# TECHNICAL REPORT - RESOURCE AND RESERVE UPDATE FOR THE TENKE FUNGURUME MINE, KATANGA PROVINCE, DEMOCRATIC REPUBLIC OF CONGO

**Prepared for**

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# CAUTIONARY NOTE WITH RESPECT TO FORWARD LOOKING INFORMATION

This document contains “forward-looking information” as defined in applicable securities laws. Forward looking information includes, but is not limited to, statements with respect to the future production, costs and expenses of the project; the other economic parameters of the project, as set out in this report, including expansion plans; the success and continuation of exploration activities; estimates of mineral reserves and resources; the future price of copper and cobalt; government regulations and permitting timelines; estimates of reclamation obligations that may be assumed; requirements for additional capital; environmental risks; and general business and economic conditions. Often, but not always, forward-looking information can be identified by the use of words such as “plans”, “expects”, “is expected”, “budget”, “scheduled”, “estimates”, “continues”, “forecasts”, “projects”, “predicts”, “intends”, “anticipates” or “believes”, or variations of, or the negatives of, such words and phrases, or statements that certain actions, events or results “may”, “could”, “would”, “should”, “might” or “will” be taken, occur or be achieved. Forward-looking information involves known and unknown risks, uncertainties and other factors which may cause the actual results, performance or achievements to be materially different from any of the future results, performance or achievements expressed or implied by the forward-looking information. These risks, uncertainties and other factors include, but are not limited to, the assumptions underlying the production estimates not being realized, decrease of future copper and cobalt prices, cost of labour, supplies, fuel and equipment rising, the availability of financing on attractive terms, actual results of current exploration, changes in project parameters, exchange rate fluctuations, delays and costs inherent to consulting and accommodating rights of local communities, title risks, regulatory risks and uncertainties with respect to obtaining necessary surface rights and permits or delays in obtaining same, and other risks involved in the copper and cobalt production, development and exploration industry, as well as those risk factors discussed in Lundin Mining Corporation’s latest Annual Information Form and its other SEDAR filings from time to time. Forward-looking information is based on a number of assumptions which may prove to be incorrect, including, but not limited to, the availability of financing for the projects production, development and exploration activities; the timelines for exploration and development activities on the property; the availability of certain consumables and services; assumptions made in mineral resource and reserve estimates, including geological interpretation grade, recovery rates, price assumption, and operational costs; and general business and economic conditions. All forward-looking information herein is qualified by this cautionary statement. Accordingly, readers should not place undue reliance on forward-looking information. Lundin Mining Corporation and the authors of this report undertake no obligation to update publicly or otherwise revise any forward-looking information whether as a result of new information or future events or otherwise, except as may be required by applicable law.

# DATE AND SIGNATURE PAGE

**Title: Technical Report - Resource and Reserve Update for the Tenke Fungurume Mine, Katanga Province, Democratic Republic of Congo**

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|---|---|
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**Qualified Persons:**

John Nilsson, P.Eng. President of Nilsson Mine Services Ltd, was responsible for preparation of portions of Section 1 through 13, Section 15 through 27 of the report. For information concerning legal, environmental, social, political, product market and metal prices the author has relied on without verification information provided by Lundin Mining Corporation and their employees who have intimate knowledge and responsibility for those aspects of the information.

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Ronald G. Simpson, P.Geo. President of GeoSim Services Inc, was responsible for preparation of portions of Section 1, Section 7 through 12 and Section 14 and 26 of the report including a review of the resource estimation procedures.

Signed: Date: 21st July 2014

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## Abbreviations and Units - Unless otherwise noted:

| | |
|---|---|
| $ | United States dollars |
| Anticline | A fold, generally with strata dipping in opposite directions, which core contains the stratigraphically older rocks. |
| AS | Acid Soluble |
| Blank | Sample without metal content to check possible contamination during assaying (e.g. crushed vein quartz) |
| CIM | Canadian Institute of Mining, Metallurgy and Petroleum |
| Cut-off | Grade above which mineralized material is considered to be ore. |
| DGPS | Differential Global Positioning System - More accurate version of GPS |
| Dilution | Non-ore material that gets mixed with ore during the mining process |
| Dip | The angle at which a stratum is inclined from the horizontal, measured perpendicular to the strike and in the vertical plane. |
| DTM | Digital terrain model - Electronic computer model of topography |
| Duplicate | Sample that has been split from another to check the field sampling or laboratory's precision |
| HQ | Diamond drill core diameter 63.5 mm |
| Jones Riffle Splitter | Equipment to split particulate samples into smaller, representative amounts for assay |
| Kriging | Grade estimation technique incorporating variability by distance |
| lb | pound |
| Lerchs Grossman | Algorithm used to maximize the gross value of the pit. |
| LME | London Metal Exchange - one of the world's premier non-ferrous markets |
| LAK | Local Anisotropy Kriging |
| Minesight | Computer program by Mintec that is used to carry out resource estimation and mine planning. |
| Mlb | Million pounds |
| mRL | The relative height as compared to the sea level - meters |
| Mtpa | Million tonnes per annum |
| NQ | Diamond core diameter 47.6 mm |
| Ordinary Block Kriging | Estimation of grades into block model using a grade estimation technique incorporating variability by distance |
| Ore | Mineralized material that can be economically mined |
| ppm | Parts per million. |
| PQ | Diamond core diameter 85.0mm |
| Precision | The ability to obtain the same result each time |
| RC | Reverse Circulation Percussion Drilling – style of drilling which gives chip samples rather than a core sample |
| Reference sample/material | Specially prepared sample whose metal grade is very accurately known and certified |
| ROM | Run of Mine |
| SAG | Semi Autogenous Grinding - a grinding technology which uses a smaller amount of grinding media (i.e. mill balls) compared with ball milling |
| Strike | The direction of the line formed by the intersection of the bedding plane of a bed or stratum of sedimentary rock with a horizontal plane. |
| Strip Ratio | Ratio of waste that needs to be mined to obtain a unit of ore. Usually expressed as tonnes of waste to tonnes of ore |
| Syncline | Folded rock strata, with younger layers closer to the center of the structure. |
| Tailings | The reject material from the processing plant |
| Tpa | Tonnes per annum |
| Tpd | Tonnes per day |
| TCu | Total Copper |
| TCo | Total Cobalt |
| TSX | Toronto Stock Exchange |
| UTM | Universal Transverse Mercator grid is an internationally recognised coordinate system to enable the pinpointing of any location on the planet. |
| Variogram | Mathematical and graphical way of representing variation of data as a function of separation distance |

# 1 SUMMARY

Lundin Mining Corporation ("Lundin" or the "Company") indirectly owns a minority equity position in Tenke Fungurume Mining S.AR.L. ("TFM") which operates the Tenke Fungurume mine. This Technical Report has been prepared for Lundin to provide updated information on the overall operation, the related facilities, the completion of the Phase 2 Expansion and the Mineral Resource and Reserve estimates at December 2013.

## 1.1 TENKE FUNGURUME MINE - PROPERTY DESCRIPTION

The Tenke Fungurume copper-cobalt deposits are believed to be among the world's largest known copper-cobalt resources. The deposits are found within contiguous mineral concessions totaling 1,437 km$^2$ and located at approximately latitude 10°S and longitude 26°E, some 175 km northwest of Lubumbashi, the administrative centre and capital of Katanga Province, Democratic Republic of Congo (DRC), as shown in Figure 1-1 .

**Figure 1-1 Tenke Fungurume Location Map**

Commercial production from these resources commenced in 2009 from a new large-scale, long-life, low unit cost mine that was developed at a capital cost of approximately $1.8 billion. A Phase 2 Expansion of the operation was substantially completed in 2013 that increased the name plate production capacity to 195,000 tpa of copper cathode. Freeport-McMoRan Copper and Gold Inc ("FCX") is the operator of the mine. The 2013 full year production was 210,000 t of copper cathode. The deposits are made up of oxide, mixed oxide/sulphide and sulphide zones. The December 31, 2013 FCX Mineral Reserve estimate is 113.4 million metric tonnes with an average grade of 3.34% copper and 0.36% cobalt. In addition, accumulated low grade work-in-progress (WIP) stockpiles total 30.7 million metric tonnes with an average grade of 1.25% copper and 0.33% cobalt.

## 1.2 OWNERSHIP

TFM was established in December 1996 under the DRC Companies Act and formed for the purpose of developing the deposits of copper, cobalt and associated minerals under mining concession nº 198[1] and mining concession nº 199[2] granted to TFM in 1996 at Tenke and Fungurume. FCX, who indirectly owns 56% of TFM, is the operating partner. La Générale des Carrières et des Mines (Gécamines), the Congolese state mining company, holds a repayable carried 20% interest in the operation. Owing to Gécamines' carried interest, capital funding is provided by FCX and the Company as to 70% and 30%, respectively.

Lundin Mining originally held an indirect 24.75% interest in TFM, which holds the Tenke Fungurume copper and cobalt concessions in the DRC. The Company's interest in TFM was reduced to 24% in March 2012 after receiving the required government approval of the modifications to TFM's bylaws.

## 1.3 PROPERTY DEVELOPMENT

Construction of Tenke Fungurume was formally approved by the Phelps Dodge Corporation ("Phelps Dodge") prior to year end 2006. Phelps Dodge was subsequently acquired by FCX in March 2007. The project was commissioned during the first half of 2009, with the first copper cathodes stripped in March and first cobalt hydroxide produced in May. The final capital cost of the project, at approximately $1.8 billion, represented the largest ever foreign direct investment in the DRC. This figure does not include approximately $250 million in loans and oversight payments projected to be paid to SNEL by the end of 2015, the DRC state power authority, for regional power facility upgrades to provide reliable power through the national grid to service the Tenke Fungurume mine facilities and future expansion requirements.

The current Tenke Fungurume mine includes the mining, processing and general infrastructure on the Tenke Fungurume concession for the exploitation, initially, of oxide ores. Copper and cobalt will be recovered from Kwatebala, Fungurume, Fwaulu, Kansalawile, Mambilima, Mwandinkomba, Pumpi, Tenke, Fungurume VI, Kazinyanga, Kato L3K, Shinkusu, Zikule and Mudilandima deposits (together, the "Tenke-Fungurume Deposits"). The operation was originally designed to process 8,000 tpd of ore for the production of 115,000 tpa copper cathode and in excess of 8,000 tpa of cobalt as hydroxide. Subsequent debottlenecking, plant upgrades and the Phase 2 Expansion, including an increased mining fleet, has

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[1] Renumbered nº 123 by the *Cadastre Minier Certificat d'Exploitation* nº CAMI/CE/940/2004 dated November 3, 2004; subsequently divided and renumbered nº 123, nº 9707 and nº 9708 by the *Ministère des Mines* through Ministerial Decree

[2] Renumbered nº 159 by the *Cadastre Minier Certificat d'Exploitation* nº CAMI/CE/941/2004 dated November 3, 2004; subsequently divided and renumbered nº 159, nº 4728 and nº 4729 by the *Ministère des Mines* through Ministerial Decree.

allowed production to increase to a nameplate 14,000 tpd process plant throughput for the production of 195,000 tpa copper cathode and approximately 15,000 tpa of cobalt as hydroxide.

## 1.4 PHASE 2 EXPANSION

In February 2011, FCX initiated the TFM Phase 2 Expansion Project Feasibility Study. The objective of the study was to evaluate the technical, social, environmental and cost requirements to increase the throughput of the existing facility from 10,000 to 14,000 tonnes of ore processed per day, with a resulting increase in copper production from 135,000 tpa to 195,000 tpa.

The Phase 2 Expansion Project scope included expanding the existing facility to achieve a 40% increase in ore processing capacity. The project scope included upgrades to all systems required to achieve the specified plant throughput, including upgrades to the mine, process plant, site utilities/services and off-site infrastructure. Also included in the project scope were new facilities, or upgrades to existing facilities, required to execute the capital project, such as the construction camp, temporary construction facilities, etc. The total capital expenditure required to provide the incremental capacity was estimated to be $850 million. The original approved budget for the project was $755 million and with some further reductions in 2013 to $715 million. The overall capital cost of the expansion was $670 million at December 31, 2013.

The key Phase 2 Expansion scope/budget items included were:

- Expansion of the mine equipment fleet to increase annual material moved from 23 to 54 million tonnes.
- The installation of a new jaw crusher and a SAG mill pebble crusher to the grinding circuit, and the later addition of a ball mill.
- Upgrades and reconfiguration throughout the leach, CCD and copper and cobalt purification plants to pumps, piping, thickeners and clarifiers to cater for the increased flows.
- The completion of four new mixer settlers in the Solvent Exchange section of the process plant.
- A 100% expansion of the existing Electro-Winning tankhouse with 280 new cells, two high speed stripping machines and two new cranes. The new tankhouse capacity is approximately 270,000tpa of copper cathode.
- An additional sulphuric acid storage tank and, in 2014, commencement of a second new acid plant, schedule to start up in 2016.
- An additional two 60 tpd burners in the $SO_2$ plant.
- Appropriate expansions to all other ancillary services and infrastructure.

The expansion is substantially complete with a demonstrated mill throughput capacity of up to approximately 15,500 tpd, in excess of the 14,000 tpd nameplate capacity. The 2013 full year production was 210,000 tonnes of copper cathode and 12,800 tonnes of cobalt in hydroxide. At the time of report writing, FCX's first quarter 2014 guidance is 200,000 t copper cathode and 13,600 tonnes of cobalt in hydroxide for full year 2014.

The current Life of Mine plan ("LOM") is based upon 14,500 tpd mill throughput.

The plant site configuration from 2010 and the completed expansion in 2013 are shown in the following figures.

**Figure 1-2 Plant Site Perspective View 2010**

**Figure 1-3 Tankhouse Completed as seen in November 2013**

## 1.5 ENVIRONMENTAL AND SOCIAL ASPECTS

Environmental and social aspects of the Tenke Fungurume concession development have been assessed carefully and systematically since the inception of project planning and site activity.

Key environmental issues addressed have included mitigation of damage to indigenous flora unique to the copper belt, installation of tailing impoundments and process water containment areas with impermeable liners, management of drainage systems to provide sediment control and minimize impacts on local water courses and other project development measures to achieve high international environmental development standards.

Key social issues addressed by the operation included relocation of approximately 1,500 villagers from three subsistence level settlements nearby the Kwatebala plant site, upgrading agricultural practices to improve local productivity, generation of an unprecedented level of regional employment both during construction and permanent operations, malarial abatement programs, construction of 6 primary schools, fresh water supply and other medical and regional social condition improvement programs. Local opportunities have also been generated by support provided to more than two dozen micro enterprise initiatives stimulating indirect employment.

The operation has invested in provincial infrastructure to provide rebuilding support to the DRC. This includes loans and direct investment, technical and project management assistance to rebuild hydro power generation and transmission capability and reliability, upgrade of the national road between Likasi and Kolwezi, and improvements at the DRC-Zambian border crossing at Kasumbalesa aimed at improving bulk road transport efficiency to the region. The N'Seke project loan through December 31st was $152 million net of interest and repayments and SNEL oversight. The current projection is for $250 million loan and oversight by the end of 2015.

FCX and Lundin are committed to the development and operation of the Tenke Fungurume mine under the following standards:

- Equator Principles
- Voluntary Principles of Security and Human Rights
- Applicable IFC and World Bank guidelines
- Applicable WHO guidelines
- Extractive Industry Transparency Initiative

An initial reclamation and closure plan has been developed for the mining of the Kwatebala, Tenke and Fwaulu orebodies with their associated processing facilities and other infrastructure. The development of this closure plan has been ongoing and will evolve over the life of mine as additional deposits are mined and processing facilities enlarged. The overall objective of the closure and reclamation plan will be, to the extent possible, reinstate the mosaic of agricultural land and Miombo woodland present taking into account the unavoidable mining disturbances.

The original Kwatebala Environmental and Social Impacts Assessment ("ESIA") issued in 2007, the Phase 2 Expansion Project ESIA Addendum issued in March 2011, and the Oxide Project ESIA issued in August 2013 (for future oxide mining areas) were each prepared in accordance with best international practice and in general conformance with the policies and guidelines of the World Bank Group as well as the environmental quality standards of the DRC.

Preparation of the Plant Expansion ESIA Addendum began with a draft report in August 2010. Following an additional round of public open house consultations in November/December 2010, the final

Addendum was completed and submitted to the DRC government (in French) in March 2011. A Letter of No Objection was received from the DRC Government June 27, 2011.

As part of ongoing development of the Mineral Resources within TFM's mining concession, TFM intends to expand its mining operations to include some of the oxide deposits in the Fungurume Hills, North and South Dipeta and Pumpi regions of the concession as well as expanding the tailings storage facility ("TSF") near the existing Kwatebala plant. This expansion is defined as the Oxide Project as detailed in the 2013 ESIA, which is being implemented to ensure that the environmental and social consequences of the project are fully understood and that potential impacts are adequately managed.

TFM commits to obtaining all necessary permits and authorization to proceed with the Oxide Project as well as to comply with applicable international treaties and agreements to which the DRC is signatory, including treaties that protect biodiversity, endangered species, various ecosystems and monitoring of greenhouse gas emissions.

It should be noted that the Oxide Project ESIA includes definition of future heap leach facilities in addition to the currently permitted Tenke heap leach facility. The design and location of these future facilities have not been determined and will need to be addressed through a future addendum to the Oxide Project ESIA.

The original ESIA identified 115 million tonnes as the tailings design capacity and includes expansions to the southwest towards the Fwaulu deposit. The LOM tailing storage requirement is estimated at 157 million tonnes. The Amended ESIA assessed expansions of the existing tailing storage facility beyond those included in the original ESIA (i.e., northwest extension) and, if necessary, the construction of a new TSF. An alternative site selection study for tailing storage facilities prepared by Montgomery Watson Harza America Inc. ("MWH") in December 2008 was included in the Amended ESIA.

For the Oxide Project, no significant differences between the nature of the different tailings materials from the different pit areas are expected. Oxide Project tailings that will go into the Northwest Extension TSF will be a blend of processed ore from the Oxide Project pits, Kwatebala pit, and Tenke and Fwaulu pits.

### ISO 14001-2004 Certification

On January 21, 2013, TFM received the ISO 14001-2004 Certification following a December 2012 audit. This is a internationally recognized environmental management standard that specifies a set of environmental management requirements for environmental systems. The purpose of this standard is to help organizations to protect the environment, to prevent pollution and to improve their environmental performance.

## 1.6 GEOLOGY AND MINERALIZATION

The Tenke-Fungurume Deposits are sediment hosted copper deposits located in the Lufilian arc, a 500 km fold belt formed between the Angolan Plate to the southeast and Congo Plate to the northwest during the late Neoproterozic approximately 650 to 600 million years before present (Ma). The arc trends north-easterly from Kolwezi in the southern DRC to Luanshya in Zambia. The Central African Copperbelt lies within the Arc and contains the world's largest resources of cobalt and is one of the most significant copper-bearing regions of the world.

Copper-cobalt mineralization at Tenke-Fungurume is stratabound and is mainly associated with two dolomitic shale horizons (RSF and SDB respectively), each ranging in thickness from 5 to 15 m, separated by some 20 m of cellular silicified dolomite (RSC). Primary copper and cobalt mineralogy is predominately chalcocite ($Cu_2S$), digenite ($Cu_9S_5$) bornite ($Cu_5FeS_4$), and carrollite ($CuCo_2S_4$). Oxidation has resulted in widespread alteration producing malachite ($Cu_2CO_3(OH)_2$), pseudomalachite ($Cu_5(PO_4)_2(OH)_4$), chrysocolla (hydrated copper silicate) and heterogenite ($Co_3+O(OH)$) .Regional structure is dominated by folding and faulting of an allochthonous terrane with a relatively thin skin of sedimentary rocks thrust over younger rocks. Overturned stratigraphy and smaller thrust slivers are common as a result of regional compression. The Tenke Fungurume concession encloses thrust slices of various dimensions and orientations. The northern portion is relatively undisturbed with a gentle northerly dip, while the southern portion is occupied by the Dipeta syncline. At its eastern extremity the syncline is closed by a series of thrust blocks which form the Fungurume section of the deposits. At the western end, the northern limb of the syncline is terminated by a major dislocation which offsets the Tenke deposits to the northeast.

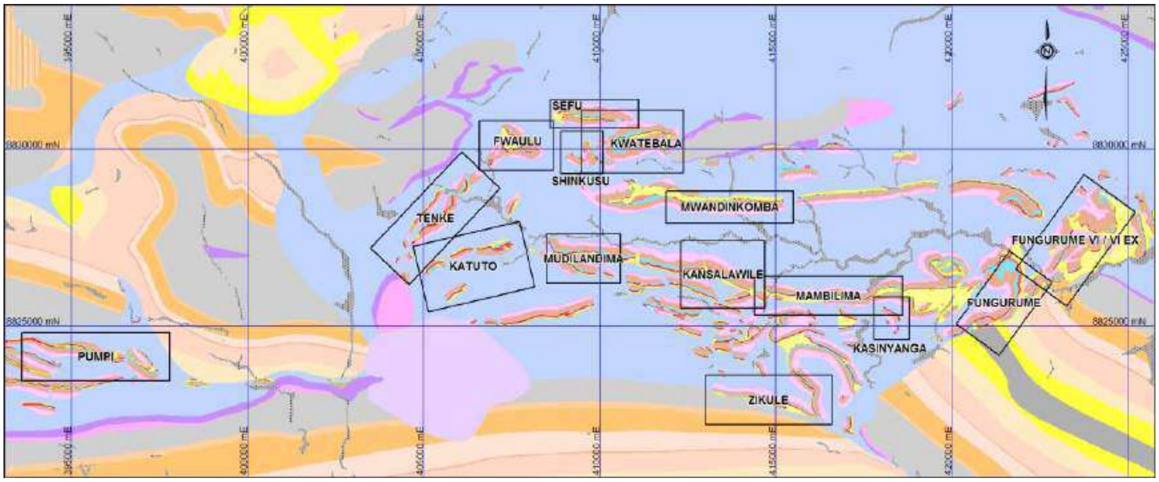
The dissolution of evaporites primarily in the RAT Lilac and Dipeta Group have resulted in additional structural complications that result in large blocks of deformed pieces of the productive sedimentary package “floating” in a sea of RAT and Dipeta. The numerous anticlines containing the mines Series écailles are cored by RAT polymictic breccias, brecciated RAT siltstones, and by RGS units. Gaps along blocks of the Mines Series within the RAT breccia are commonly filled in toothpaste fashion by RAT injection breccias which crosscut Mines Series units and can pierce up to the stratigraphic level of the CMN.

