in an electric furnace set at (1050-1100°C).



Fig. 4 Crucible

- During this process, the precious metals in the sample are collected by the melting lead. Some samples with high sulphur or copper content may interfere with cupellation process. The results will depend on how much sulphur and other impurities are in the samples. In case of that situation, addition of nails during fusion is needed so as to remove sulphur and other impurities.
- At the end of the fusion, the molten mixture of metallic lead and slag is poured into a conical mould and is allowed to cool. A lead button, containing the precious metals, forms at the bottom of the mould and is readily separated from the glassy slag. The lead button is weighed and then hammered to a rectangular shape. Lead foil is added to form a cupellation lead button of not less than 90g.

3.6.2 Cupellation

- In cupellation, the lead button obtained from **matte, magnetic, or slag** sample is placed into a small porous crucible called cupel and heated in an electric furnace set at 950°C. The lead metal turns back into oxide which volatilizes away from the precious metals and soaks into cupel, leaving the minute amount of precious metals (gold & silver) as a metallic speck of metal called a "bead" on the bottom of the cupel.



Fig. 5 Cupellation Process

- The cupellation time always depend on the oxidation rate, which usually takes up to 160 minutes.
- At the end of cupellation, the cupel is removed from the furnace and allowed to cool slowly, and then the bead is taken from the cupel and weighed ready for parting.
- For a **bullion sample**, cupellation is done by taking usually 200mg from a 4g sample. The 200mg is then wrapped with 6g of lead foil. The leaded sample is hammered into a cube and placed into a cupel to undergo cupellation. During cupellation process, some impurities like base metals contained in the bullion are removed. After cupellation, the bead produced is weighed. At this stage, the bead is assumed to contain only precious metals (gold and silver) and is ready for parting.

3.7 Parting and Annealing

3.7.1 Parting

- Parting is the process whereby silver and gold are separated .Parting will be effective if the weight ratio of silver is three times to that of gold.
- To accomplish parting process, the bead(s) obtained after the cupellation process are weighed and known amount of silver (at a ratio of silver 3: gold 1) is added.

- The silver and bead are wrapped into 6g lead foil and cupelled to produce dore bead.
- The dore bead is weighed, flattened and then passed between a hand operated roller to form spirals called cornets.
- The cornets are put into a platinum vessel containing platinum thimbles with fine slits.
- The platinum vessel is then placed into a large beaker containing parting acid.
- Parting is done with 33% nitric acid and finish with 66% nitric acid. The silver in the cornet forms a solution of silver nitrate that is washed away until only gold remains.

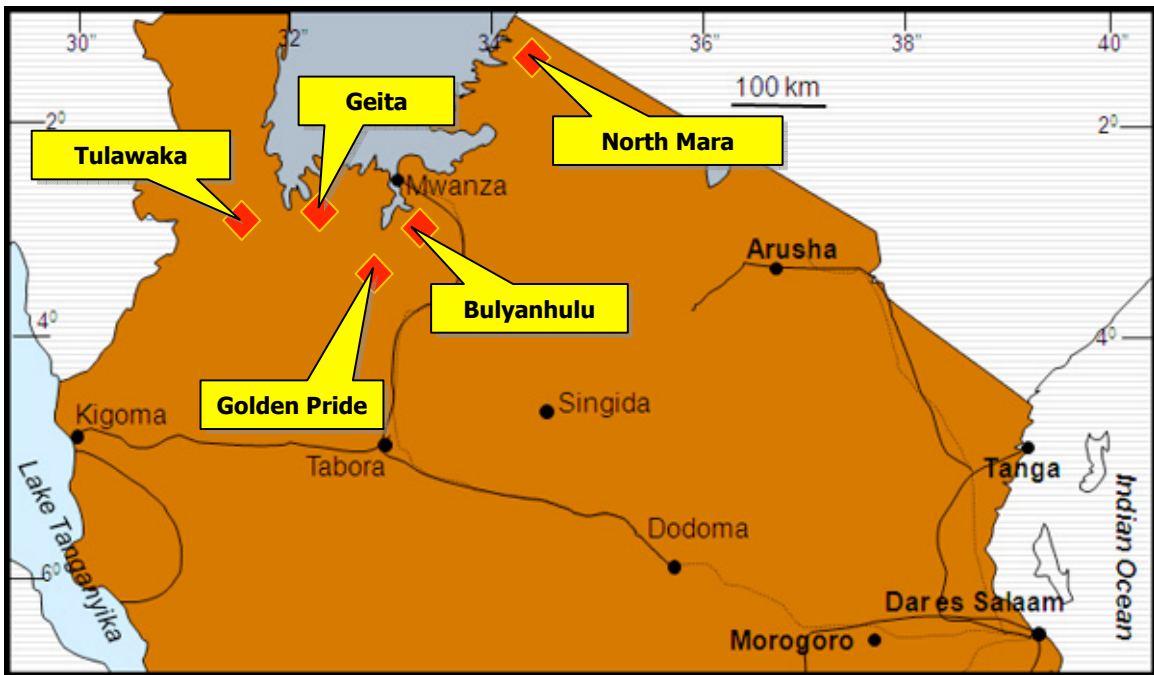
3.7.2 Annealing

- Annealing is done by heating the parted cornet in an oven at 750°C for five minutes and cooling to room temperature. Annealing improves ductility and reduces brittleness of the parted gold (cornet).
- Finally the annealed cornet is weighed as pure gold.



Fig. 6 Weighing of fine gold

GOLD MINES CURRENTLY UNDER GAP AUDIT



GOLD AND SILVER PRODUCTION SUMMARY 2003 – 2006