The elongate geometry of many anticlines, their RAT/RGS breccia cores, evaporite geochemistry and mineralogical evidence suggest that they represent former subvertical salt walls. Such salt walls can be several kilometers tall, several kilometers long, but commonly only tens to hundreds of meters across. Individual écailles can also move upward within the rising salt. Some of the anticlines appear to have been subjected to late Lufilian low-angle thrusting and folding. However, recent studies have suggested that these complex anticlinal apices are primarily products of diapirism, dissolution, and collapse.

## 1.7 MINERAL RESOURCES

The concessions host a large number of deposits as shown in the figure below. Resource models for Kansalawile, Kazinyanga, Kwatebala, Katuto, Shinkusu, Fungurume VI, Fwaulu, Mambalima, Mudilandima, Tenke, Zikule, Fungurume, Mwadinkomba and Pumpi are summarized in this report.

**Figure 1-4 Deposit Location Map**



The Tenke-Fungurume Mineral Resources with an effective date of 31 December, 2013 are summarized in the table below. A cut-off grade of 1.3% copper equivalent has been used for reporting. The cut-off grade is based on a copper price of $2.00/lb and cobalt price of $10.00/lb. It represents a potential economic cut-off based on relative recoveries and estimated average mining and processing costs. Mineral Resources have continued to increase due to TFM's extensive and successful mineral exploration programs on the concession. Mineral Resources have been reported inclusive of Mineral Reserves.

**Table 1-1 Tenke Fungurume Mineral Resource Summary**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| MEASURED | oxide | 108,699.5 | 2.77 | 0.32 | 4.04 |
| | ref. oxide | 229.0 | 1.94 | 0.15 | 2.54 |
| | mixed | 42,940.1 | 3.35 | 0.35 | 4.74 |
| | sulphide | 7,776.8 | 4.29 | 0.33 | 5.61 |
| | leached | 1,103.1 | 0.19 | 0.61 | 2.64 |
| | **Combined** | **160,748.4** | **2.98** | **0.31** | **4.22** |
| INDICATED | oxide | 231,076.0 | 2.24 | 0.26 | 3.26 |
| | ref. oxide | 1,057.3 | 1.55 | 0.13 | 2.08 |
| | mixed | 159,768.5 | 2.56 | 0.26 | 3.60 |
| | sulphide | 24,415.8 | 3.09 | 0.22 | 3.99 |
| | leached | 2,193.2 | 0.18 | 0.51 | 2.21 |
| | **Combined** | **418,510.8** | **2.40** | **0.26** | **3.42** |
| MEASURED & INDICATED | oxide | 339,775.5 | 2.41 | 0.27 | 3.50 |
| | ref. oxide | 1,286.2 | 1.62 | 0.13 | 2.15 |
| | mixed | 202,708.6 | 2.73 | 0.27 | 3.79 |
| | sulphide | 32,192.6 | 3.38 | 0.25 | 4.39 |
| | leached | 3,296.3 | 0.18 | 0.54 | 2.36 |
| | **Combined** | **579,259.2** | **2.56** | **0.27** | **3.65** |
| INFERRED | oxide | 80,496.9 | 1.88 | 0.206 | 2.71 |
| | ref. oxide | 115.4 | 2.51 | 0.12 | 2.98 |
| | mixed | 227,548.1 | 2.00 | 0.25 | 2.99 |
| | sulphide | 31,532.6 | 2.40 | 0.22 | 3.29 |
| | leached | 3,543.5 | 0.12 | 0.50 | 2.12 |
| | **Combined** | **343,236.6** | **1.99** | **0.24** | **2.94** |

## 1.8 MINERAL RESERVES

The open pit Mineral Reserves estimated for Tenke Fungurume are summarized in the table below. Reserves have been reported based upon break-even net ore value using variable recovery and operating costs that reflect variable gangue acid consumption and acid soluble grades. The 2013 Mineral Reserves are based on pit limits defined in the current mine plan, which use a breakeven cut-off grade of approximately 1.33% copper equivalent. Mineral Reserves have declined slightly for 2013 and head grades have increased marginally reflecting increased operating costs, unchanged metal price assumptions and resultant higher cut off grades. Exploration success has largely replaced depletion by mining.

Total Mineral Reserves are summarized in the table below including Probable stockpile material classified as work in-progress ("WIP-Probable").

**Table 1-2 Tenke Fungurume Mineral Reserves**

| Area | Ore t x 1000 | Cu% TCu | Co% TCo | Waste t x 1000 | Recoverable Cu% RCu | Recoverable Co% RCo | Recoverable Cu t x 1000 payable | Recoverable Co t x 1000 payable |
|---|---|---|---|---|---|---|---|---|
| **Summary** | | | | | | | | |
| **Proven** | 52,115.5 | 3.66 | 0.39 | | 3.14 | 0.29 | 1,638.7 | 151.7 |
| **Probable** | 61,323.2 | 3.07 | 0.33 | | 2.66 | 0.25 | 1,632.2 | 155.9 |
| **Subtotal** | **113,438.7** | **3.34** | **0.36** | **698,021.8** | **2.88** | **0.27** | **3,270.9** | **307.6** |
| **WIP - Probable** | 30,696.0 | 1.25 | 0.33 | | 1.14 | 0.27 | 349.6 | 84.0 |
| **TOTAL** | **144,134.7** | **2.89** | **0.35** | **698,021.8** | **2.51** | **0.27** | **3,620.4** | **391.6** |

## 1.9 MINE AND PRODUCTION PLANS

The table below shows the shows the build up of production from Tenke Fungurume for the last 5 years with the initial ramp up of production and latterly the impact of the Phase 2 expansion.

**Table 1-3 Historical Production**

| **Historical Production Statistics** | **Units** | **2009** | **2010** | **2011** | **2012** | **2013** |
|---|---|---|---|---|---|---|
| **Mine** | | | | | | |
| Ore Mined | mt | 6.2 | 8.5 | 10.0 | 12.8 | 13.2 |
| Waste Mined | mt | 10.3 | 10.5 | 13.8 | 25.0 | 37.0 |
| Total Mined | mt | 16.5 | 19.1 | 23.8 | 37.8 | 50.3 |
| Strip Ratio | | 1.7 | 1.2 | 1.4 | 1.9 | 2.8 |
| **Plant** | | | | | | |
| Ore Milled | mt | 2.1 | 3.8 | 4.0 | 4.7 | 5.4 |
| Average Cu grade milled | TCu% | 3.69 | 3.51 | 3.41 | 3.62 | 4.22 |
| Average Co grade milled | TCo% | 0.41 | 0.40 | 0.40 | 0.37 | 0.37 |
| Average TCu recovery | % | 92.1 | 91.4 | 92.5 | 92.4 | 91.4 |
| Average TCo recovery | % | 30.0 | 61.9 | 71.4 | 66.4 | 63.2 |
| **Production** | | | | | | |
| Copper Cathode | kt | 70.0 | 120.3 | 127.4 | 157.7 | 209.8 |
| Cobalt in Hydroxide | kt | 2.6 | 9.2 | 11.2 | 11.7 | 12.8 |

The Tenke Fungurume deposits are being mined using continuous surface miners combined with conventional drill-blast, load and haul open pit techniques. The mine and mill production plans are developed to maximize the copper and cobalt grades fed to the plant to fully utilise the processing capacities available. Nominal daily mill feed of oxide ore is 14,500 tpd. High grade copper ore is selectively fed to the plant while lower grade ore is stockpiled for treatment following the completion of mining. Current proven/probable reserves including WIP stockpiles support a facility life of 28 years of oxide ore feed to the mill (2014 to 2041) despite mining being completed in 2030. Total waste mined in the current mine plan will be 698 million tonnes.

Annual mine ore and waste production will be maintained at 53 million tonnes for thirteen years to 2026 followed by two years of 41 million tonnes (2027 and 2028) and gradually falling to 17 million tonnes in the final year of mining in 2030. The mill feed will have an average recoverable copper ("RCu") grade of 3.93% for nine years as a result of the high grade philosphy followed by a steady decline for the remaining 19 years of processing. Recoverable cobalt ("RCo") grade averages 0.28% through 2037 as low grade copper but higher grade cobalt ore is recovered from the WIP stockpiles. Copper cathode production will average 208,000 tpa over the 2014 to 2022 period followed by declining output for the remainder of the mine life. Cobalt production will average 15,000 tpa through 2037 then declines when processing final low grade stockpiles.

It should be noted that regular quarterly reporting updates by FCX and Lundin provide a more accurate forecast of copper and cobalt production in the short term, whereas production from the LOM plan as shown above is a forecast for the long term.

Development plans continue to progress for future phases of expansion at Tenke Fungurume with the long term objective of producing in excess of 450,000 tpa of copper. FCX and TFM continue to engage in exploration activities and metallurgical testing of mixed and sulphide mineralisation to evaluate the potential of the highly prospective minerals district at Tenke Fungurume. These analyses are being incorporated in future plans for potential expansions of production capacity. Future expansions are subject to a number of factors, including economic and market conditions, and the business and investment climate in the DRC.

## 1.10 MINERAL PROCESSING

The LOM model for the expanded Phase 2 processing plant processes 14,500 tpd to produce up to 208,000 tpa copper cathode and an average of 15,000 tpa cobalt contained in cobalt hydroxide.

Run-of-mine (ROM) ore is delivered by haul truck to the ROM pad. Front-end loaders feed a blend of ore to a mobile jaw crusher and conveyer to a single stage SAG mill. The SAG mill operates in closed circuit with a cluster of hydrocyclones and a pebble crusher to achieve the desired grind size.

The ground slurry is thickened, pumped to leach tanks and mixed with sulphur dioxide ($SO_2$), sulphuric acid ($H_2SO_4$) and raffinate to achieve a leach feed pulp. Copper and cobalt leach extractions are achieved in the leach operation. The leached slurry is thickened and the overflow is clarified and pumped to the high-grade (HG) pregnant leach solution (PLS) pond. After cooling the HG PLS is clarified to remove colloidal silica and suspended solids and then pumped to the HG solvent extractions circuit.

Thickener underflow is pumped to the counter-current decantation (CCD) circuit to recover dissolved copper and cobalt values from the leached solids. CCD 1 overflow is clarified and pumped to the low-grade (LG) PLS pond. The washed solids from CCD 5 are pumped to the neutralization circuit. CCD 5 underflow, excess CCD wash solution, and iron-aluminium-manganese (“FAM”) residue slurry streams are neutralized using hydrated lime. Hydrated lime is added to precipitate magnesium and trace heavy metals. The final neutralized slurry is pumped to the polyethylene lined tailings storage facility.

The solvent extraction facility has been expanded to include an additional four mixer settlers. The new configuration will be 2E(HG)-2E(LG)-2S-2E(HG)-2S. The expanded SX circuit consists of ten mixer settlers. The HG circuit has four extraction stages, the LG circuit has two extraction stages and the common organic stream is stripped in four stages. The circuit is configured to run in either a common organic loop or as a separate organic loop with 2E-2E-2S configuration of the existing circuit and 2E-2S for the expansion circuit.

Copper is extracted from the PLS solution using an organic extractant. The copper is subsequently stripped from the organic phase to produce strong electrolyte. The strong electrolyte is filtered to remove any entrained organic, prior to electrowinning. The LME Grade A cathodes are removed, washed, stripped, weighed and dispatched using semi-automatic stripping machines. The stainless steel cathode blanks are returned to the cells for re-use.

The HG raffinate and electrolyte bleed are combined in the HG raffinate pond and are returned to the leach circuit to reduce fresh $H_2SO_4$ consumption and to achieve the desired pulp density. LG raffinate from the solvent extraction is neutralized using limestone. Sulphur dioxide and air are sparged into agitated tanks to precipitate iron, aluminum and manganese under oxidizing conditions. The resultant slurry is thickened and filtered to recover the cobalt solution. The filter cake, containing predominantly gypsum, iron and aluminum hydroxides, is repulped and pumped to the neutralization circuit.

Milk of lime is added to the solution from the Fe/Al/Mn removal circuit to precipitate the remaining soluble copper. Sulphur dioxide and air are sparged into the agitated tanks to promote the precipitation of any remaining manganese. The slurry is thickened and the solids are returned to the leaching circuit for recovery of the precipitated copper.

Milk of magnesia is added to the solution from the copper precipitation circuit to produce cobalt hydroxide. Two stages of precipitation are used to improve the purity of the hydroxide precipitate and consequently reduce the consumption of magnesia. Magnesia is added in the first stage of precipitation and milk of lime is added in the second stage. Thickened underflow solids from the second stage are recycled back to the FAM circuit. The thickened cobalt hydroxide is filtered and bagged as a wet product for export or flash dried and bagged as a dry product for export. The cobalt-free solution is predominantly used as CCD wash solution, with the excess reporting to the neutralization circuit.

## 1.11 CAPITAL AND OPERATING COSTS

In September 2011, a feasibility study for the Phase 2 Expansion Project was completed by Hatch Ltd. (based in Toronto, Canada), which estimated a Phase 2 Expansion capital cost of $850 million. In 2012, TFM executed a value engineering exercise that reduced the project scope from the scope identified in the feasibility study by eliminating those scope items that did not directly contribute toward the Phase 2 Expansion copper production objective of 195,000 tpa. The result was the reduction to and approval of a $755 million capital budget allocation for the Phase 2 Expansion.

In 2013, TFM substantially completed the Phase 2 expansion project on time and under budget at $670 million spent at year-end 2013. A high level breakdown of the capital cost spent is shown in the table below.

**Table 1-4 Phase 2 Expansion Capital Cost Spent (Year-end 2013)**

| TFM Phase 2 Expansion | Capital Cost (US$ million) |
|---|---:|
| Mine Equipment | 108 |
| Crushing | 3 |
| Grinding | 3 |
| Cobalt | 3 |
| Leaching | 2 |
| DCS | 1 |
| Electrowinning | 130 |
| CCD | 11 |
| Reagents & Chemicals | 25 |
| Site Infrastructure | 26 |
| Tailings | 1 |
| Solvent Extraction | 55 |
| Utilities | 10 |
| Bulk Orders & Supplier P&Gs | 67 |
| Contracted Indirect Services | 64 |
| Project Management | 161 |
| Contingency | - |
| **Total Phase 2 Expansion** | **670** |

With the substantial completion of the Phase 2 Expansion and production of over 200,000 tpa copper cathode and 12,500 tpa cobalt in hydroxide in 2013, TFM continues to evaluate further debottlenecking and plant optimization actions to take advantage of the already installed excess tank house capacity as part of the operations' sustaining capital program.

### 1.11.1 SUSTAINING CAPITAL ESTIMATE

TFM plans for the installation of a new ball mill and new acid plant, which were a part of the Phase 2 expansion, were deferred in 2013 under a program of capital restraint. The timing of these projects and their subsequent commissioning were reviewed, with the decision being made that the addition of this second acid plant is now expected to be completed in 2016 and the ball mill in 2017.

The following table shows an estimate of annual capital spending to 2023, which excludes future potential phases of expansion. This estimate, based on 2013 year end Mineral Reserves and LOM plan, includes both the new acid plant and ball mill, as well as sustaining capital items such as support equipment, tailings dam raises and ongoing additions, replacements, and refurbishment of the mining equipment.

It should be noted that direct capital for future phases of potential expansion at Tenke have not been included in the TFM life of mine sustaining capital plans. Futures phases of potential expansion continue to be evaluated by TFM and FCX.

**Table 1-5 Sustaining Capital Cost Estimates**

| **Sustaining Capital Estimate** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|---|---|---|
| Annual Capital (US$ million) | 189 | 313 | 66 | 82 | 181 | 52 | 77 | 36 | 45 | 74 |

## 1.12 OPERATING COST ESTIMATES

Due to global economic changes and the natural volatility in commodities prices, operating cost projections are regularly updated by TFM on a quarterly basis. Costs reported reflect the Phase 2 plant operation with annual production varying year-to-year according to ore processed, ore composition and acid requirements.

The operating cost drivers which are particularly sensitive to change are fuel, sulphur (for acid), lime and transportation. Predicted annual operating costs by major category per tonne milled are shown in Table 21-3 below. These unit costs do not include royalties, advisory fees, by-product credits or cash taxes.

**Table 1-6 Operating Costs per Tonne Milled (Life of Mine: 2014 to 2041)**

| **Operating Cost** | **US$/ t milled** |
|---|---|
| Mine | 18.7 |
| Process | 47.5 |
| G&A (incl. export duties & non-cash taxes) | 16.4 |
| Delivery (transport) | 10.8 |
| **Total** | 93.4 |

## 1.13 EXPLORATION POTENTIAL

The Tenke Fungurume mineral concessions contain numerous outcropping mineral deposits many of which have not yet been drilled or modeled. Recent exploration programs have been focused on finding additional high-grade oxide resources to support expansion of the existing leach plant, with infill drilling upgrading the known reserves. Exploration has also targeted deeper mixed and sulphide mineralization to support metallurgical sampling and future development programs. Geophysical (IP) and seismic surveys have been employed, together with simple bedrock drilling/sampling programs using a reverse circulation rig and regional soil and stream sediment sampling to develop a pipeline quality long term and greenfield targets.

Seven new exploration targets are scheduled for drill testing over the next 4 years. Eleven developed deposits will be tested for definition and expansion of oxide, mixed and deep sulphide resources over the next 3 years.

Additional targets are expected to be identified once the new geophysical data is processed.

Drilling between Kansalawile and Mwadinkomba in 2013 confirmed the continuity of the Dipeta Syncline and Mine Series between these deposits at depth representing an enormous volume of prospective stratigraphy.

The exploration plan for 2014 encompasses 30,000m of drilling with a budget of $19M.

## 1.14 CONCLUSIONS

The main conclusions arising from review of the Mineral Resource and Reserve estimates and the current operations are as follows:

- The Mineral Resource and Reserve estimates have been prepared to NI 43-101 Standards.
- The Phase 2 Expansion has been substantially completed and the processing plant is now expected to operate with a throughput of 14,500 tpd or more.
- The current Mineral Reserves used for the mine plan are considered adequate to supply the process plant with 14,500 tpd over the remaining life of mine.
- All environmental and social permitting/plans are in place in support of continued operations.
- It is anticipated that ongoing exploration will continue to upgrade the confidence of known oxide Mineral Resources. In addition, mixed and sulphide Mineral Resources will continue to be added.
- Metallurgical test work and flow sheet development continue in support of developing additional Mineral Resources and Reserves for processing of low grade oxide, plus mixed and sulphide mineralization in the future. Associated mining, infrastructure, transportation, environmental and social studies are also underway with a view to further phases of expansion.
- Reconciliation between the long range mine plan (LRM), short range mine plan (SRM) and material sent to the process plant has been an ongoing issue since start-up. The SRM predicts more tonnes at lower copper grades but higher cobalt grades then the LRM. Improvements to short range mine grade control model are planned in mid to late 2014 after more information is gathered. Forecast improvement work will focus on sampling, geological interpretation, grade control, and short-range model development.

# 2 INTRODUCTION AND TERMS OF REFERENCE

Lundin Mining Corporation indirectly owns a minority equity position in TFM. TFM is operator and developer of the Tenke Fungurume deposits. This technical report has been prepared for Lundin Mining Corporation. This report updates and replaces the previously filed report titled "***Technical Report Expansion Study for the Tenke Fungurume Mine, Katanga Province, Democratic Republic of Congo***" dated December 15, 2011. The changes reflected in this Technical Report provide updated information regarding Mineral Resources and Reserves and development of the Tenke Fungurume Mine. The report has been prepared in accordance with National Instrument 43-101 Standards of Disclosure for Mineral Projects and has been prepared for Lundin Mining Corporation in compliance with its disclosure obligations according to Canadian regulatory requirements.

In 2007 a technical report was prepared by GRD Minproc Inc. entitled "***Tenke Fungurume Feasibility Study February 2007, Technical Report, Katanga Province, DRC***". In addition to the technical report previously filed in 2011, updates were also produced in 2008 and 2009.

Qualified personnel have visited the Tenke Fungurume property.

- John Nilsson P.Eng. undertook visits to Tenke Fungurume between February 16 to February 18, 2006, January 26 to January 30, 2009, November 30 to December 2, 2009, November 1 to November 5, 2010, October 31 to November 4, 2011 and November 18 to November 21, 2013 during which time he reviewed geological and mining data and visited the subject properties.
- Ronald G. Simpson P.Geo. undertook visits to Tenke Fungurume between January 26 to January 30, 2009, November 30 to December 2, 2009, October 31 to November 4, 2011 and November 18 to November 21, 2013 during which time he reviewed geological data and visited the subject properties.

# 3 RELIANCE ON OTHER EXPERTS

This report has been prepared by John Nilsson P.Eng. and Ronald G. Simpson P.Geo. The information for input into the resource models presented in this report that provide the basis for Mineral Resource and Mineral Reserve statements and mine plans have been prepared by staff of FCX.

The authors of this report state that they are qualified persons for those areas as identified in the appropriate "Certificate of Qualified Person" filed with this report. The authors have relied upon, and believe there is a reasonable basis for this reliance, the experts and reports, who/which have contributed key information as listed in Section 27.

All information relating to Social and Environmental aspects, infrastructure, mineral rights, legal regime, market analysis, product pricing, capital and operating costs and corporate structures are as supplied either by FCX or Lundin Mining Corporation.

# 4 PROPERTY DESCRIPTION AND LOCATION

## 4.1 LOCATION AREA AND BOUNDARIES

The Tenke Fungurume property comprises two concessions totaling 1,437 $km^2$ in the Katanga Province of the DRC. The Tenke Fungurume mine is located approximately 175 km northwest of Lubumbashi, Katanga Province, and 150 km due north of the border with Zambia.

The site is located about the following coordinates:

- Latitude $10^o$ 34' south of the equator
- Longitude $26^o$ 11' east of the Greenwich Meridian

The property boundaries were located consistent with the New Mining Code procedures and the boundary identification and filing system of the new Ministry of Mines Cadastre system, including identification and approval of refined boundaries set by GPS and physical monuments.

## 4.2 TENURE, TITLES ENCUMBRANCES

TFM has the right to develop the deposits of copper, cobalt and associated minerals under mining concession no. 198[3] and mining concession no. 199[4] at Tenke and Fungurume, respectively, in the Katanga Province of the DRC.

The mining concessions were granted to TFM in 1996 pursuant to DRC mining law under a mining convention dated November 30, 1996 ("Original Convention") by and among Lundin Holdings Ltd. (a Bermudan company, which owned 82.5% of TFM) ("LHL"), the Republic of Zaire, and La Générale des Carrières et des Mines (which owned 17.5% of TFM) ("Gécamines"). The mining rights were later amended and restated in an amended and restated mining convention dated September 28, 2005 ("ARMC"). Lundin Holdings Ltd. has subsequently been renamed TF Holdings Limited.

When the TFM investment project was agreed to in 1996, the applicable legislation governing the mining industry in the DRC was Ordinance-Law No. 81-013 dated April 2, 1981, enacting the general legislation on mines and hydrocarbons ("Mining Law"). The TFM investment project also was subject to the Ordinance-Law No. 86-028 dated April 5, 1986, ("Investments Code"), establishing criteria for the eligibility to the conventional system under the Mining Law.

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[3] Renumbered nº 123 by the *Cadastre Minier Certificat d'Exploitation* nº CAMI/CE/940/2004 dated November 3, 2004; subsequently divided and renumbered nº 123, nº 9707 and nº 9708 by the *Ministère des Mines* through Ministerial Decree dated February 20, 2009.

[4] Renumbered nº 159 by the *Cadastre Minier Certificat d'Exploitation* nº CAMI/CE/941/2004 dated November 3, 2004; subsequently divided and renumbered nº 159, nº 4728 and nº 4729 by the *Ministère des Mines* through Ministerial Decree dated July 7, 2006.

Under the Mining Law, large-scale mining is conducted pursuant to the granting of a mining concession, which grants an exclusive right to conduct all operations regarding prospecting, research and exploitation of the mineral substances within the delimited perimeter of the concession, without limit as to depth. The mining concession entitles its holder to proceed with all operations of concentration (milling), metallurgical and chemical treatment and transformation.

Under the Mining Law, a mining concession is granted for a term of 20 years and is renewable once or twice for successive 10-year terms. Thereafter, the mining concession holder may seek to obtain a new concession. The renewal is automatic, provided the concession holder justifies a real activity, presents an exploitation program deemed sufficient by the Service of Mines and duly preformed its legal duties during the prior concession period. TFM's right for renewal of its mining concessions is further secured by the ARMC, under which the DRC agreed to renew as of right TFM's mining concessions provided the property remains exploitable.

The Government of the Republic of Zaire and Gécamines entered into the Original Convention with LHL pursuant to the Mining Law on November 30, 1996. The Original Convention was further supported by the Investments Code, satisfying the criteria of an investment of major interest to the economic and social development of the DRC. The Original Convention governed the acquisition and operation by TFM of the deposits of copper, cobalt and other minerals under mining concessions no. 198 and mining concession no. 199 located in Tenke and Fungurume in the Katanga Province and further granted to TFM inter alia, a certain number of tax, customs and other advantages and incentives.

On July 11, 2002, the DRC established a new mining code for mining rights under Law No. 007/2002 ("New Mining Code"). The New Mining Code provided an exception from the application of the New Mining Code for mining conventions which were already duly signed and approved, hence TFM opted to remain under the Original Convention and the Mining Law. The effect is that the Original Convention (and the ARMC as described below) will continue to be governed by the Mining Law, however it was agreed to adopt fiscal terms consistent with those of the New Mining Code (taxes, duties and royalties) so that TFM developed the project providing fiscal benefits to the DRC in concert with fiscal principles included in the new World Bank sponsored code. It was also agreed to apply applicable provisions of the New Mining Code to the Project concerning validation and conformation of the mining concessions granted to TFM in the Original Convention.

After discussions with the DRC and Gécamines, the Original Convention was renegotiated between TFM and the DRC resulting in the ARMC dated September 28, 2005, effective since October 27, 2005. The ARMC amends and restates the Original Convention and is governed by the Mining Law. It sets out the contractual framework for the operation of the Project, the holding of the mining rights, the tax, customs and para-fiscal regimes, the financial and exchange system, the personnel and social investments and the environmental protection regime.

Pursuant to a stability of legislation clause in the ARMC, the rights and obligations of the parties unrelated to the statutory mining regime are primarily governed by the general laws of the DRC in force on November 30, 1996, the date of the Original Convention. The ARMC remains valid so long as the property in the concessions is exploitable.

Originally, mining concessions no. 198 and no. 199 belonged to Gécamines. In 1996, pursuant to the Original Convention, these concessions were transferred to TFM in exchange for a transfer bonus payment. At that time, LHL paid Gécamines US$50 million of the transfer bonus payment. Pursuant to the ARMC, LHL (now TF Holdings Limited) paid Gécamines an additional US$50 million upon achievement of certain milestones. Upon the entry into force of the ARMC, TF Holdings Limited paid Gécamines US$15 million, and completed payment of the remainder of the transfer bonus with transfers of US$5 million in 2008, and US$10 million annually from 2009 to 2011**.** Pursuant to the Original Convention and as restated in the ARMC, TFM enjoys all rights and privileges with respect to mining activity in mining concessions no. 198 and no. 199, as renumbered.

In February 2008, the Ministry of Mines, Government of the DRC, sent a letter seeking comment on proposed material modifications to the mining contracts for the Tenke Fungurume concession, including the amount of transfer payments payable to the government, the government's percentage ownership and involvement in the management of the mine, regularization of certain matters under Congolese law and the implementation of social plans.

In October 2010, the government of the DRC announced the conclusion of the review of Tenke Fungurume Mining SARL's mining contracts. The conclusion of the review process confirmed that TFM's existing mining contracts are in good standing and acknowledged the rights and benefits granted under those contracts. TFM's key fiscal terms, including a 30 percent income tax rate, a 2% mining royalty rate and a 1% export fee, will continue to apply and are consistent with the rates in the DRC's current Mining Code. In connection with the review, TFM made several commitments, which have been reflected in amendments to its mining contracts, including: an increase in the ownership interest of Gécamines, which is wholly owned by the government of the DRC, from 17.5% (non-dilutable) to 20.0% (non-dilutable), resulting in a decrease of Freeport effective ownership interest from 57.75% to 56% and Lundin Mining's effective ownership interest from 24.75% to 24%; an additional royalty of $1.2 million for each 100,000 tonnes of proven and probable copper reserves above 2.5 million tonnes at the time new reserves are established by FCX; additional payments totaling $30 million to be paid in six equal installments of $5 million upon reaching certain production milestones; conversion of $50 million in intercompany loans to equity; a payment of approximately $5 million for surface area fees and ongoing surface area fees of approximately $0.8 million annually; incorporating clarifying language stating that TFM's rights and obligations are governed by the Amended and Restated Mining Convention ("ARMC"); and expanding Gécamines' participation in TFM management.

TFM has also reiterated its commitment to the use of local services and Congolese employment. In connection with the modifications, the annual interest rate on advances from TFM shareholders increases from a rate of LIBOR plus 2% to LIBOR plus 6%. In December 2010, the addenda to TFM's ARMC and Amended and Restated Shareholders' Agreement were signed by all parties. In April 2011 the amended agreements were ratified by a Presidential Decree. On March 26, 2012 the President and Prime Minister of the DRC signed a decree approving the bylaw changes for TFM. Accordingly, the change in Lundin Mining's ownership interest in TFM and the conversion of intercompany loans to equity is now effective.

## 4.3 PERMITTING REQUIREMENTS

The development and operation of the mine is subject to a number of laws, regulations, standards and international best practice frameworks dealing with the protection of public health, public safety and the environment. Permits and authorizations are required, such as the construction of the four villages in a new location within the mining concession; wood felling; mine establishments; and mine operations including use of water resources, stormwater management and electrical infrastructure improvements.

In addition, TFM will augment these applicable performance standards (legally required) with a number of reference guidelines (not legally required), intended to assure that the project environmental performance meets or exceeds the expectations of the DRC and international stakeholders. Environmental and social action plans have been developed as part of an overall Environmental and Social Impact Assessment (ESIA) to guide compliance with these applicable standards and reference guidelines. The applicable standards are those embodied in the Equator Principles, those set forth in the Amended and Restated Mining Convention (ARMC) and those elaborated in a number of applicable DRC laws. The reference guidelines chosen for the project are USEPA environmental standards, standards of the World Health Organization and standards contained in the 2002 DRC Mining Law (including its 2003

Regulations). Under the terms of the Project's ARMC, TFM is not legally subject to the environmental and social provisions of the 2002 Mining Law. However, reference will be made to the environmental and social standards contained within the law and the operation has been designed to achieve general conformance with the standards.

Additionally, the DRC is a signatory to international treaties. The ones potentially applicable to the Project include the United Nations Framework Convention on Climate Change ("UNFCCC") and the Kyoto Protocol, Convention on Biological Diversity ("CBD"), Convention on the International Trade of Endangered Species of Wild Flora and Fauna ("CITES"), Treaty on the Central African Forests Commission ("COMIFAC Treaty") and The Convention on Wetlands of International Importance especially as Waterfowl Habitat ("Ramsar Wetlands Convention"). These treaties and their requirements were considered in the ESIA.

Based on the Amended EISA, the DRC Government – Mining Environment Protection Department issued a Letter of No Objection on June 27, 2011, which allowed the Phase 2 Expansion to proceed.

Based on the Oxide Project ESIA, the DRC Government - Mining Environment Protection Department issued a Letter of No Objection in late 2013, which legally permits TFM to mine the Fungurume to Pumpi deposits.

# 5 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

## 5.1 TOPOGRAPHY, ELEVATION AND VEGETATION

The dominant landform in the area of the facilities at Kwatebala is the Dipeta Syncline. This formation forms an east-west trending valley approximately 15 km long and 3 km wide. The Dipeta River runs along the valley bottom while the Kwatebala, Tenke and Fwaulu orebodies lie on the north-western crest of this valley. The orebodies presently form hills and ridges rising to elevations of about 1,500 m above sea level and up to 170 m above adjacent valleys. The plant site elevation is 1,200 m above sea level. Hillside slopes are generally steep, while valley bottoms are relatively flat. Valley bottoms and gentler slopes generally are farmed by hand or with oxen. The ore deposits lie on a surface water divide, with waters to the north flowing into the Mofya River and waters to the south flowing into the Dipeta River. These rivers are perennial and are used extensively by the local population for all domestic uses.

The project region is within the Miombo woodland belt of central Africa. The flora of the Tenke Fungurume Mine land surface area (“LSA”) is dominated by an agricultural mosaic of croplands and fallow fields. The second most common vegetation type is Miombo woodland. The third most common type of vegetation is degraded Miombo woodland (Miombo woodland that has been impacted by agricultural clearing activity). Copper-cobalt vegetation types occupy less than five percent of the LSA.

Of all vegetation types, the Miombo woodland had the greatest species diversity found. There are floral similarities between this vegetation type, the degraded Miombo woodland and agricultural mosaic because much of the landscape, if left undisturbed, would be the Miombo type. Remnant plants from Miombo woodland still exist in the other two vegetation types. Miombo woodland is under pressure from human activities. Clearing for agricultural purposes, charcoal and fuel wood collection, urbanization, infrastructure and industrial development are all reducing the size of the Miombo woodland community.

## 5.2 ACCESS

The TFM concession area is located in the DRC, approximately 175 km northwest of Lubumbashi. Infrastructure within Katanga Province is generally in a poor state of repair. There are no viable port facilities in this region of the DRC. Port facilities are available in The Republic of South Africa (RSA), Tanzania and Namibia. Access routes to ports are via Zambia, Botswana and Zimbabwe.

Road access within the DRC generally comprises hardened dirt roads that can be highly variable in quality. The road from Lubumbashi between Likasi and Tenke Fungurume was upgraded in 2008 to support the transportation of supplies for construction and operation of the mine. Seal coating was carried out during 2011.

The air strip at Tenke Fungurume consists of a 1,650 m long asphalt topped surface suitable for medium sized aircraft. TFM maintain the air strip in a good condition.

A regional map showing the road from Kitwe (Zambia) to the border at Kasumbalesa, through to Lubumbashi, Likasi, Fungurume and Tenke is presented in Figure 5-1.

**Figure 5-1 Regional Map Showing Access Route from Zambia to Tenke**

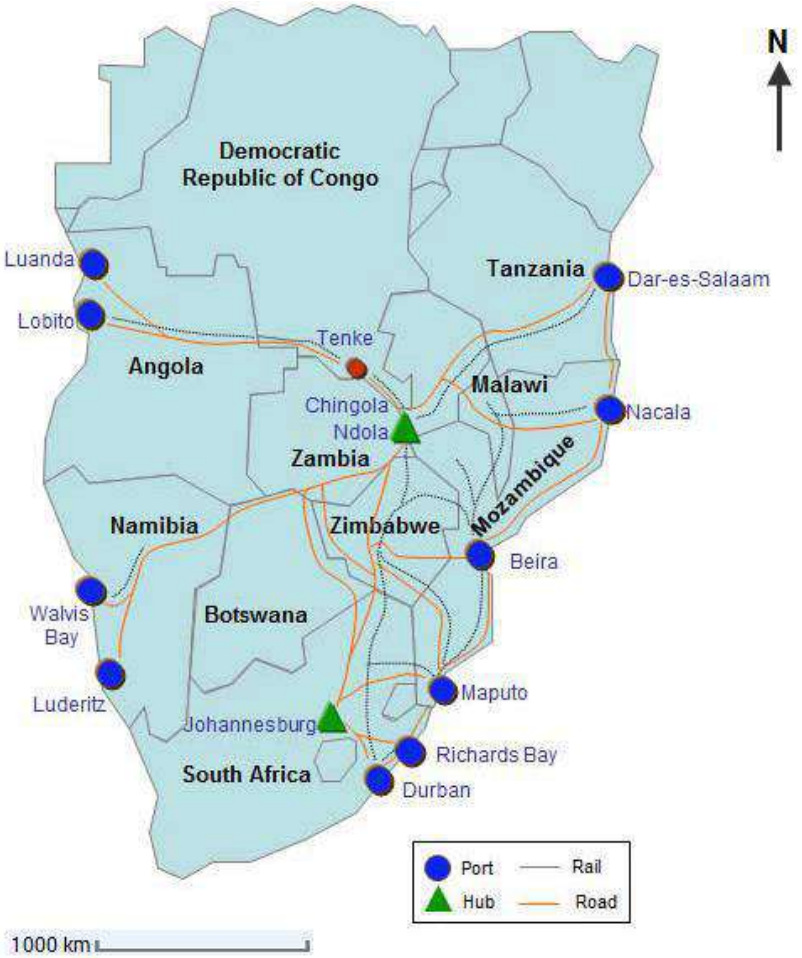
The rail system in the Katanga province servicing Tenke and Fungurume is a single track, accommodating only two trains per week with speeds limited to 25 km per hour, due to lack of maintenance of the tracks, and is inadequate for projected project requirements. No attempt has been made to upgrade this system.

From the DRC/Zambian border at Kasumbalesa, apart from some rail limitations, the transport infrastructure of the transit countries is generally adequate and provides a number of options for construction and operational requirements.

Road distances from Tenke to points of transit or import/export are as follows:

| | |
|---|---|
| Ndola (Zambia – transit) | 460 km |
| Johannesburg (RSA – transit) | 2,560 km |
| Dar es Salaam (Tanzania – port) | 2,490 km |
| Walvis Bay (Namibia – port) | 2,955 km |
| Richards Bay (RSA – port) | 3,000 km |
| Durban (RSA – port) | 3,160 km |

**Figure 5-2 Railroad, Road and Port Locations**



### 5.2.1 PROXIMITY TO LOCAL POPULATION CENTERS

The mine site is located in a hilly region within the Kolwezi District, between the urban centers of Fungurume and Tenke. A total of 41 rural villages also fall within the TFM project's LSA, including Mpala, Mitumbu, Mulumbu, Kiboko, Amoni, Mwela Mpande Gare, Kwatebala Gare and Lukotola. With a combined population of over 100,000, Tenke and Fungurume each serve as a primary transportation center and marketplace for the region. Between the urban centers of Tenke and Fungurume is a patchwork of farm fields, villages, forests and mineralized lands, which have undergone significant artisanal mining activities in the recent past.

Volumes of motorized traffic along roadways within the LSA are variable. Bicycle and pedestrian traffic remain the primary modes of transportation and account for a significant amount of the road traffic. The general condition of roads in the LSA is continually improved to facilitate the movement of goods, supplies and people.

### 5.2.2 SUFFICIENCY OF SURFACE RIGHTS

The DRC Mining Code provides surface usage rights to the owner of mineral concessions, which have reached the exploitation level. Given the extent of the mineralization, and the considerable size of the Tenke Fungurume mineral concessions, it is considered that there is ample area for expansion in the future. Future expansion potential has been considered and the following areas have been designed to accommodate expansion on surface areas controlled by TFM:

- the permanent village, Mikuba, to house operations personnel, has been designed on a modular basis for expansion purposes;
- the process plant layout allows for either incremental expansion or addition of complete unit operations;
- road and power corridors have adequate space for expansion and additional sites have been identified for tailings impoundment.

### 5.2.3 AVAILABILITY AND SOURCES OF POWER

The power supply to the plant site is provided via a high voltage overhead line from the Fungurume substation to the switchyard at the plant site. The power distribution around the plant is at 11 kV, 33 kV, 220 V, 380 V and 690 V as necessary for the operation of equipment. Power is also supplied to the permanent village from the Fungurume substation via a separate overhead line.

The Fungurume substation has been upgraded to provide a reliable power supply to TFM. TFM electrical load has been interconnected to the Fungurume substation in the Katanga grid, which is supplied by hydroelectric power. La Société Nationale d'Electricité (SNEL) is the state owned electric utility company serving the region and also exporting power to Zambia and South Africa. The Katanga grid receives 125 MW power from the Inga grid (1,800 MW installed generation capacity) through a DC link (500 MW inverter capacity). To satisfy the local load and the export to Zambia, the Katanga grid utilizes the following installed hydro-generation capacity (465 MW):

Nseke: (4 X 65 MW – 3 operating); 120/220 kV step-up; installed in 1956

Nzilo: (4 X 25 MW – 2 operating); 120 kV; installed in 1952

Mwadingusha: (3 X 10 MW & 3 X 12 MW – 3 operating); installed in 1928 and one additional unit added in 1953

Koni: (3 X 12 MW – 2 operating); installed in 1953

Smaller hydroelectric generation is connected to the 120 kV subsystem

The Katanga grid has two subsystems: 220 kV (Kolwezi SCK) and 120 kV (Kolwezi R.O.). Kolwezi R.O. connects to the Nzilo generation (120 kV). Kolwezi SCK connects to the Inga DC link and Nseke 220 KV stepped up voltage.

Kolwezi R.O and Kolwezi SCK are connected by 220/120 kV transformers. Fungurume substation is approximately 100 km from Kolwezi TFM is connected to Fungurume with a new transmission line (17 km). The local Tenke load is served by both the 120 kV line from Kolwezi R.O. and the 120 kV system stepped down from the three 220 kV transmission lines from Kolwezi SCK. The 120 kV local system is interrupted when the power is needed to support the export requirements.

TFM has signed a long term contract with Société National d'Électricité Limitée (SNEL) for supply of electricity from SNEL`s Nseke Power Station located west of the Tenke concessions towards Kolwezi. A separate contract includes provisions for TFM to loan SNEL the funds required to recondition the hydro electric station and increase generating capacity from three to four 65 megawatt units, as well construct new local transition lines to service the mine and neighbouring communities. The costs for this work will be repaid to TFM through a credit against future electricity charges. The initial phase of reconditioning the power station and construction of power lines was completed during the second quarter of 2009. The first generating unit refurbishment was completed in January 2011, a second has since been completed and the remaining two units will be refurbished in sequence with full completion expected in 2015.

TFM has secured five agreements with SNEL: a long-term purchased power agreement (PPA) to set the price TFM will pay for power, two finance agreements to finance improvements to the power system infrastructure, a maintenance agreement to ensure system reliability and an administration agreement to implement the finance and maintenance agreements.

There have been ongoing issues with power supply interruptions that occasionally limits production capability of the processing facility. Foreign investments in new and refurbishment of power generation and associated infrastructure in Katanga and DRC have increased in recent years and this trend is expected to continue. Katanga also draws power from the Southern African with power being routed via Zambia.

### 5.2.4 AVAILABILITY AND SOURCES OF WATER

Water supply is available within a reasonable distance of the mine site and plant. Appropriately spaced wells in three sub-catchments surrounding Kwatebala will sustain the mining and plant processes, with standby capacity. The three well-field areas in order of preference or convenience are near the plant site, south of Kwatebala and northwest of the TSF.

Additional process water requirements come from a combination of water from the TSF supernatant return water and potentially impacted run-off stormwater collected from the waste rock stockpiles and plant site.

Potable water is supplied to and reticulated throughout, the permanent village located north of Fungurume. The water for this application will be sourced from independent wells located at Fungurume.

### 5.2.5 AVAILABILITY OF TAILINGS AND MINE WASTE STORAGE SITES

The tailing facility lies to the west of the process plant and north-west of the Kwatebala pit. Othere areas for future tailings storage to support expansion have been indentified to the north and east of the current facility. Waste rock from Kwatebala open pit will is placed in several sites to both the north and south of the plant site. Future open pits on the other identified orebodies will have waste dumps located at suitable sites in close proximity.

### 5.2.6 MANAGEMENT OF WASTE

Management of wastes will include dedicated facilities for tailings, waste rock, and domestic, industrial and hazardous waste. All hazardous waste will be transported off site. Objectives for waste management are:

- Waste reduction, recycling, reuse and composting, and onsite treatment, as applicable

- Safe storage of any waste produced. Storage of waste is conducted such that the negative impacts to the environment (air, surface water, groundwater) will be minimized

The tailings facility is lined with an impermeable liner and virtually all tailings water will be recycled to the processing plant. Stormwater runoff from waste rock stockpiles, low grade ore stockpiles and from the plant site will also be collected and recycled to the processing plant and mining areas as required to maintain a net neutral water balance.

Solid wastes will be classified and sorted according to their characteristics as recyclable, suitable for clean landfill, compostable, or hazardous.

A comprehensive monitoring program will be implemented to track waste volumes and types, assess surface and groundwater conditions up-gradient and down-gradient of each major facility, and assess the integrity of the leachate collection systems, diversion berms and monitoring systems.

### 5.2.7 PROCESSING PLANT AND LOCATION

The processing plant is located 16 km west of the Fungurume village and 8 km north east of the Tenke settlement. The location was selected on the basis of proximity to the Kwatebala and Tenke deposits and topography in that area. As a result of the Phase 2 Expansion completion, the plant has demonstrated maximum ore throughput rates above 15,500 tpd during 2013. The plant is presently capable of and has been producing in excess of 200,000 tonnes of copper cathode and 15,000 tonnes of cobalt in cobalt hydroxide on an annual basis.

## 5.3 CLIMATE

The DRC's location in Africa, together with its undulating to high plateaus places it within the Köppen climatic classification of Cw, i.e. mild rainy, moist sub-tropical mid-latitude with dry winters. Three seasons can be recognized. The climate is cool and dry between May and August, hot and dry between September and October, and rainy between November and April.

The average annual rainfall is approximately 1,150 mm. The daily average relative humidity in the most humid month of January is 85%. The daily average in the least humid months between July and September is 55%.

| | |
|---|---|
| Monthly average temperature | 28°C (max); 20°C (min) – September<br>22°C (max); 13°C (min) – June |
| Extreme maximum temperature | 36.2°C – September |
| Extreme minimum temperature | 3.8°C – June |
| Maximum annual recorded rainfall | 1,419 mm |
| Average annual rainfall | 1,161 mm |
| Dry season | May – October |
| Wet season | November – April |
| Heaviest rains | December/January/March |

# 6 HISTORY

The Tenke Fungurume deposits have a history dating back to 1917. Although numerous studies, drilling campaigns and development efforts have been undertaken, the deposits had never been mined commercially until developed by Phelps Dodge. There are numerous discrete, generally outcropping deposits located within the concessions. The current mine plan addresses the development of and production from fourteen deposits; Kwatebala, Tenke, Fwaulu, Fungurume, Mambilima, Mwadinkomba, Kansalawile, Pumpi, Kanzinyanga, Mudilandima, Zikule, Kato-L3K, Fungurume VI and Shinkusu. A summary of the history of Tenke Fungurume is given in Table 6-1.

**Table 6-1 History of Tenke Fungurume**

| Date | Event or Milestone |
|---|---|
| 1917 to 1921 & 1942-1968 | Union Minière du Haut Katanga (UMHK) drilling, trenching, pitting and adit development at Fungurume and Tenke |
| 1969 to 1970 | La Générale des Carrières et des Mines du Zaïre (Gécamines) Limited drilling at Fungurume and Tenke |
| 1971 | Société Minière de Tenke Fungurume (SMTF) operating Arm of partners Charter Consolidated Limited (28%), Amoco Minerals Co (28%), Tempelsman and Son (3%), Omnimine (7%), Mitsui (14%) and the Zairian Government (20%) assumed control |
| 1971 to 1976 | $280 M expended for exploration, various studies, equipment and site infrastructure |
| 1976 | SMTF terminated interest due to deteriorating political and social situation, falling copper price and delays in construction of a power line through the region control reverted to Gécamines |
| 1994 | Lundin Holding Limited (LHL) commenced discussions with Gécamines |
| 1994 | Lundin commissioned SNC Lavalin Ltd's Mining and Metallurgical Division to assist in completing technical evaluation |
| Dec 1994 | Gécamines issued invitations for proposals to develop property |
| Jan 1995 | Gécamines issued invitations to five additional companies and extended the deadline to April 1995 |
| July 1996 | LHL was advised they were the successful bidder |
| Nov 1996 | TFM Mining Convention and Formation Agreement negotiated |
| Jan 1997 | KSLE, wholly-owned company in SNC Lavalin Group, started bankable feasibility study using seven sub-consultants. LHL was supported by nine specialty sub-consultants. |
| May 28, 1997 | TFM Mining Convention and Formation Agreement finalized under DRC Law |
| Dec 1998 | BHP enters into Exclusive Option to Purchase LHL Shares |
| Feb 1999 | LHL halts Feasibility Study work and declares force majeure |
| 2000 | BHP commissioned Bateman to conduct conceptual study |
| Dec 2000 | Phelps Dodge enters into option agreement to acquire one-half of BHP's interest |
| Sept 2002 | Phelps Dodge acquires remaining interest in the Exclusive Option to Purchase LHL Shares |
| Jan 2003 | Phelps Dodge commissions Bateman Engineering to prepare a scoping study |
| Sept 2003 | Phelps Dodge and TMC submit formal proposal to amend the existing project agreements |
| 2004-2005 | Phelps Dodge supports TFM negotiations with DRC for Amended and Restated Mining Convention (ARMC) |
| Sep 28, 2005 | ARMC and Amended Shareholder Agreement executed by DRC government and Gécamines |
| Oct 27, 2005 | Presidential Decree authorizes ARMC and Amended Shareholder Agreement |
| Nov 1, 2005 | Phelps Dodge exercises option to take 70% direct interest in LHL |
| Nov 4, 2005 | Force majeure lifted by LHL |
| 2005-2006 | Feasibility Study conducted by GRD Minproc; ESIA conducted by Golder |

| Date | Event or Milestone |
|---|---|
| Feb – Dec 2006 | 16,000 meter core drilling program by Phelps Dodge |
| Aug 2006 | Commenced detailed design |
| Dec 2006 | Phelps Dodge Board conditionally approved construction |
| Feb 2007 | Civil work mobilized on site |
| Mar 2008 | Open pit stripping commences |
| Mar 2009 | Pre-commissioning and plant startup |
| Mar 31, 2009 | First copper production |
| Oct 2010 | Successful conclusion of the Tenke Fungurume mining contract by the DRC government |
| Nov 2011 | Announcement of the Phase 2 Expansion of Tenke Fungurume to increase daily throughput to 14,000tpd. |
| March 2012 | President and Prime Minister of the DRC signed a decree approving the bylaw changes for TFM. Lundin ownership drops to 24.0% |
| Jan-Mar 2013 | Phase 2 Expansion substantially completed |
| Dec 2013 | Full year production exceeds 200,000 tpa |

# 7 GEOLOGICAL SETTING AND MINERALIZATION

## 7.1 REGIONAL AND LOCAL GEOLOGY

The Tenke Fungurume copper-cobalt deposits are typical of those that comprise the Central African Copperbelt. The Copperbelt is located in a major geological structure called the Lufilian Arc, a 500 km fold belt that stretches from Kolwezi in the southern DRC to Luanshya in Zambia. The deposits of the Tenke Fungurume district are located at the northernmost apex of the arc as shown in Figure 9.1. The arc formed between the Angolan Plate to the southeast and Congo Plate to the northwest during the late Neoproterozic, approximately 650 to 600 million years before present (Ma). Rocks in the arc are exposed in a series of tightly folded and thrust anticlines and synclines, generally trending east-west to southeast-northwest in the southern DRC.

The Tenke Fungurume group of sediment hosted copper cobalt deposits occurs near the base of a thick (>7,000 m) succession of sedimentary rocks belonging to the Katanga Supergroup of Neoproterozoic age (570-880 Ma).

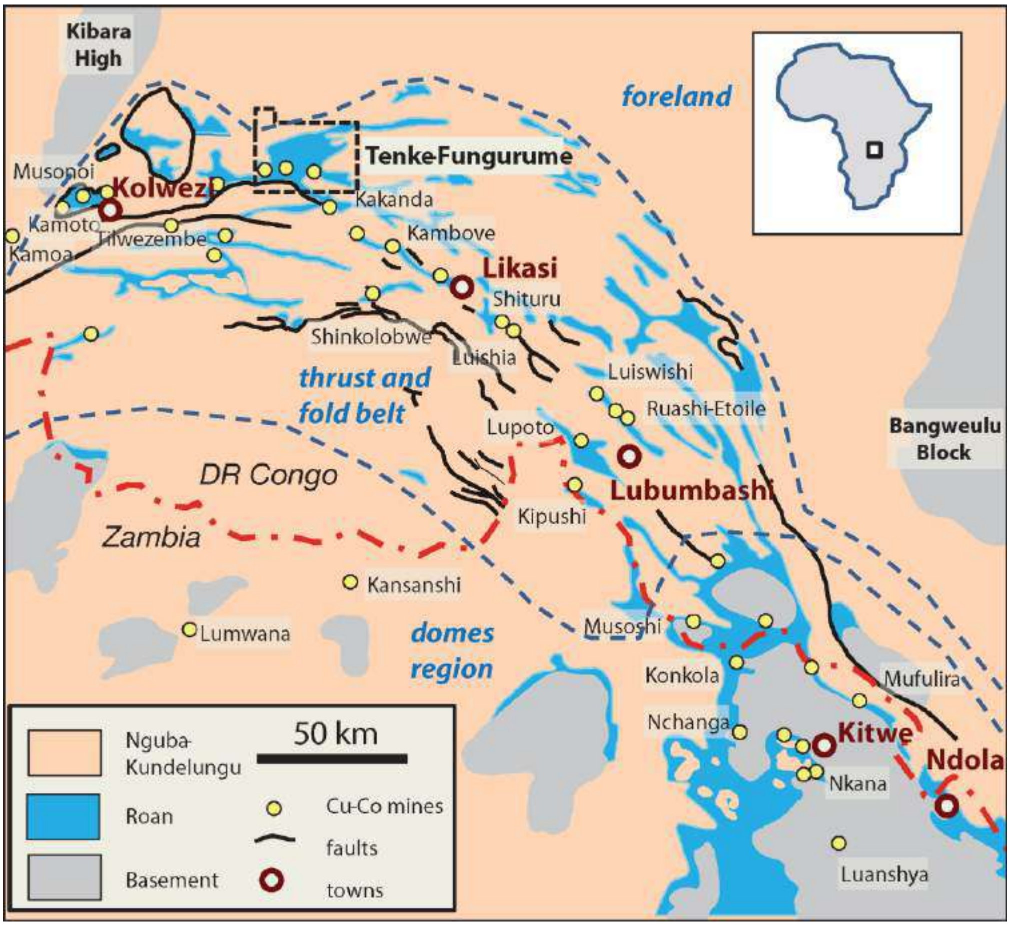
The older rocks of the basement complex belonging to the Kibara Supergroup, form the framework within which the Katangan sediments were deposited and consist of granitic rocks and metamorphosed sediments. Sedimentation took place in shallow intra-cratonic basins bounded by rifts.

The erosional source for the ore-hosting Roan sedimentary rocks (860−735 Ma) in Tenke-Fungurume is the Bangweulu basement block, which contains high K, calc-alkaline, subduction-related volcanic rocks. There is strong evidence for evaporite formation during periods of desertification in both the Roan R1 and R3 subgroups.

A series of cratonic events of Pan African age (650 Ma to 500 Ma) resulted in extensive deformation of these rocks. The principal tectonic event is referred to as the Lufilian Orogeny and this led to the formation of the Lufilian Arc.

Above the Katangan succession only Tertiary eolian Kalahari sands and Late Cenozoic valley-fill sediments are present, suggesting the area was largely quiescent throughout the Paleozoic and Mesozoic.

**Figure 7-1  Regional Geology (From Schuh, 2012)**



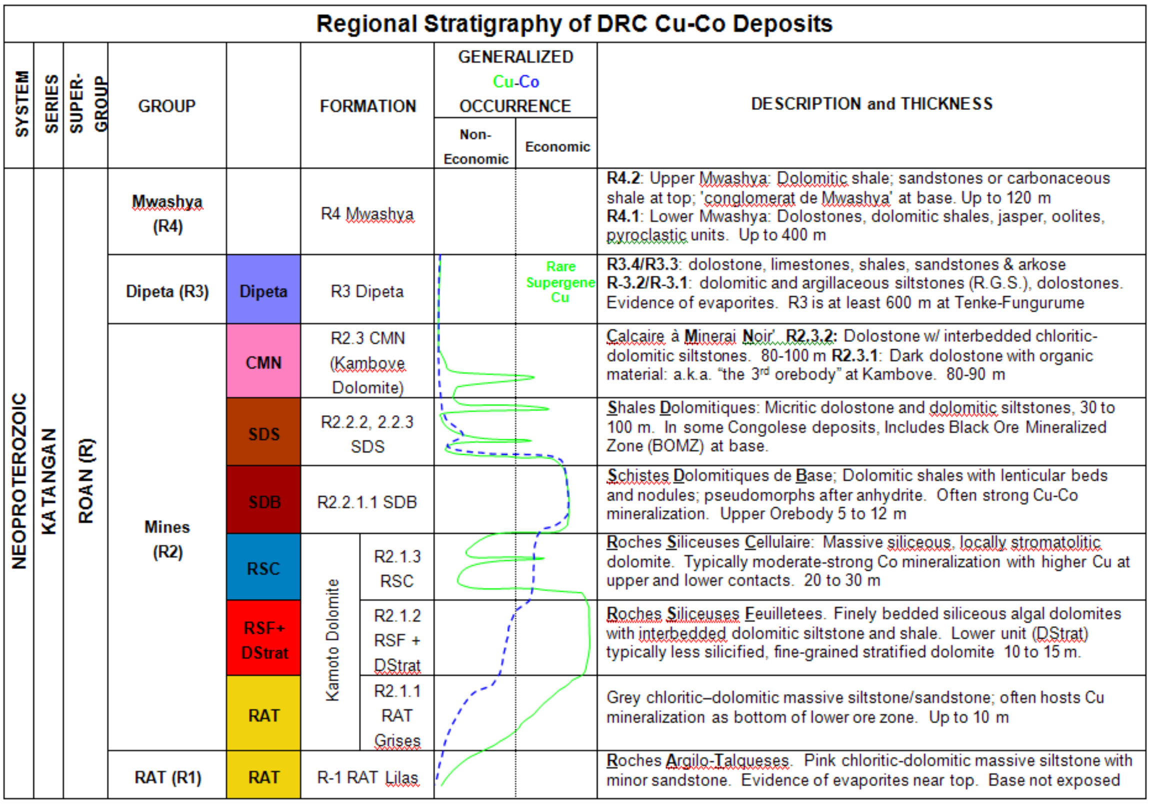
The Roan Supergroup comprises a series of detrital and shallow marine sediments deposited in settings ranging from continental rift basins to intra-cratonic shallow marine platforms. Two major transgressions have been documented. The first commenced with the deposition of the RAT Group (R1) and ending with the Mines Group (R2). The second started with the Dipeta Group (R3) and ended with the Mwashya Group (R4). The stratiform copper-cobalt deposits occur at the base of the Mines Group.

The onset of Katanga sedimentation was marked by deposition of coarse continental sediments in rift bounded basins of restricted extent. In Zambia, the base is well defined by the presence of very coarse conglomerates. At Tenke Fungurume, the sediments of the initial rift-filling phase form the RAT Group (R1), a sequence of reddish, massive and stratified terrestrial sediments. The reddish coloration is due to the abundance of hematite. Pseudomorphs after anhydrite and gypsum, and desiccation cracks, argue for a shallow (possibly inter-tidal) depositional environment at the close of deposition of the RAT Group. The upper 4-8 m of the RAT Group, which is often well mineralized, is characterized by a change in composition. Here chlorite is an important constituent, which is reflected by a change in color to greyish-green. This change in color occurs immediately below the base of the Mines Group (R2), a series of siliceous, laminated, locally stromatolitic, carbonates (dolostones).

In the unweathered zones, these rocks are predominantly grey, often with significant carbonaceous material present along bedding planes. The color change reflects the transition from oxidizing to reducing conditions, which accompanied the change in depositional environments from continental to shallow marine (tidal and lagoonal) in an intra-cratonic platform setting. The change occurred near the end of the first transgressive cycle and is an important and Copper-belt wide control on the formation of the copper-cobalt deposits. Whatever the ultimate process of the ore formation in the Katanga Copperbelt was, it is significant that the principal copper-cobalt mineralization is hosted in the first shales to be deposited in an anoxic environment (representing a critical favorable horizon) following the deposition of the hematitic RAT group.

In Katanga Province, the stratigraphic column is divided into a younger Kundelungu Supergroup and an older Roan Supergroup as illustrated in Table 7-1.

**Table 7-1 Stratigraphic Column**



**Regional Stratigraphy of DRC Cu-Co Deposits**

| SYSTEM | SERIES | SUPER-GROUP | GROUP | | FORMATION | | GENERALIZED Cu-Co OCCURRENCE | | DESCRIPTION and THICKNESS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Non-Economic | Economic | |
| NEOPROTEROZOIC | KATANGAN | ROAN (R) | Mwashya (R4) | | R4 Mwashya | | | | **R4.2**: Upper Mwashya: Dolomitic shale; sandstones or carbonaceous shale at top; 'conglomerat de Mwashya' at base. Up to 120 m<br>**R4.1**: Lower Mwashya: Dolostones, dolomitic shales, jasper, oolites, pyroclastic units. Up to 400 m |
| | | | Dipeta (R3) | Dipeta | R3 Dipeta | | | Rare Supergene Cu | **R3.4/R3.3**: dolostone, limestones, shales, sandstones & arkose<br>**R-3.2/R-3.1**: dolomitic and argillaceous siltstones (R.G.S.), dolostones. Evidence of evaporites. R3 is at least 600 m at Tenke-Fungurume |
| | | | Mines (R2) | CMN | R2.3 CMN (Kambove Dolomite) | | | | Calcaire à Minerai Noir' **R2.3.2:** Dolostone w/ interbedded chloritic-dolomitic siltstones. 80-100 m **R2.3.1**: Dark dolostone with organic material: a.k.a. "the 3rd orebody" at Kambove. 80-90 m |
| | | | | SDS | R2.2.2, 2.2.3 SDS | | | | Shales Dolomitiques: Micritic dolostone and dolomitic siltstones, 30 to 100 m. In some Congolese deposits, Includes Black Ore Mineralized Zone (BOMZ) at base. |
| | | | | SDB | R2.2.1.1 SDB | | | | Schistes Dolomitiques de Base; Dolomitic shales with lenticular beds and nodules; pseudomorphs after anhydrite. Often strong Cu-Co mineralization. Upper Orebody 5 to 12 m |
| | | | | RSC | Kamoto Dolomite | R2.1.3 RSC | | | Roches Siliceuses Cellulaire: Massive siliceous, locally stromatolitic dolomite. Typically moderate-strong Co mineralization with higher Cu at upper and lower contacts. 20 to 30 m |
| | | | | RSF+ DStrat | | R2.1.2 RSF + DStrat | | | Roches Siliceuses Feuilletees. Finely bedded siliceous algal dolomites with interbedded dolomitic siltstone and shale. Lower unit (DStrat) typically less silicified, fine-grained stratified dolomite 10 to 15 m. |
| | | | | RAT | | R2.1.1 RAT Grises | | | Grey chloritic–dolomitic massive siltstone/sandstone; often hosts Cu mineralization as bottom of lower ore zone. Up to 10 m |
| | | | RAT (R1) | RAT | R-1 RAT Lilas | | | | Roches Argilo-Talqueses. Pink chloritic-dolomitic massive siltstone with minor sandstone. Evidence of evaporites near top. Base not exposed |

## 7.1 PROPERTY GEOLOGY

The Tenke-Fungurume deposits lie in the largest tectonic window of Roan Group rocks in the Central African Copperbelt (Figure 7-3). This central Roan window is surrounded by Nguba and Kundelungu lithotectonic assemblages. The Mines Series forms a series of scattered tectonic blocks referred to as 'écailles'. These are fault bounded on all sides and tend to form tight, upright or recumbent anticlines or monocliines. The écailles can range from several 10's to over 500 m in length and extend downdip from 20 to 200 m.

The Mines Series and adjacent stratigraphic units in the Roan Group are described below in order from oldest to youngest:

### 7.1.1 RAT LILAS – ROCHES ARGILO-TALQUESES

This formation is dolomitic and talcose argillite and dolomitic argillaceous sandstone. It contains abundant specularite and is "***lilac***" in color. These rocks are highly incompetent and include polymictic chaotic breccias which are now believed to be the result of evaporate dissolution (Schuh et al, 2012). The base of the formation is not observed as it rests on a thrust plane. Its equivalent in Zambia is a basal conglomerate that rests unconformably upon granites and gneisses of the basement complex.

### 7.1.2 RAT GRISES – ROCHES ARGILO-TALQUESES

This formation is fine to medium grained, grey and white-bleached sandstones ranging in thickness from 2 m to 5 m. Normally massive the unit sometimes appears bedded due to the presence of dolomitic bands. This formation is similar to the RAT lilas in that it is equally incompetent and is frequently brecciated and altered. In many locations it is well mineralized.

### 7.1.3 D-STRAT – DOLOMIES STRATIFIEES

D-Strat occurs in some areas where it forms the lowest part of the lower mineralized zone. It is normally a fine grained well bedded to laminated dolomite and dolomitic shale that is commonly silicified. The presence of anhydrite nodules suggests that it represents an evaporate facies. The formation is generally grey to black, not uniformly developed and ranges in thickness from 0 m to 5 m.

### 7.1.4 RSF – ROCHES SILICEUSES FEUILLETEES

The RSF forms the major part of the lower mineralized zone. It consists of a thinly-banded, sililcified algal dolomites. It is generally pale to dark grey with copper and cobalt minerals as disseminations within the rock and along bedding planes and joints.

### 7.1.5 RSC – ROCHES SILICEUSES CELLULAIRES

RSC is generally a fine to coarse grained, silicified stromatolitic dolomite, with a consistent thickness of 20 m. This formation has been leached of carbonate near surface and has a cavernous and cellular cherty appearance. It is normally highly resistant to erosion, and consequently forms conspicuous ridges and hill features. It also contains 1-2 m thick lenses of cobalt-rich tan mudstone known as *schistes intercalaires*.

The RSC is typically mineralized close to the contacts with the RSF and SDB units.

### 7.1.6 SD – SHALES DOLOMITIQUES

SD is finely laminated dolomitic shale with subordinate dolomite and sparse discontinuous graphitic shale bands. The SD was assumed to be about 90 m thick in the Kwatebala area based on the bulk of the drill intercepts, although regionally it varies from about 30 to 130 m. The basal 10 m known as SDB, consists of pale to dark bluish grey sericitic and dolomitic shale which hosts copper and cobalt mineralization along bedding, joints and other fracture planes. This lower unit comprises the upper mineralized zone.

At Tenke the top of the SDB is represented by a variable thickness of grey medium grained, massive dolomitic sandstone which grades downwards through shaley sandstone into underlying shales and forms a useful marker horizon. The succession also shows a higher proportion of siliceous and argillaceous dolomites within the SD than has been observed at Fungurume.

### 7.1.7 BOMZ – BLACK ORE MINERALIZED ZONE

Within the SD is a dolomitic unit characterized by the presence of abundant black oxide minerals consisting primarily of manganese oxide and often containing cobalt oxides. It is not always present.

### 7.1.8 CMN - CALCAIRE A MINERAL NOIRE

The CMN is a dolostone that can be broken into two units, a dark, organic dolostone at the base and clean dolostone interbedded with chloritic and dolomitic siltstones at the top (Cailteux, 1994). Drilling at Kwatebala does not distinguish these units consistently and they are not modeled separately. Drill intercepts through CMN at Kwatebala suggest a true thickness of about 90 to 110 m. The unit is unmineralized at Tenke.

### 7.1.9 DIPETA

The Dipeta Formation is the youngest unit in the Kwatebala deposit. In some reports, the designation RGS is used for the lower part of the Dipeta. It consists of dolostone and argillaceous and dolomitic siltstones in the lower portions and dolostone, limestone, shale, sandstone, and arkose at the top. The Dipeta Formation forms the center of Kwatebala Hill where it is penetrated by many drill holes beneath a nappe of productive Mines Series rocks. Strong Cu-Co mineralization is locally noted at this brecciated fault contact. This is best explained as clasts of the mineralized section caught up in the breccia but could also be from strong supergene mineralization.

## 7.2 ALTERATION

### 7.2.1 MAGNESIAN ALTERATION

Dolomitic rocks within the Mines Series have been extensively recrystallized. Up to four separate dolomitization phases have been recognized by petrography. The Mg alteration event is quantitatively the largest and most extensive metasomatism to have affected the host rocks at Tenke-Fungurume. It is multistage and intrinsically associated with both diagenetic and epigenetic sulphide mineralization events.

### 7.2.2 SILICIFICATION

Silicification appears to have alternated and partially overlapped with an equally complex sequence of four dolomitization events. It occurs lateral to and beyond the zone of copper sulphide mineralization and is the second most important alteration in the mineral deposits at Tenke-Fungurume.

### 7.2.3 SODIC ALTERATION

A number of outcrops of sodic-altered ferruginous siltstones occur in the Tenke-Fungurume district, primarily to the north of the known ore deposits in rocks stratigraphically above those that host the major mineral deposits. Riebeckite, a bluish-colored Na-Fe amphibole, has been observed at the Mofya and Salabwe quarries, 800 m northeast of Kwatebala, road cuts on the Mulumbu road, and at several other locations in the Dipeta subgroup. Current field mapping information suggests that sodic alteration forms a broad outer halo many 100s of meters above the Mines Series.

### 7.2.4 POTASSIC ALTERATION

Potassic alteration is not well developed on the property. Early diagenetic quartz-dolomite alteration shows remnant K-feldspar which was probably detrital. Minor secondary muscovite replaces Mg chlorite in the RAT. The SDB displays extensive sericite flakes in bedding-parallel dislocation planes but their genetic origin is not constrained. The content of potassium within the rocks of the Mines Series generally increases upward.

## 7.3 STRUCTURE

The Luflian Arc is an intensely folded zone composed of three distinct but related structural units. The outer unit, within which the Tenke Fungurume group of deposits is located, is the most northerly, consisting of tightly folded and thrust blocks of Roan age rocks which have been tectonically transported from south to north, and now rest upon a younger Kundelungu foreland.

The Tenke Fungurume concession encloses thrust slices of various dimensions and orientations. The northern portion is relatively undisturbed with a gentle northerly dip, while the southern portion is occupied by the Dipeta syncline. At its eastern extremity the syncline is closed by a series of thrust blocks which form the Fungurume section of the deposits. At the western end, the northern limb of the syncline is terminated by a major dislocation which offsets the Tenke deposits to the northeast.

Within the east-west trending Dipeta syncline both the northern and southern limbs can be traced in more or less continuous ridges of Lower Roan rocks, with more resistant RSC forming the crestal spines. These ridges run approximately parallel for a distance of 14 km, apparently undisturbed. Drilling and geophysical surveys indicate that the syncline is a gently box-folded recumbent isoclinal fold with steep to overturned inside flanks and a relatively flat bottom.

As is the case with the Kolwezi Nappe, it is possible that the mineralized mega-fragments represent transported blocks of large dimension riding as nappes, or related structures, on series of decollement planes. The overall transport direction has been interpreted as being from south to north.

Both to the north and south, the Dipeta syncline is flanked by numerous écailles of Lower Roan rocks. They attain a maximum development south of the syncline where they form, in general, randomly oriented blocks. By contrast the thrust blocks to the north of the northern flank of the syncline are smaller and fewer in number, generally aligned sub-parallel to the strike of the Dipeta syncline, and are seen to rest upon the lower member of the Dipeta formation (RGS) of Upper Roan age.

### 7.3.1 ROLE OF EVAPORITES

(Summarized from Schuh et al, 2012)

Although no preserved evaporate beds have been discovered at Tenke-Fungurume, significant evidence exists for large volumes of undissolved salt present in the Katanga Supergroup. Saline springs have been worked at industrial scale for NaCl at Nguba village which is located on the concession. There is also extensive evidence pointing to arid and hyper saline conditions during Roan deposition in the form of laminates, algal mats and dolostones. Other evidence includes pseudomorphs of gypsum crystals, anhydrite nodules, enterolithic folds and chickenwire texture. Trace and major element geochemistry is indicative of evaporative lacustrine environments.

It is postulated that stratigraphic gaps in Roan intervals separated by breccias can be explained by dissolution of at least three regional and two local evaporate beds of undetermined thickness. The red clay breccia matrix of the RAT unit is believed to represent the insoluble residue from dissolution of evaporites while polylithic RAT breccias have been interpreted as friction breccias associated with liquefaction of evaporite beds and expulsion brines related to decollement faulting.

The numerous anticlines containing the mines Series écailles are cored by RAT polymict breccias, brecciated RAT siltstones, and by RGS units. Gaps along blocks of the Mines Series within the RAT breccia are commonly filled in toothpaste fashion by RAT injection breccias which crosscut Mines Series units and can pierce up to the stratigraphic level of the CMN. These injections are typically 10 to 100 m in length and up to 20 m wide.

The elongate geometry of many anticlines, their RAT/RGS breccia cores, evaporite geochemistry and mineralogical evidence suggest that they represent former subvertical salt walls. Such salt walls can be several kilometers tall, several kilometers long, but commonly only tens to hundreds of meters across. Individual écailles can also move upward within the rising salt. Some of the anticlines appear to have been subjected to late Lufilian low-angle thrusting and folding. However, recent studies have suggested that these complex anticlinal apices are primarily products of diapirism, dissolution, and collapse.

## 7.4 MINERALIZATION

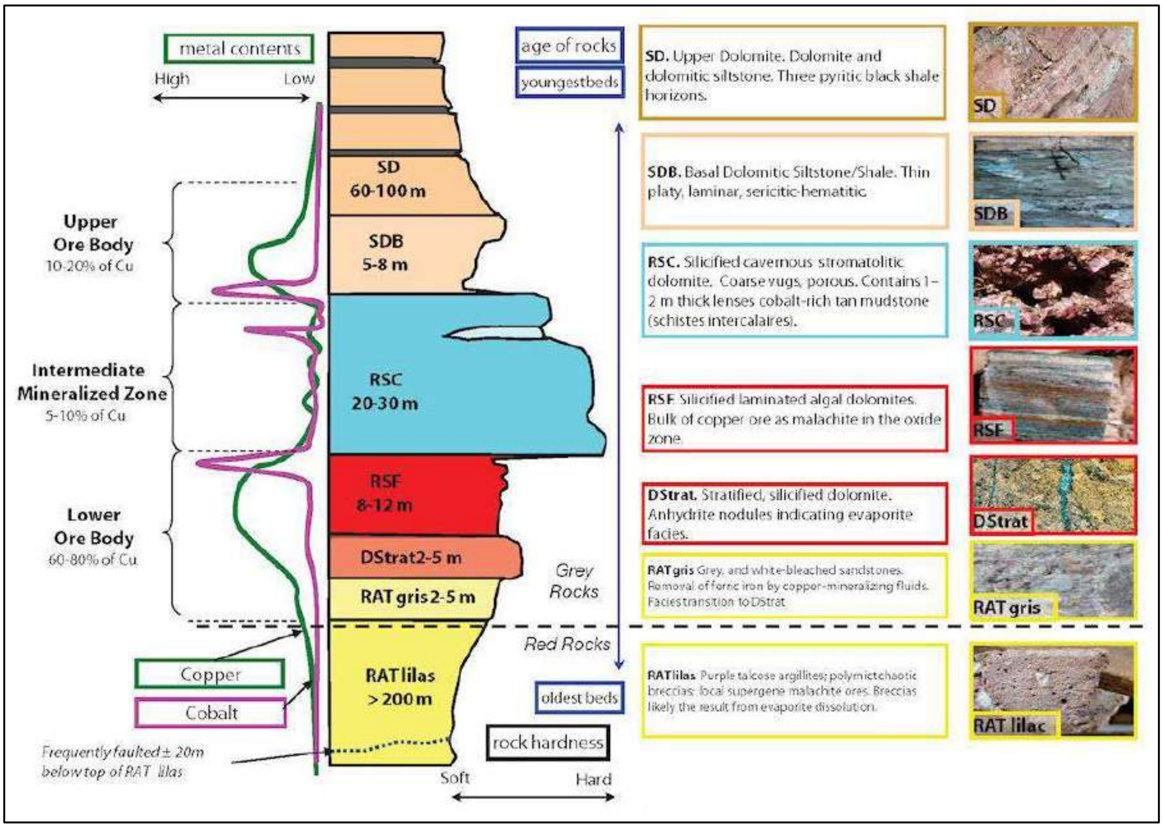
### 7.4.1 GENERAL

The copper-cobalt mineralization at Tenke-Fungurume is mainly associated with two dolomitic shale horizons (RSF and SDB respectively), each ranging in thickness from 5 to 15 m, separated by some 20 m of cellular silicified dolomite (RSC). Primary copper and cobalt mineralogy is predominately chalcocite ($Cu_2S$), digenite ($Cu_9S_5$) bornite ($Cu_5FeS_4$), and carrollite ($CuCo_2S_4$). Oxidation has resulted in widespread alteration producing malachite ($Cu_2CO_3(OH)_2$), pseudomalachite ($Cu_5(PO_4)_2(OH)_4$), chrysocolla (hydrated copper silicate) and heterogenite ($Co_3$+O(OH)) .

Dolomite and quartz are the main gangue minerals present. Dolomite or dolomitic rocks make up the bulk of the host strata. Weathering of the host rocks is normally depth related, intensity decreasing with increasing depth, producing hydrated iron oxides and silica at the expense of dolomite, which is leached and removed. As a result, gangue acid consumption (GAC) is lower in the oxide zone.

The relative distribution of copper and cobalt in the Mine Series is shown in Figure 7-2 below.

**Figure 7-2 Mine Series Copper and Cobalt Distribution from Schuh et al (2012)**



### 7.4.2 LEACHED CAPPING

Tenke, Mwadinkomba, Kansalawile, and parts of Pumpi have leached capping from the surface down to 50- to 80-m depth. These appear to have developed best downdip along acid-leachable, hydrologically favorable units. Cobalt is not remobilized as much as copper.

### 7.4.3 PRIMARY MINERALIZATION: DISSEMINATED SULPHIDES

Early-stage, disseminated copper sulphide minerals are, in order of abundance (1) chalcocite, (2) bornite, (3) carrollite, and (4) chalcopyrite. Carrollite, bornite, chalcopyrite, and digenite also form small inclusions in quartz grains.

Chalcopyrite is the most common sulphide ore mineral in the SDB. Chalcocite, bornite, and carrollite are the most common ore minerals in the RSF and DStrat. However, minor bornite occurs in the SDB and minor chalcocite and pyrite in the RSF and DStrat.

### 7.4.4 EPIGENETIC: CROSSCUTTING HYPOGENE MINERALIZATION

Late-stage veins cut earlier bedding parallel veins at Tenke-Fungurume. Late veins are best developed and most abundant in zones of complex deformation such as fold noses or adjacent to major faults. Sulphide minerals in the crosscutting veins are mainly chalcocite; other sulphide phases (bornite, carrollite, chalcopyrite) occur but are less common; however, textural evidence suggests that most of the chalcocite in the crosscutting veins has replaced earlier sulphide phases.

### 7.4.5 SUPERGENE MINERALIZATION

Supergene sulphide minerals are mainly chalcocite and minor covellite and digenite replacing earlier sulphide phases. Supergene oxide phases are copper carbonates (malachite, azurite, and cobaltoan dolomite), phosphates (libethenite, pseudomalachite), silicates (chrysocolla), and oxides (cuprite, heterogenite).

Near-surface oxide ores tend to have the highest copper grades in the first 15 to 30 m, with a transition downward into deeper oxide ore, without significant leached capping development.

### 7.4.6 GANGUE MINERALS

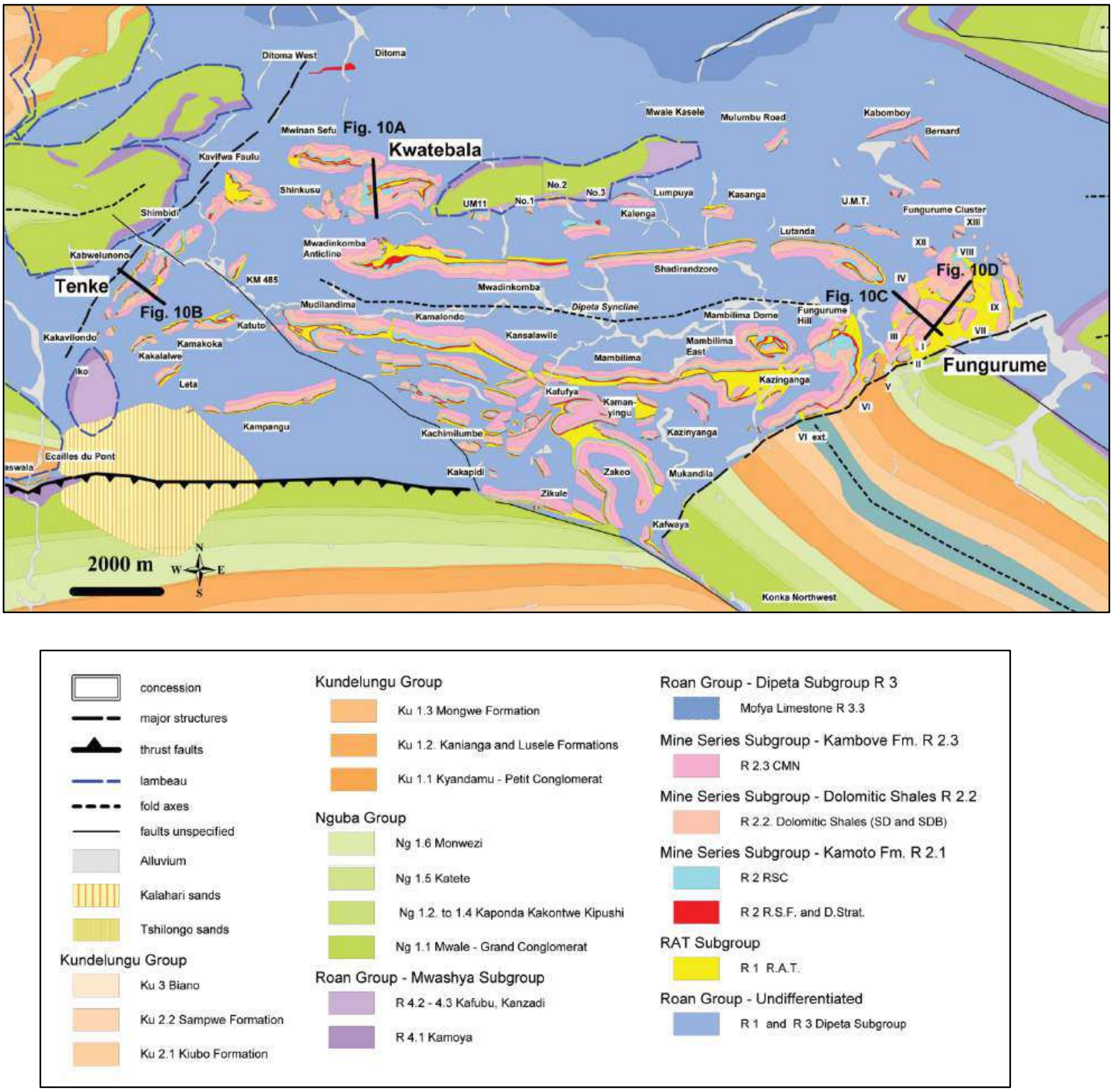
Major gangue minerals include silica phases (quartz, cryptocrystalline quartz, and chalcedony), dolomite, and Mg chlorite. Anhydrite is the earliest mineral, now replaced by rectangular laths of quartz and dolomite plus chalcocite pseudomorphs but with visible anhydrite inclusions still present.

Chalcedony occurs in distinctive, commonly brown-colored fans. These fans are crosscut and locally replaced by euhedral dolomite crystals, quartz pseudomorphs after dolomite, and quartz veins. Chalcedony is most common in the RSC and is rare in other Mines Series strata.

Quartz is common in all Mines Series strata and is most heavily concentrated throughout the RSC and for 1 to 2 m above and below it. Coarse-grained dolomite replaces and is pseudomorphous after quartz crystals but is overgrown by other dolomites.

Coarse-grained dolomite occurs as two types readily distinguishable in cathodoluminescence. One type is commonly partly replaced by quartz leaving pseudomorphs. The second type is found as overgrowths on quartz in vens and commonly intergrown with an oxide-carbonate copper suite.

**Figure 7-3 Property Geology**



# 8 DEPOSIT TYPES

The section below is taken primarily from Schuh et al, 2012:

Tenke-Fungurume is classified as a strata-bound copper cobalt deposit. Multistage mineralization took place with at least four separate dolomitization and four silicification events associated with several sulphide stages, with differing mineral assemblages. During syngenetic to early diagenetic stages of basin extension, highly oxidized and saline residual marine bittern brines migrated through the RAT basal red-bed sequence. The brines also possibly circulated into the basement, mobilizing copper as chloride complexes. With increased subsidence, lithostatic load from the 7,000 m of overlying Katanga Supergroup drove copper-cobalt− rich brines laterally and vertically toward basin edges. Copper and cobalt sulphides were precipitated where the brines encountered reductants, including organic-rich, stromatolitic, sour gas, or pyrite-rich beds. Sulfur sources appear to be from evaporitic anhydrite in proximal and deeper parts of hypogene ores. Diagenetic pyrite may have contributed additional sulfur in the reduced, stratigraphically higher parts of the Mines Series. The bulk of the copper sulphides appear to have formed during diagenetic stages. At peak orogeny, local remobilization of early stage sulphides took place, resulting in mineralogically distinct late-stage sulphide veins that cut clean earlier mineralization assemblages. Supergene oxidation in the Miocene to Pliocene led to the development of high-grade oxide copper-cobalt mineralization.

The paragenesis of the Tenke-Fungurume copper-cobalt deposits reflects a long-lived, complex, and multi-stage series of mineralization and alteration events as follows:

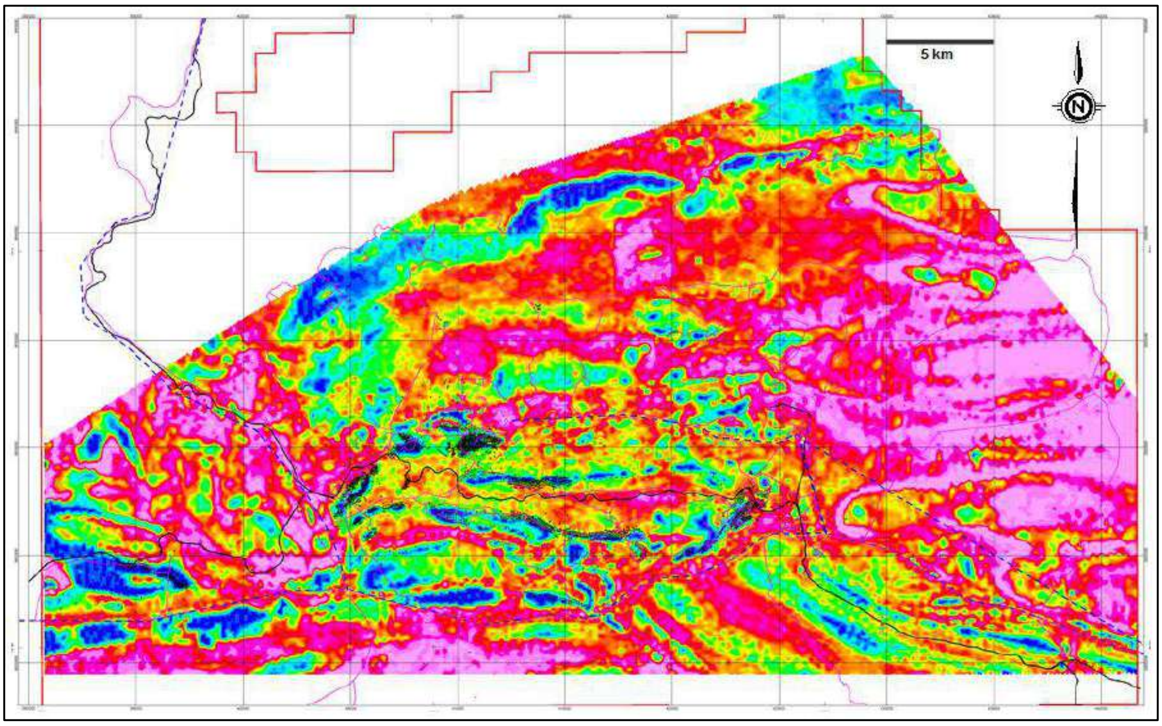
1. Early diagenetic: (a) Synsedimentary to early diagenetic celestite, gypsum, and anhydrite nodules. (b) Cryptocrystalline quartz deposition with minor early dirty carrollite in bedding-parallel bands and blebs. (c) BSR of anhydrite nodules leads to replacement by dolomite plus Cu-Co sulphide.
2. Diagenetic: (a) Bornite-digenite cogenetic and replaced by carrollite. (b) Diagenetic coarse dolomite plus chalcocite replaced early carrollite. (c) Diagenetic quartz replaced dolomite 1. (d) Early copper and cobalt sulphides in bedding parallel veins and replacement of reactive, reduced (formerly organic-rich?) laminations; fine disseminated sulphides follow bedding parallel laminations. (d) Diagenetic silica 2 was deposited, followed by dolomite 2 + barite + magnesite. (e) Extensive Mg chlorite, Mg tourmaline alteration.
3. Epigenetic: (a) Crosscutting vein stage, with silica 3, then silica 4 + sulphides, includes clean carrollite 2. (b) Formation of main orogenic dolomite + chalcopyrite + bornite + chalcocite 2. (c) Late orogenic crosscutting quartz and dolomite-sulphide veins developed at sites of most structural deformation. Veins are clean, lacking any alteration selvages.
4. Supergene: (a) In the highly oxidized RAT, coeval mineralization may have included hematite-chalcocite crackle veining, late Fe chlorite, and apatite. (b) Supergene weathering and oxidation, leached capping development and local supergene sulphide enrichment during the Miocene; formation of heterogenite, malachite, cuprite, native copper, chrysocolla, cobaltoan dolomite. (c) Late generation chalcocite replacing carrollite.
5. Weathering and selective dissolution of coarse dolomite.

# 9 EXPLORATION

Exploration prior to 2012 has been documented in previous Technical Reports (GRD Minproc and Nilsson et al, 2007, 2008, 2009 and 2011).

A concession-wide airborne geophysical survey was carried out in June and July of 2013 by Fugro Airborne Surveys Ltd. Previous airborne data only covered the southern portion of the property and was flown by the Belgians in 1969. A total of 5,545 line kilometres were flown over an area of approximately 1000 km$^2$. The aircraft carried a domain electromagnetic CGG:TEMPEST system and also gathered radiometric data. TEMPEST was designed to acquire high resolution, fully calibrated TEM data that can be used in a quantitative fashion for both conductivity mapping applications and conductive target detection. Post processing of the electromagnetic data is still in progress. A few lines will need to be re-surveyed in 2014 as the altitude was too high for reliable data collection. Results will be used to define new exploration targets in the Mines Series units characterized by low conductivity near surface and higher conductivity at depth due to the presence of sulphide minerals.

**Figure 9-1: Conductivity Image from 2013 Airborne Geophysical Survey**

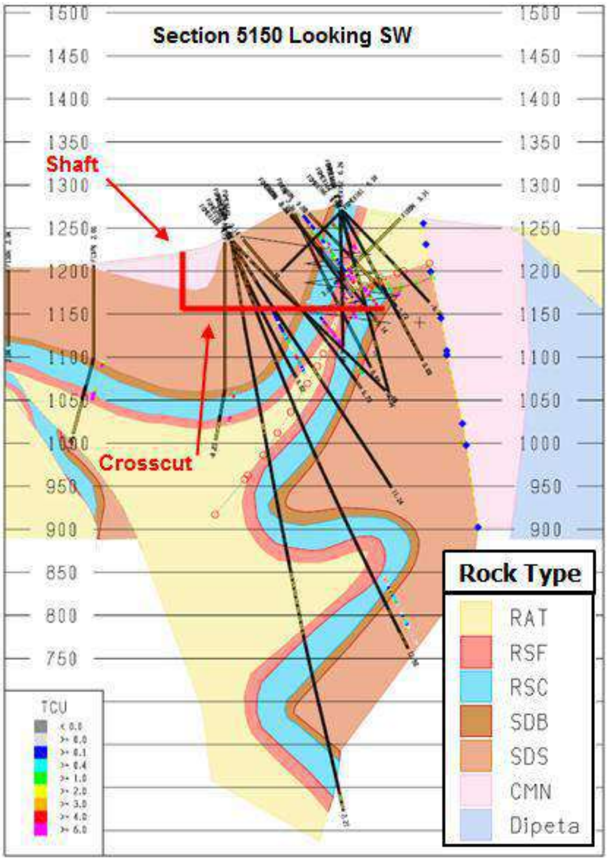


New satellite imagery from May 8, 2013 was obtained and processed to obtain large scale orthophotos of the terrain, operations and facilities.

Underground development for bulk metallurgical sampling was started at Fungurume in 2012. A vertical shaft was started in June, 2012 and completed in 2013 and a crosscut has been started (Figure 9-2 and Figure 9-3). The goal is to obtain mixed oxide-sulphide material for testing in 2014. If results are positive, there is potential for bringing this category of material into the mine plan and increasing the reserve base.

Figure 9-2 Fungurume Shaft Headframe (November 2013 site visit)

Figure 9-3: Fungurume Shaft Cross Section



# 10 DRILLING

## 10.1 HISTORICAL DRILLING

The drilling history of the Tenke Fungurume Deposits goes back as far as 1919. Various drilling campaigns have been undertaken by UMHK, Gécamines, SMTF, TMF, Phelps Dodge and FCX. Descriptions of historical drilling programs are documented in previous technical reports.

## 10.2 2009 - 2012 DRILLING

Drilling carried out by FCX prior to 2012 is documented in previous technical reports (GRD Minproc and Nilsson et al, 2007, 2008, 2009 and 2011).

## 10.3 2012-2013 DRILLING

Between the start of 2012 and the end of 2013, FCX completed 1225 drill holes totaling 214,676 m. Drill contractors were Boart-Longyear (7 rigs) and Layne Drilling (6 rigs) and T-Three Drilling (5 rigs). The exploration objectives were to convert oxide and mixed resources to reserve class, locate additional oxide resources, add to existing resources of sulphide and mixed material and supply samples for mixed ore metallurgical sampling.

Drill holes generally started with PQ core (85 mm diameter) and then were reduced to HQ (64 mm) and NQ (48 mm), as needed. The larger core diameters were required to attain acceptable recovery in the weathered and oxide zones.

Resource conversion and infill drilling at 9 of the deposits confirmed expected extents and grades to support updated resource models in 2012 and 2013.

Table 10-1 and Table 10-2 list the drilling and meterage by target area for 2012 and 2013. Plan maps of the drill hole locations are shown in Figure 10-1 to Figure 10-4.

**Table 10-1 2012-13 Drilling in Resource Areas**

| Deposit | Model Codes | Holes | Metres |
|---|---|---|---|
| Mwadinkomba | MWAN | 178 | 34,614.5 |
| Fungurume | FGME | 154 | 25,917.2 |
| Mambilima | MAMB | 79 | 24,106.5 |
| Tenke-Goma | GOMA | 117 | 22,835.0 |
| Pumpi | PUMP | 133 | 20,985.7 |
| Kansalawile | KASA | 93 | 14,519.1 |
| Fungurume VI, VI Ext. | FGVI | 73 | 9,897.5 |
| Kwatebala | KWAT | 47 | 5,916.3 |
| Katuto & Vicinity | KATO KAWE KOKA LETA | 96 | 13,025.5 |
| Fwaulu | FWAL | 14 | 1,971.5 |
| | Total | **984** | **173,788.8** |

**Table 10-2 2012-13 Exploration Drilling**

| Deposit | Code | Holes | Metres |
|---|---|---|---|
| Mwadinkomba Anticline | MATI | 48 | 8,160.3 |
| Mwinansefu | SEFU | 39 | 3,231.0 |
| General Concession | GCON | 28 | 8,391.0 |
| KM 485 | KMFE | 28 | 3,946.0 |
| Kamalondo | KAMA | 25 | 3,806.0 |
| Shadirandzoro | ZORO | 23 | 5,748.0 |
| Kamalondo South | KAMS | 19 | 2,975.5 |
| Kalebi | LEBI | 15 | 1,312.0 |
| Salabwe | SALA | 8 | 789.0 |
| Iko | IKHO | 4 | 624.0 |
| Dipeta Syncline | DSYN | 3 | 1,815.9 |
| District | DIST | 1 | 88.5 |
|  | Total | **241** | **40,887.2** |

**Figure 10-1 Drill Plan – Fungurume Target area**

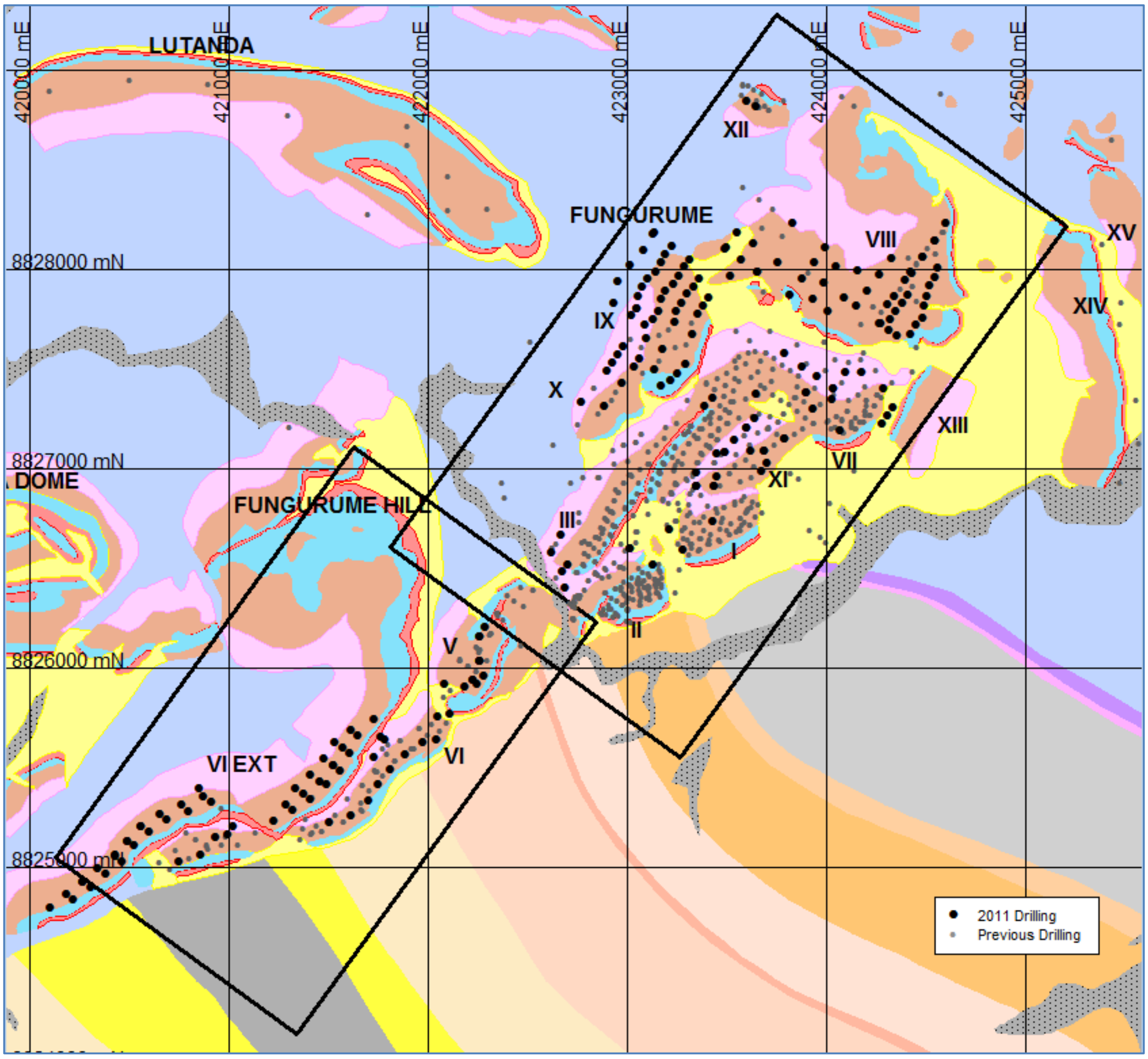


Figure 10-2 Drill Plan - Mwandinkomba to Kasinyanga Target Area

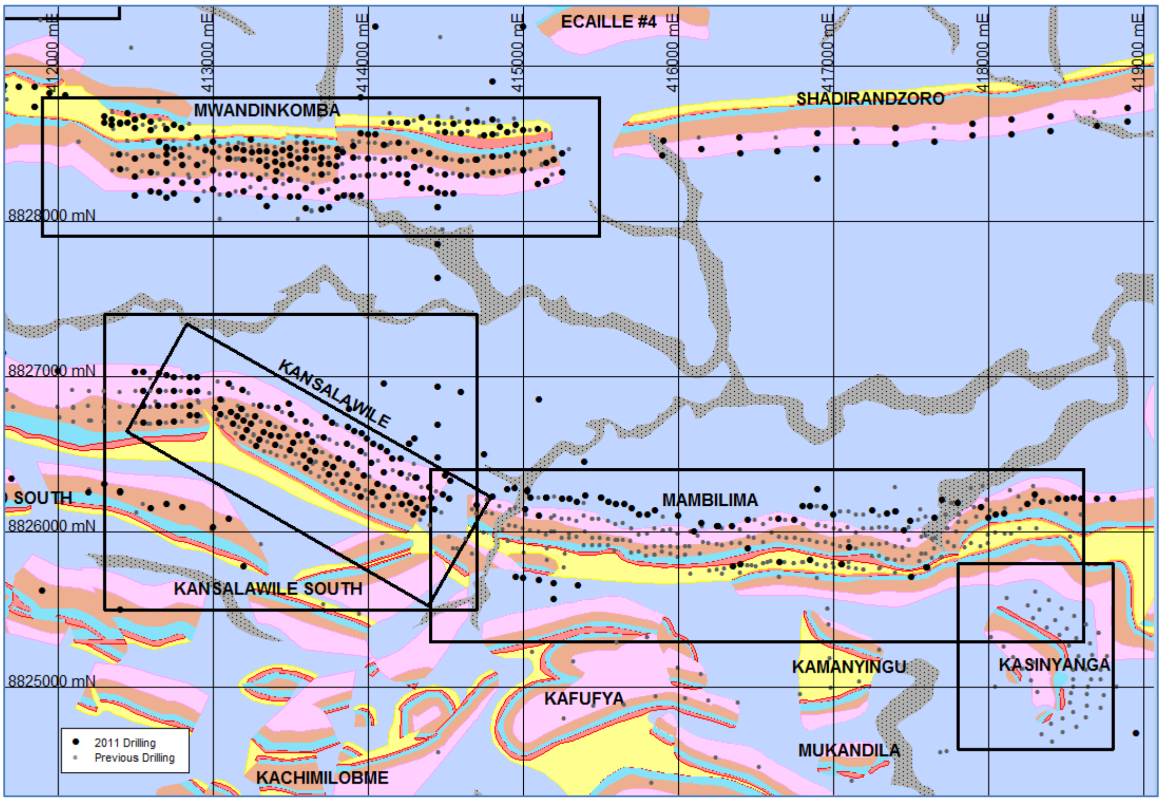


Figure 10-3 Tenke to Kwatebala Target Area

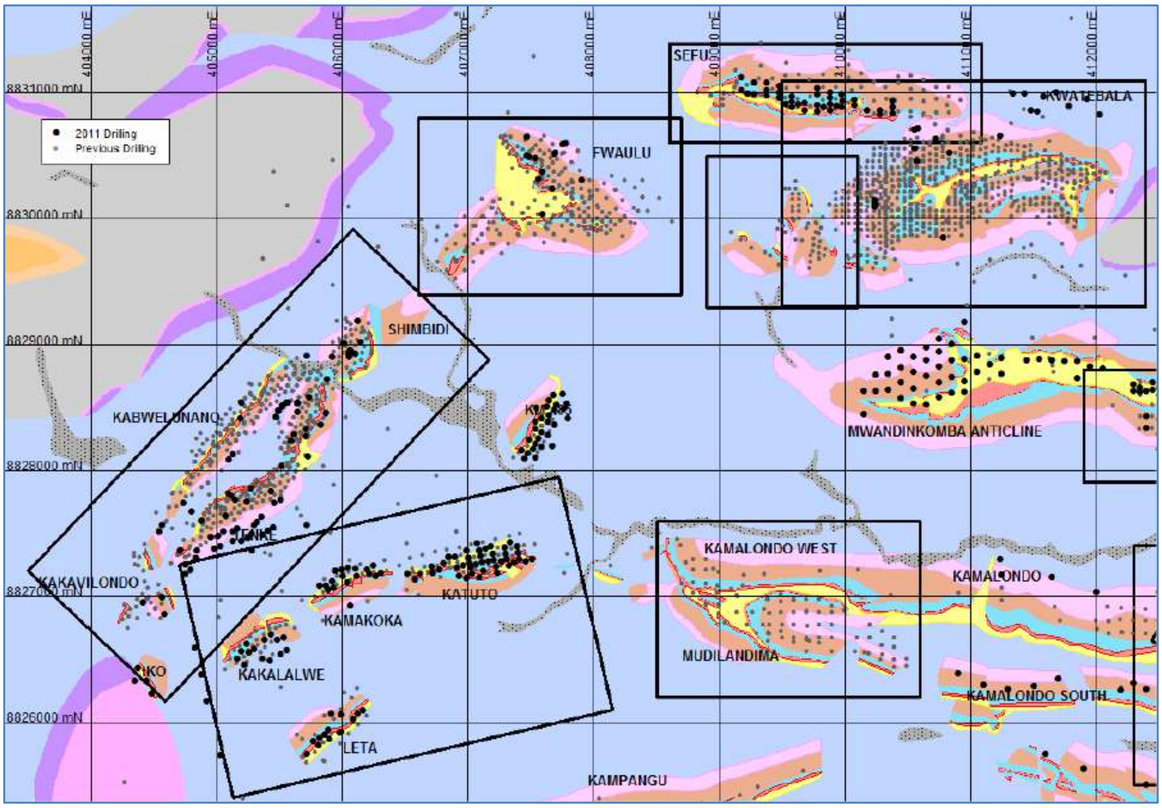
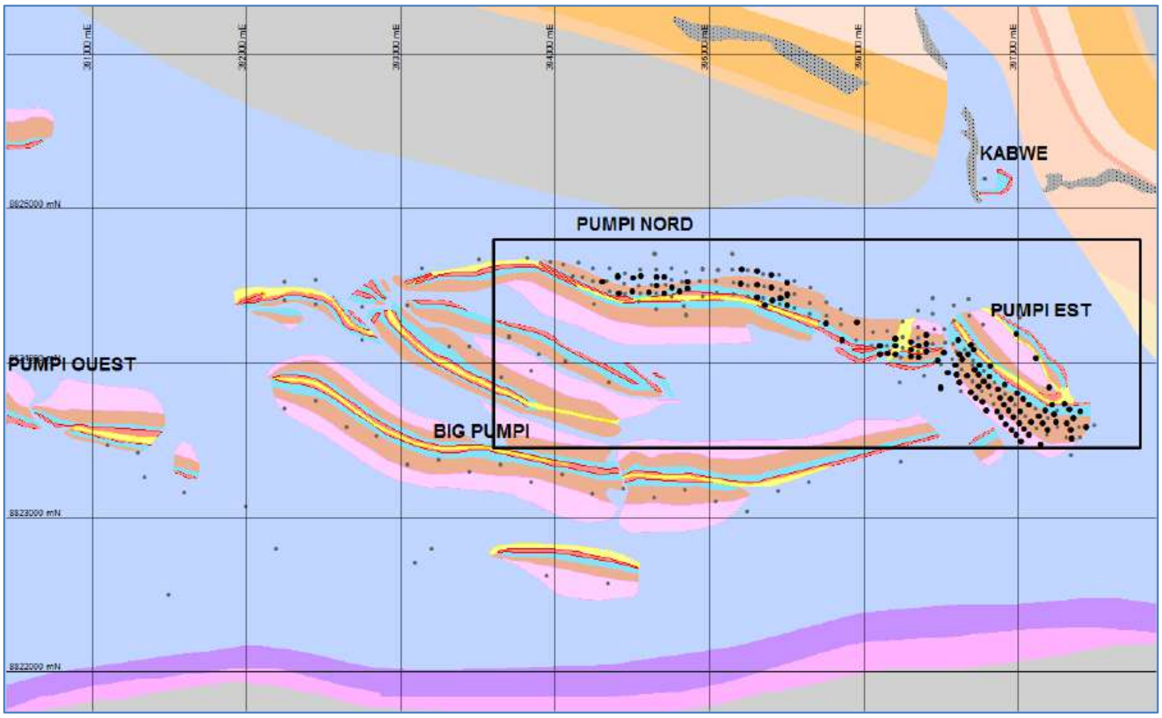


**Figure 10-4 Pumpi Target Area**



## 10.4 EXPLORATION TARGETS

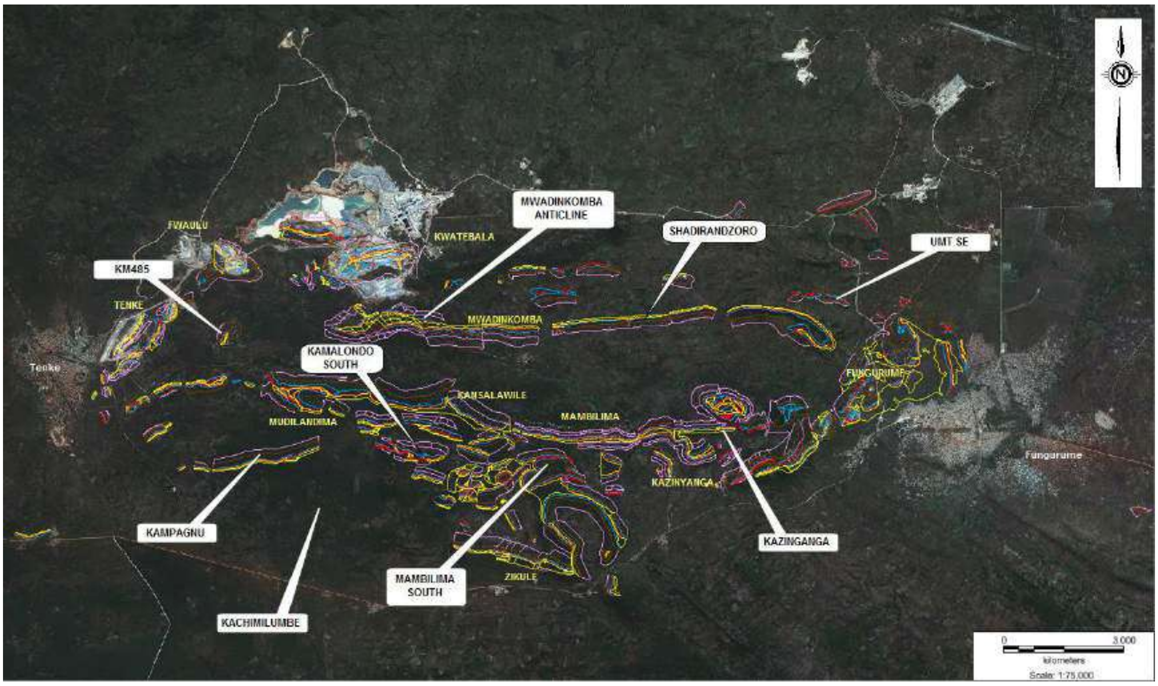
Seven new exploration targets are scheduled for drill testing over the next 4 years. Eleven developed deposits will be tested for definition and expansion of oxide, mixed and deep sulphide resources over the next 3 years.

Additional targets are expected to be identified once the new geophysical data are processed.

Drilling between Kansalawile and Mwadinkomba in 2013 confirmed the continuity of the DIpeta Syncline and Mine Series between these deposits at depth representing an enormous volume of prospective stratigraphy.

The exploration plan for 2014 encompasses 30,000m of drilling with a budget of $19M.

**Figure 10-5 New Exploration Targets**



# 11 SAMPLE PREPARATION ANALYSIS AND SECURITY

## 11.1 SAMPLING METHODS

All drilling in the databases used for modeling the Tenke Fungurume mineralization is core. For UMHK, the logs record hole diameter in inches, but the actual core size is unclear. SMTF holes generally started with 100 mm core and then were reduced as needed due to ground conditions. TMC holes generally started with PQ core (85 mm diameter) and then were reduced to HQ (64 mm) and NQ (48 mm), as needed.

Core holes were logged to varying degrees of detail, typically recording the stratigraphic unit, rock type and any obvious copper mineralogy. Cobalt mineralogy doesn't appear to be as consistently logged. The UMHK logs are in French, while the SMTF and TMC campaigns were logged in English. The SMTF logs typically note, in addition to stratigraphic unit, rock, and copper minerals, the degree of weathering of the core, an estimate of the intact nature of the core, presence of iron oxides, comments on bedding or lamination, relative hardness, and strength of mineralization, if appropriate. Core recoveries are noted on most of the drill logs. Water level was noted on most SMTF logs, but only rarely for UMHK and TMC holes. RQD information was recorded for only the TMC holes. In general, the logging is sufficient to allow the coding of sample intervals for stratigraphic horizon and copper mineralogy and to record core recovery. The water data were used to develop a reasonable estimate of the surface of the water table.

Only portions of the core were assayed in all of the drilling programs. TMC typically assayed a greater proportion of the core than UMHK or SMTF. All three companies assayed all of the RSF and SDB. The SD, RSC and RAT were selectively assayed based on the visual presence of copper mineralization and the proximity to the SDB and RSF contacts. At Kwatebala, 12,472.89 m of the 40,456 m of core was assayed in 10,462 assay intervals, giving an average assay sample length of 1.19 m.

The core from the SMTF and TMC programs was usually stored on site in Fungurume in wooden or metal core trays on shelving in covered but open-sided structures. Assay pulps from these campaigns are also stored on site. A fairly extensive search for the UMHK core on site and in Likasi indicates that few or no samples remain of UMHK drilling from Kwatebala, Tenke and Fwaulu. This has raised some concerns about using these data for resource estimation. Earlier models by Mintec and PD used the UMHK drilling, while models were constructed for feasibility that both used and omitted the UMHK drilling. The final models used in planning included UMHK drilling.

Exploratory trenches, mostly oriented north-south at Kwatebala, but also nearly perpendicular to strike across the Mines Series, were originally dug by UMHK and later cleaned, mapped and sampled by SMTF. At Tenke, the trenches were typically oriented northwest-southeast, again, nearly perpendicular to strike. Mapping was completed by sketching the trench showing the sample localities. Typically, most of the trench was sampled and assayed. Adits were also mapped by SMTF, recorded as a sketch of the ribs (walls) of the drift showing sample locality. Samples were taken across bedding, that is, to get a true thickness of the unit for assay.

## 11.2 CORE HANDLING

Drill core is packed into wooden or metal core trays at the drill site, with the depth of each run marked on wooden blocks and inserted in the trays. These are collected by the geologists and delivered to the core handling area shown in Figure 11-1 and Figure 11-2. Core handling consisted of:

- Geological logging
- Measuring core recoveries
- Photographing core
- Point load tests
- Density measurements
- Marking out samples
- Cutting core for sampling
- Sampling core

- Racking and storage

All logging and sampling of core is carried out by TFM geologists. Photography and recovery measurements are carried out by assistants under geological supervision.

Drill core is logged directly to computer by TFM geologists according to the existing stratigraphic nomenclature and coded using the KSLE coding system established for incorporation into Medsystem®. One additional coding system was introduced at site. The resource code (RESCODE) is used to allow different stratigraphic units to be easily identified and extracted from the geological and assay databases.

Sample intervals are generated by the acQquire database system based on logged lithology and nominal sample lengths of 1 m. Samples as short as 0.5 m or as long as 1.5 m are permitted where lithologic breaks prevent sampling of a 1 m interval.

At least one point load test and density (SG) measurement are taken for each lithologic unit. Density measurements are made at the core storage facility using the water immersion method.

Core recoveries are recorded for each borehole, and all core is photographed before sampling to preserve a permanent record.

All cores intersecting mineralized zones are systematically sampled, following the procedure outlined below:

- Mineralized/potentially mineralized zones marked out
- Core marked for cutting. The core is diamond sawed longitudinally to produce two halves - one to be analyzed, the other kept as a permanent record
- Where sawn core is used to provide metallurgical composites, the second half-cores are re-sawn to produce quarter-cores for assay
- Sample intervals are marked on cut core - sample number, top depth and bottom depth
- The core is sampled from above the top of the UMZ to below the base of the LMZ to establish a continuous grade profile through the mineralized sections
- Samples are bagged and numbered
- All samples are logged and the sample number, depths, sample length and stratigraphic unit recorded for each sample
- Samples are delivered to the sample preparation laboratory
- The sample information and analytical results are entered into the computer database
- All core is stored under cover at the facility after logging, sampling and photography
- All pulps and coarse rejects are stored at the facility

**Figure 11-1: Core handling and storage area (November 2013 Site Visit)**

**Figure 11-2 Sawing core samples (November 2013 Site Visit)**

## 11.3 ANALYTICAL AND TEST LABORATORIES

### 11.3.1 SMTF STUDIES

From the start of SMTF's studies in 1971 to May 1972 all assaying was done at the Rhokana laboratories at Kitwe in Zambia. At that point the Fungurume laboratory was commissioned and from then on all of SMTF's copper and cobalt assays were done at Fungurume (utilizing the same analytical techniques as at the Rhokana laboratory). From 1972 onwards, the Fungurume laboratory undertook to evaluate the gangue acid consumption (GAC) properties of the material sent for assay, as well as performing routine assays for copper and cobalt.

Assaying for total and acid soluble copper and cobalt was carried out by atomic absorption spectrophotometry (AAS) techniques. For the determination of acid soluble copper and cobalt, samples were leached with warm 5% sulfuric acid saturated with sulfur dioxide for exactly one hour, and the leach solutions analyzed.

Atomic absorption results were checked daily by assaying for total copper by electrolysis. Twelve to 18 samples out of the original daily throughput of 100 samples were selected at random, and atomic absorption results were accepted only if they came within 3% of the figures obtained by electrolysis. Otherwise, the entire batch was re-assayed, in accordance with standard practice at the Rhokana laboratory.

A selection of the trench, adit and drill core sample pulps which had been assayed at Rhokana prior to May 1972 were subsequently re-assayed at Fungurume. In addition, some samples originally assayed at Fungurume were later re-assayed at Fungurume.

According to SMTF reports, an independent check was made on the performance of the Rhokana and Fungurume laboratories by Alfred H. Knight Ltd. in the U.K. It is not known whether these checks were performed on pulps, rejects or second splits of core. The results of these repeat assays were subject to statistical analyses by SMTF to determine whether significant differences existed between the results of the three laboratories. According to SMTF this work showed that the correlation in the linear regression graphs and significance tests between Fungurume's and Knight's results, and between Fungurume's and Rhokana's results were good for both total copper and acid soluble copper. The study of variance tests revealed with high levels of confidence, 93% and 97%, that "between laboratory" variance was insignificant compared to differences due to metal distribution within the deposit. There are no details available of any comparison between Rhokana's and Knight's results.

As an independent check by SMTF, eighteen drill holes from Fungurume Gisement IIh originally assayed at Rhokana were re-split on the original sample intervals and the quarter core samples were assayed by the Fungurume laboratory. There is no indication in SMTF's report as to where the preparation of the original samples was carried out. Weighted mean grades of the horizon intersections were calculated for both sets of assays. Intersections through the upper horizon were quoted by SMTF as showing close correlation within 5% to 8% of the original copper grades, with the exception of two individual samples. The lower horizon re-sampling results were within 12% of the original figures, with the exception of one intersection.

### 11.3.2 TFM STUDIES

Assaying was done on site at Fungurume by Société Générale de Surveillance S.A. (SGS), who refurbished the existing facilities with new equipment.

Based on previous exploration results and a long history of exploitation elsewhere on the copperbelt, only four assays were specified for the current program: total copper (TCu), total cobalt (TCo), acid soluble copper (ACu) and acid soluble cobalt (ACo). Both procedures (total and acid soluble) involve digestion of the sample and assay finish by AA to determine copper and cobalt contents. The major difference lies in the digestion methods used. Selected samples were also analyzed for additional elements.

An extensive series of assay checks on site was instituted by TFM to ensure not only that the results reported are accurate and repeatable, but also that the relationship between total metal content and acid soluble metal content is properly reported.

Re-analysis of selected samples by external laboratories (SGS Zimbabwe and Anamet in the UK) was also carried out by TFM.

Sample material provided to the laboratory consisted of a complete spectrum of mineralization types ranging from oxide through mixed oxide-sulphide to sulphide. These compositions are reflected in the ratios of ACu to TCu and ACo to TCo which range from 0-100%.

One hundred and twenty five standards and 124 blanks (equivalent to > 4% of the total of 2 959 samples that were submitted) were used to monitor accuracy and contamination at the site laboratory. Of these, 57 standards and 57 blanks were submitted for the Kwatebala sampling, representing 7% of the 1,564 original samples.

In summary, analysis of results indicated that:

- TCu and TCo assays were accurate and repeatable
- ACu results for oxide material were been slightly over reported relative to TCu by SGS but that the error is small and lies within levels of detectability
- Cutting ACu to TCu (where the former exceeded the latter, within the limits of detectability) did not significantly alter the average composite values
- ACo was more sensitive to temperature variations in the sample digestion procedure than ACu
- ACo results did not exceed TCo results, meaning that average composite values are not significantly reduced by using cut values

During November 1997, KSLE carried out an on-site audit of sampling and assaying procedures practiced at Fungurume. The audit encompassed the supervision and preparation of a number of samples under strictly controlled conditions. In summary, KSLE found that these procedures appeared to conform to internationally acceptable standards.

### 11.3.3 PHELPS DODGE 2006

Core was split on site and sent to ALS Chemex laboratories in Johannesburg, South Africa for analysis. Samples were analyzed for TCu, TCo, ASCu and ASCo using standard Phelps Dodge methods. Other elements were analyzed by ICP.

Data from this campaign were not received in time to be used for the initial feasibility model; however, the Kwatebala database was updated with information from the PD drilling in subsequent models.

### 11.3.4 FREEPORT-MCMORAN 2007 -2008

Prior to October, 2008 all split drill core was sent to ALS Chemex laboratories in Johannesburg, South Africa for analysis. Since that time the primary analytical work has been carried out at the on-site laboratory with checks performed at PTC Safford.

Since January 2007, at least one quarter-core duplicate sample, one coarse reject duplicate and one pulp duplicate sample were collected within each unit of the 3 Mine Series and for 4% of the other intervals.

Three reference standards (low/medium/high grade) and blanks were inserted with at least one standard and blank per hole. Blank material used was clean quartz from Kolwezi.

After analysis at the TFM laboratory, a split of the pulps are taken and forwarded to PTC Safford.

### 11.3.5 FREEPORT- MCMORAN 2010 - 2013

#### TFM Laboratory

At the beginning of 2010, issues related to Quality Assurance and Quality Control (*QAQC*) of sample preparations performed in TFM's laboratory in 2009 were discovered. A full audit of the lab was conducted following a standard operating protocol prepared by an external consultant geochemist. During the shutdown of the lab, interim procedures including external laboratory analysis were used to ease the backlog. All samples found to be failing QAQC were also reanalyzed at the external laboratory.

Sample preparation resumed at the Fungurume Exploration Laboratory in March 2010 with a new QAQC protocol following the recommendations of the audit.

At the end of the 2011, the sample preparation facilities were transferred to the Kwatebala lab as part of the future consolidation of both labs. This laboratory facility at Kwatebala is in its fifth year of operation and is currently processing approximately 30,000 samples per month. The preparation facility for exploration samples in a separate building and can process over 500 samples per day.

During 2012 sample preparation was completed at the Tenke Fungurume Process Laboratory (TFM) and pulps were sent to TFM Exploration lab in Fungurume, ALS Chemex (ALS) in Johannesburg, South Africa and Skyline Labs (Skyline) in Tucson, Arizona. Analyses at the ALS Chemex lab were discontinued in 2013.

Starting in 2014, all prepared exploration samples will be sent to Skyline Laboratories in Tucson, AZ for analysis.

## 11.4 METALLURGICAL SAMPLING

Metallurgical sampling carried out by FCX prior to 2012 is documented in previous technical reports (GRD MInproc and Nilsson et al, 2007, 2008, 2009 and 2011).

Metallurgical sampling from the Fungurume and Kwatebala shafts is scheduled for 2014.

## 11.5 QUALITY ASSURANCE AND QUALITY CONTROL

### 11.5.1 2009-2012 QA/QC

QA/QC carried out by FCX prior to 2012 is documented in previous technical reports (GRD Minproc and Nilsson et al, 2007, 2008, 2009 and 2011).

### 11.5.2 2012-2013 QA/QC

References:

- QAQC Report on the 2012 Assay Data from the Tenke Fungurume Exploration Program by Jean-Pierre Mpoyo under the supervision of Linda Dufek dated March 12, 2013.
- QAQC Report on the 2013 Assay Data from the Tenke Fungurume Exploration Program by Jean-Pierre Mpoyo under the supervision of Linda Dufek dated March 14, 2014.

In 2012 approximately 53,800 exploration samples were submitted to laboratories including standards, blanks, duplicates and 10% lab check samples. The approximate distribution of assays by laboratory is as follows:

- 830 (1.5%) to Skyline Laboratory (Tucson, AZ)
- 52,800 (8.1%) to TFM Laboratory
- 170 (<1%) to ALS Laboratory (Johannesburg)

Standards, blanks, and duplicates were included in the samples analyzed based on the protocol recommended by Jeff Jaacks of Geochemical Applications Intl. Inc. in early 2009 and revised in mid-2011. All quality control samples were blinded to the analytical laboratory through a preparation protocol that involved sample preparation at the Tenke Fungurume Lab (TFM). All standards were inserted in the cores sent for preparation by the Exploration QAQC team. This procedure was initiated because both labs, preparation and analytical, are under the same supervision at TFM lab. TFM Lab is using standards received from Exploration as its internal quality control standards.

TFM lab performed all of the primary analyses in 2012 with the exception of one drill hole. The analyses reported by Skyline and ALS Chemex in 2012 were for the 10% check samples from 2011, because the protocol requires that the 10% check samples be selected and analyzed after the end of the drilling campaign. Skyline analyzed the results from one drill hole outside of the 10% checks. Since the 2012 campaign ended in December, 10% of all 2012 samples were sent in February and reported in the 2013 QAQC annual report.

In 2013 approximately 50,200 exploration samples were submitted to laboratories including standards, blanks, duplicates and 10% lab check samples. The approximate distribution of assays by laboratory is as follows:

- 10,480 (20.9%) to Skyline Laboratory (Tucson, AZ)
- 39,720 (79.1%) to TFM Laboratory

QAQC procedures were as outlined above.

**Standards**

Standard analyses measure accuracy and potential bias and should be within the mean +/- 2 standard deviations as determined and stated in the certificate for the certified reference material. At the 95% confidence interval, less than 5% of the analyses should exceed the certificate mean +/- 2 standard deviations. Any sample that exceeds the mean +/- 2 standard deviations is outside of the acceptable limits and is classified as a failure.

The sixteen internal reference standards used during 2012 and 2013 are listed in Table 11-1 These were prepared from materials selected by on-site staff. These materials were chosen from mineralized portions of the RSC, RSF and SDB lithological units. Standards 7-9 were prepared and certified by Alfred H. Knight during 2009. In addition, Standards 7-9 were submitted to ALS, Skyline, PTC, and TFM labs in a Round Robin format and the initial certified values were adjusted based on these analyses.

AMIS0159 and AMIS0163 were prepared by AMIS during 2010. They were not put in use until a second Round Robin was conducted to meet the required number of analyses by a sufficient number of different labs and for the same analytical methods as used by TFM lab. Jeff Jaacks certified that these standards were good and calculated the final values to be used for these AMIS standards. Five standards were prepared by Minerals Exploration Geochemistry (MEG) in Reno, Nevada in 2010. They were STDFR1X, STDFR2X, STDFR3X, STDFR4X, and STDFR5X. These were designed for Ca and Mg analysis but have also been certified for copper and cobalt.

Ten new standards (STD10 to STD19) were prepared by Alfred H. Knight in 2011 and certified by Jeff Jaacks in 2012 based on a second round robin.

**Table 11-1: Reference Standard Certified Values**

| STANDARD ID | TCu | | AsCu | | TCo | | AsCo | |
|---|---|---|---|---|---|---|---|---|
| | Std Value | Std Dev | Std Value | Std Dev | Std Value | Std Dev | Std Value | Std Dev |
| AMIS0159 | 1.03 | 0.035 | 0.95 | 0.06 | 0.17 | 0.01 | 0.15 | 0.01 |
| AMIS0163 | 2.68 | 0.065 | 2.56 | 0.11 | 0.28 | 0.015 | 0.25 | 0.015 |
| STD07 | 0.63 | 0.03 | 0.52 | 0.03 | 0.07 | 0.01 | 0.06 | 0.01 |
| STD08 | 1.79 | 0.05 | 1.66 | 0.07 | 0.46 | 0.02 | 0.4 | 0.02 |
| STD09 | 3.77 | 0.11 | 3.48 | 0.13 | 0.15 | 0.01 | 0.12 | 0.02 |
| STD10 | 0.871 | 0.023 | 0.829 | 0.027 | 0.352 | 0.02 | 0.321 | 0.016 |
| STD15 | 3.853 | 0.093 | 3.708 | 0.131 | 0.533 | 0.03 | 0.478 | 0.021 |
| STD17 | 2.581 | 0.063 | 2.458 | 0.086 | 0.595 | 0.049 | 0.531 | 0.029 |
| STD19 | 2.448 | 0.071 | 2.313 | 0.087 | 0.278 | 0.023 | 0.255 | 0.015 |
| STDFR1X | 4.85 | 0.27 | 4.68 | 0.13 | 0.46 | 0.06 | 0.43 | 0.05 |
| STDFR2X | 5.92 | 0.25 | 4.1 | 0.49 | 0.09 | 0.01 | 0.07 | 0.02 |
| STDFR3X | 5.7 | 0.26 | 4.05 | 0.34 | 0.13 | 0.02 | 0.11 | 0.02 |
| STDFR4X | 6.53 | 0.37 | 4.51 | 0.62 | 0.08 | 0.01 | 0.07 | 0.02 |
| STDFR5X | 6.92 | 0.52 | 6.55 | 0.37 | 0.52 | 0.06 | 0.48 | 0.05 |

In 2012, approximately 2,200 standards were analyzed for total copper (TCu), total cobalt (TCo), acid soluble copper (ASCu) and acid soluble cobalt (ASCo). The certified mean and standard deviations were used to generate statistics to check the accuracy and precision of the results. Standard statistics and control charts for all lab data showed acceptable accuracy and precision for copper and cobalt.

All laboratories met the acceptability criteria for standards in 2012.

During 2013, approximately 2,900 standards were analyzed. Standard statistics and Control charts for all lab data show acceptable accuracy and precision for Copper and Cobalt. All laboratories met the acceptability criteria for standards in.

### Blank Samples

Blank analyses measure sample preparation contamination and should be within 5x the detection limit. Any sample that exceeds 5x the detection limit is outside of the acceptable limits and is classified as a failure.

The blank material is composed of quartz crystals purchased from a local supplier. These quartz crystals are hand sorted to eliminate specimens containing impurities and contain no measurable concentrations of copper or cobalt

In 2012, approximately 1,300 blanks were submitted. No blank was found with concentrations of copper and cobalt that exceeded the acceptance criteria.

In 2013, approximately 1,600 blanks were submitted to the labs. The analysis of blanks indicates that no significant contamination occurred with the Tenke samples during sample preparation or the analytical process.

### Duplicates

Duplicate pulp analyses measure analytical reproducibility and should have a precision of +/- 10%. Thus, one would expect that 95% of the pulp analyses are within +/- 10% of each other. Any pulp duplicate pair that exceeds 10% precision is outside of the acceptable limits and is classified as a failure.

Duplicate coarse reject analyses measure sample preparation reproducibility and these duplicates should have a precision of +/- 15%. One could reasonably expect that 95% of the crush duplicate analyses should be within +/- 15% of one another. Any sample duplicate pair that exceeds 15% precision is outside of the acceptable limits and is classified as a failure.

In May of 2011, it was determined that field duplicates would no longer be reanalyzed when the Absolute Mean Percent Relative Difference (AMRPD) was 20% or greater. A study by site geologists showed that mineralogical variations between two halves of core could be great based on the presence of veins, cavities, and the distribution of minerals. Therefore, it was determined that field duplicates that failed these 20% criteria would be noted but not be re-analyzed.

During 2012, 991 sample duplicates (field duplicates), 991 preparation duplicates (secondary splits) and 986 pulp duplicates (duplicate pulps) were submitted to the laboratories. Data from TFM at 0.1% threshold (10x the lower detection limit) show that crushed and pulp duplicates analyzed for 2012 drill holes are within the acceptable criteria for each duplicate.

During 2013, approximately 2250 sample duplicates (field duplicates), 560 preparation duplicates (secondary splits) and 560 pulp duplicates (duplicate pulps) were submitted to the labs. The continuation of improved sampling procedures commencing in 2010 and immediate re-assay of duplicate failures improved the results this year for crushed and pulp duplicates. As from 2010, the acceptable precision that could be achieved at Tenke for Cu and Co was determined to be 0.2%. Therefore, 0.2% TCu, TCo, ASCu or ASCo was chosen as the point at which a re-assay would be required when a duplicate pair failed to achieve the designated criteria. Data from TFM at 0.1% threshold show that crushed and pulp duplicates analyzed for 2013 drill holes are within the acceptable criteria for each duplicate.

### Check Assays

Check analyses are a measure of inter-lab reproducibility and are used as a verification of the original analytical data. Check analyses on pulps should exhibit better than 10% precision, assuming that the laboratories are using the same analytical digestion. The sample digestion protocol should be the same if no bias is to be observed. Any “pulp” check analysis duplicate pair that exceeds 10% precision is outside of the acceptable limits and is classified as a failure.

For the 2012 drill program, 2430 lab duplicate pairs from Skyline and TFM were evaluated. The bias between Skyline and TFM was less than 0.07% with correlation coefficients of 0.92 to 0.99 for the various analytes.

A total of 1,181 lab duplicate pairs were analyzed by ALS to check the original assays which were done by Skyline. Between ALS and Skyline, the bias is less than 0.02 with a correlation from 0.94 to 0.99 for the various analytes. The purpose of the check analysis program is to validate the original results. The results of the analyses show that the population means and variances of the original samples and checks are not significantly statistically different.

In 2013, over 3000 lab duplicate pairs from TFM and Skyline Labs were evaluated. The bias between TFM and Skyline was less than 0.06 (TFM is biased low relative to Skyline) with correlation coefficients of 0.98 to 0.99 for the various analytes. The population means and variances of the original samples and checks are not significantly statistically different, particularly in total copper and cobalt.

**Databases**

Since 2007 the drill hole data has been administered using acQuire© software, a comprehensive geologic information management system with excellent QAQC capabilities.

## 11.6 COMMENTS ON SECTION 11

The authours believe that sample preparation, security and analysis are compliant with industry standards and adequate to support mineral resource and reserve estimates as defined under NI 43-101.

# 12 DATA VERIFICATION

John Nilsson, P.Eng., has visited the property on six occasions:

- February 16 to 18, 2006
- January 26 to 30, 2009
- November 30 to December 2, 2009
- November 1 to 5, 2010
- October 31 to November 4, 2011
- November 18 to 22, 2013.

Ronald Simpson, P.Geo., has visited the property on four occasions:

- January 26 to 30, 2009
- November 30 to December 2, 2009
- October 31 to November 4, 2011
- November 18 to 22, 2013.

Annual visits were also made to the FCX office in Tucson, AZ to review data related to Mineral Resource and Reserve models.

Site visit inspections included:

- Tours of active mining operations
- Site examination of all deposits with existing or potential Mineral Resources/Reserves
- Inspection of exploration, process plant, and laboratory facilities
- Examination of sample preparation and drill core storage facilities
- Inspection of drill core and mineralized outcrops
- Reviews of grade control methodology
- Confirmation by hand-held GPS of various drill sites and workings
- Audits of all block models used for resource/reserve estimates
- Meetings with site geology and mining staff
- Visits to metallurgical sampling sites
- Inspection of active exploration areas
- Visits to local towns and housing facilities

The Qualified Persons did not carry out any independent check sampling. However, during inspection of outcrops, drill core and active mining operations they were able to visually identify copper and cobalt mineralization consistent with reported grades.

## 12.1 DATABASE VERIFICATION

The authors are of the opinion that the data quality is adequate to support the Mineral Resources and Mineral Reserves stated in this Technical Report.

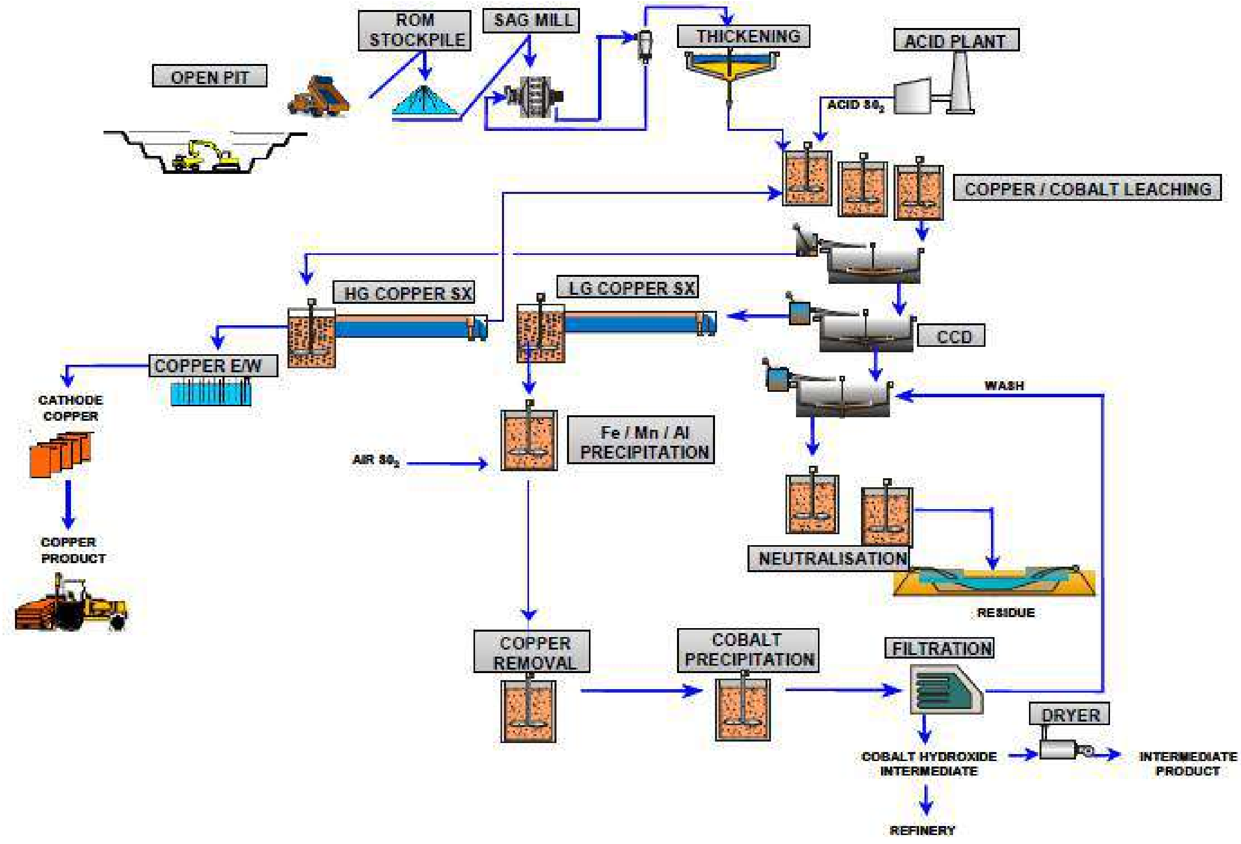
# 13 MINERAL PROCESSING AND METALLURGICAL TESTING

## 13.1 CURRENT OXIDE METALLURGY AND FLOWSHEET DEVELOPMENT

The Tenke Fungurume District in the DRC consists of several deposits in which the average valuable metal content varies from 2.0% to 6.0% copper (Cu) and 0.2% to 0.5% cobalt (Co). Copper occurs in the ore as copper oxide, predominantly malachite with trace amounts of pseudomalachite and chrysocolla. Cobalt appears as heterogenite, a hydrated cobalt oxide which may contain variable quantities of copper, iron and nickel. Gangue mineralization is quartz, muscovite, tourmaline and chlorite; dolomite is a significant part of certain areas within the ore zones.

Metallurgical extraction of copper from oxide-type minerals has been commercially practiced for many decades. Unit operations required for the process are technically proven and many examples of similar type units currently operating can be found. The Tenke flowsheet, shown in Figure 13-1 includes atmospheric leaching of ground ore followed by solution extraction and electrowinning for copper recovery.

**Figure 13-1 Tenke Fungurume Copper Circuit and Cobalt Purification**



The presence of cobalt in the ore requires additional processing operations. A reducing condition is required to co-extract cobalt as the readily soluble cobaltous (+2) ion, rather than the relatively insoluble cobaltic (+3) ion. Reducing conditions are achieved through the addition of gaseous Sulphur dioxide to the leach. Cobalt-rich liquor, bled from the copper solution extraction process, undergoes purification steps prior to precipitation of an intermediate hydroxide. The intermediate hydroxide is then re-dissolved in acid and undergoes further refining prior to electrowinning of the metal. Flowsheet development has focused on optimizing the copper recovery unit operations in conjunction with identifying and optimizing cobalt purification and refining steps.

The initial Tenke flowsheet evolved through three throughput options: 50,000 tpa, 130,000 tpa, and 115,000 tpa copper. The 115,000 tpa option was selected for the first phase of the project and was successfully commissioned in March 2009. With operational experience and modest debottlenecking exercises output was increased to circa 135,000 tpa copper in 2011. Cobalt flowsheet options included intermediate cobalt hydroxide products, off-site refining to electrowon metal and on-site refining, with the hydroxide option originally selected. On-site refining to electrowon metal was contemplated for a future expansion, but in March 2013, the TFM shareholders extended their joint-venture partnership to acquire the Kokkola cobalt refinery in Finland and related business for downstream processing of the cobalt hydroxide product.

The Phase 2 Expansion at Tenke, completed in 2013, has expanded processing operations to a nameplate capacity of 195,000 tpa copper and circa 15,000 tpa cobalt. No significant modifications to the flowsheet were undertaken and the expansion comprises the largely installation of additional crushing, solvent exchange and electrowinning facilities.

Current investigation work includes front-end debottlenecking and trial heap leach options to take advantage of excess SX/EW tank house capacity in the plant.

Historically, three phases of flowsheet development were undertaken at Tenke. The flowsheet and test work documented in the 1998 Definitive Feasibility Study were reviewed, optimized through option studies and then used as a basis for the 50,000 tpa plant option. Verification of design criteria was limited to test work on samples obtained during previous studies. The recovery of bulk samples from site was not possible until late 2005. The second phase of flowsheet development occurred when surface samples were recovered from site and data specific to the Kwatebala orebody became available to improve the accuracy of design parameters. The third phase of flowsheet development was a result of the integrated pilot plant test work undertaken on Kwatebala orebody samples from adits and trenches.

As part of ongoing development of the Mineral Resources within TFM's mining concession, future mining operations will include some of the oxide deposits in the Fungurume Hills, North and South Dipeta and Pumpi regions of the concession. Extensive metallurgical testing of these oxide ores demonstrate similar characteristics to ores currently processed, and therefore do not require changes to the existing plant.

## 13.2 INTEGRATED PILOTING ON KWATEBALA SAMPLES

A thorough metallurgical ore testing program was undertaken on samples representing the early years of mining activity at Tenke Fungurume and encompassed materials from the Upper, Intermediate and Lower Ore Zones. This work began with bench scale development and confirmation testing and concluded with three pilot campaigns. Bench scale and confirmatory tests were conducted with both individual and blended ore zone samples. Campaign One of the integrated pilot plant operated with a composite ore containing 60% Lower Ore Zone material and 40% Upper Ore Zone material and demonstrated the process from comminution through copper solution extraction (SX), electrowinning (EW) and cobalt hydroxide precipitation.

Approximately 1,100 kg of the composite ore was treated in Campaign One. A single LME Grade A copper cathode, weighing 38.2 kg, was produced. Cobalt hydroxide, or an intermediate basic cobalt sulfate product containing from 40% to 45% cobalt, was produced. The magnesium and copper content of this product ranged from 3% to 5% and 0.5% to 1%, respectively.

The overall copper and cobalt deportments for Campaign One are summarized inTable 13-1.

**Table 13-1 Overall Copper and Cobalt Results – Campaign One**

| Process Stream | % Cu | % Distribution | % Co | % Distribution |
|---|---|---|---|---|
| Ore Feed | 4.79 | 100.0 | 0.49 | 100.0 |
| Copper Cathode | 99.99 | 98.2 | ----- | ----- |
| Leach Residue | 0.07 | 1.3 | 0.06 | 10.0 |
| Cobalt Hydroxide | 1.1 | 0.2 | 42.0 | 88.0 |
| Iron/Aluminum/Manganese Precipitate | 0.09 | 0.3 | 0.05 | 2.0 |

Comminution testing indicated that the ore zones tested are very soft to soft, although the Intermediate Ore Zone contained some harder silica bearing material. Chemical analyses of the individual ore zone samples reaffirmed the highly variable nature of the copper and cobalt grades, further underscoring the need for stockpiling and a comprehensive blending regime prior to milling.

The first pilot plant campaign operation yielded copper and cobalt leaching extractions exceeding 98% and 90% respectively. Mineralogical assessment of the leach feed and residue confirmed that the material was well leached. Based on measured additions of concentrated Sulphuric acid ($H_2SO_4$) and 100% Sulphur dioxide ($SO_2$) to the leach circuit, the estimated annual consumption of Sulphur was 72,000 dmtpa, excluding the cobalt refinery requirements.

Copper solution extraction (SX) and electrowinning (EW) were examined in pilot scale. High and low-grade pregnant leach solutions (PLS) were fed to an “optimized series parallel circuit”, using approximately 30% (vol/vol) Cognis LIX984N extractant and Chevron/Phillips SX-80 diluent. Copper extractions realized in the high and low-grade PLS circuits were 91% and 95%, respectively.

The solution extraction operation was hampered during the last several days of Campaign One by the presence of colloidal, particulate and dissolved silica, which gradually accumulated throughout the circuit to approximate levels of 300 to 400 ppm. The presence of colloidal silica gave rise to phase separation issues and the presence of a third phase in the mixer and settler units. During Campaign Two, improved control of phase separation in the solution extraction circuit was addressed via a coagulant, Polyox, which was used to flocculate the silica, removing it from the PLS streams. The effectiveness of Polyox to maintain adequate phase separation was demonstrated again to a limited extent during Campaign Three.

Low-grade raffinate from the solution extraction circuit reported for further processing in the metal impurity removal and cobalt hydroxide precipitation stages. A two-stage impurity removal circuit was employed to first remove iron, aluminum and manganese, followed by residual copper in the second stage.

Cobalt hydroxide precipitation was carried out in a two-stage circuit, with magnesium oxide added as the precipitating agent. The resulting cobalt product contained from 40% to 45% cobalt, with magnesium and copper contents ranging from 3% to 5% and 0.5% to 1%, respectively.

Integrated pilot plant products and residues were supplied to various metallurgical and environmental consulting firms and equipment suppliers to conduct ancillary work in support of process stream filtration, thickening, tailings deposition and confirmation of process water recycle. These results were captured within the process testwork and environmental summaries in the Feasibility Study document. Mass balance data and product chemistry were provided for comparison with the MetSim® model and to potential clients interested in acquiring the crude intermediate hydroxide.

## 13.3 SUMMARY OF METAL EXTRACTIONS

The extractions for Cu, Co Fe, Mn and Al, for all three pilot plant campaigns are summarized in Table 13-2 along with the design values used. The plant design was based upon lower cobalt and copper extractions than achieved in the pilot plant testwork to be consistent with the mine plan and project economic model.

The feasibility mine plan, project economic model and process plant design were based upon overall plant recoveries of 95% Cu and 83.3% Co (for acid soluble content). The current 2013 Mineral Reserve parameters assume recoveries of 97.0% for copper and 94.0% for cobalt (for acid soluble content).

The current 2013 life of mine plan for 14.5 ktpd envisages life of mine average metal recoveries of 86.8% and 77.3% for total copper and cobalt respectively, including stockpile processing. Average copper and cobalt recoveries for the next 10 years of production, 2014 – 2023 are estimated to be 86.9% and 73.9% respectively.

**Table 13-2 Pilot Plant Extraction Results**

| Parameter | Campaign 1 | | | Campaign 2 | | | Campaign 3 | | | Pilot Plant Average [1] | Design Criteria/ Metsim® |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Average | Min | Max | Average | Min | Max | Average | | |
| **Mass Loss (%)** | -5.4 | 27.8 | 11.5 | 12.5 | 20.5 | 16.2 | 13.3 | 23.1 | 16.7 | 14.4 | 11 |
| **Co (Solids basis %)** | | | | | | | | | | | |
| Tank 6 Discharge MB | 80.3 | 96.3 | 89.8 | 95.0 | 96.3 | 95.5 | 82.8 | 93.7 | 90.2 | 90.7 | 88.5 |
| **Cu (Solids basis %)** | | | | | | | | | | | |
| Tank 6 Discharge MB | 98.4 | 99.4 | 98.8 | 98.6 | 99.1 | 98.8 | 97.8 | 98.8 | 98.5 | 98.7 | 95.6 |
| | | | | | | | | | | | |
| Mn Extraction | 71.7 | 93.2 | 86.7 | 90.4 | 90.9 | 90.5 | 88.7 | 92.4 | 90.7 | 88.9 | 90 |
| Fe (Solids basis) | -13.6 | 19.9 | 3.5 | -2.3 | 16.7 | 9.8 | -5.8 | 15.1 | 7.1 | 6.4 | 5 |
| Fe Extraction | -2.8 | 6.8 | 1.8 | -1.3 | 3.6 | 1.1 | 0.9 | 3.1 | 2.2 | 1.9 | 5 |
| Al Extraction | No values | No values | No values | -0.08 | 0.9 | 0.4 | 0.6 | 0.9 | 0.7 | 0.6 | 3 |

## 13.4 FUTURE METALLURGICAL OPTIONS

Metallurgical testwork has continued following the processing plant start up to evaluate alternative options for the oxide ores, particularly those of lower grade or high acid consumption, and to develop potential treatment solutions for the deeper mixed and sulphide ores.

### Heap Leaching Oxides

Trials on heap leaching on lower grade oxide ores have been carried out with a large number of column tests employed on representative samples. Copper and cobalt recoveries were reasonable in the approximate 50% of the columns tests that were successful while insufficient permeability and metal precipitation from the leach solution was the suspected reason for failure in remaining samples. Further testing indicated that the permeability issue could be resolved by course crushing and fines removal as well as in limiting the feed grade.

Two 20,000 tonne trial heap leach pads were constructed at site during September and October 2011. One pad has been loaded with coarse crushed and screened low grade ore and one with coarse crushed but unscreened ore. Leaching which commenced at the end of October 2011 was carried out with both sulphuric acid and low grade raffinate. It is anticipated that heap leaching will be a successful metallurgical option for treating lower grade ores and will bring significant benefit in allowing the earlier treatment of lower grade ore previously destined for stockpiles; the treatment of ore near to the orebodies and the pumping of leach solution rather than the transport of ore to a central processing plant; lower operating costs; and simpler tailings/ripios management. The heap leach pads are shown in Figure 13-2 below with crushed and screened RSC material on the pad in the foreground and run of mine material on the second pad in the background.

**Figure 13-2 Heap Leach Pad**

Evaluation of future demonstration and commercial scale heap leach pads are ongoing with consideration of trial heap leaching results as well as to the life of mine plan updates.

### Mixed/Sulphides

Many of the deposits within the Tenke Fungurume concession do not have a clear transition between the oxide and sulphide zones, and there are large zones of heavily mixed material with both sulphide and oxide mineralogy. These zones do not correlate strongly to depth or spatial location within the orebodies, and in Fungurume sulphide and oxide intervals occur throughout the deposit from 50 m to 950 m depth.

Conceptual process designs and flow sheets to treat these ore types include flotation (for both sulphides and oxides) to produce concentrate. Further treatment of the concentrate is possible via roasting or pressure oxidation, agitated leaching, solvent exchange and electro-winning. Options for leaching the flotation tailings are also being considered.

Ore characterization and metallurgical testing of a large number of master composite samples has been undertaken on mixed and sulphide ores from the Fungurume, Kwatebala, Tenke and Fwaulu orebodies. These composites have been subject to grinding, flotation testwork and followed by variability testwork on the preferred circuit configuration. Concentrates from the flotation testwork are being subject to further work with both batch kiln and fluid bed testing. Testwork on the mixed and sulphide ores has been accelerated to further define designs and flow sheets for the next phases of expansion at Tenke Fungurume.

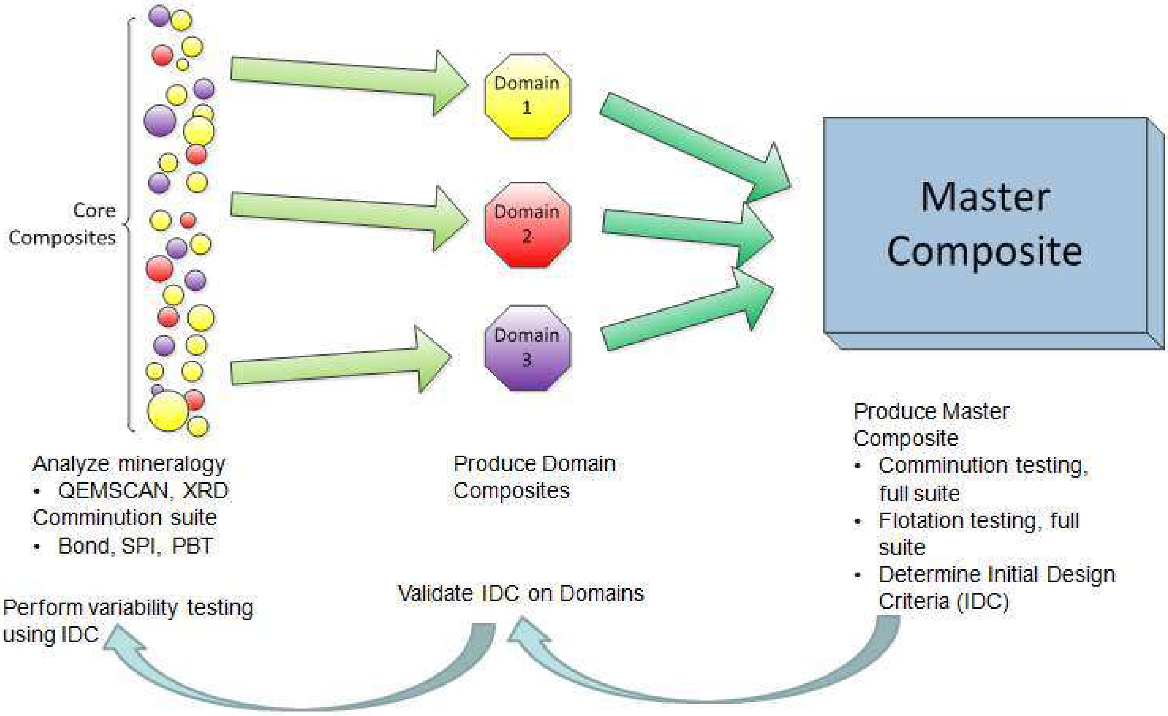
Current work includes two metallurgical sampling shafts at Fungurume and Kwatebala, which are expected produce 300-500 tonnes of mixed and sulphide material. Photos of the shafts taken in November 2013 are shown in Figure 13-3 and Figure 13-4.

**Figure 13-3 Metallurgical Sampling Shaft at Fungurume November 2013**

**Figure 13-4 - Metallurgical Sampling Shaft at Kwatebala November 2013**

The mixed and sulphide material will be used to build master composites for metallurgical testing in 2014. A conceptual methodology of ongoing work is shown in Figure 13-5.

**Figure 13-5 - Scoping Level Methodology for Geometallurgical Composite Testing**



Previously, bench scale testwork in support of a cobalt refinery and subsequent production of metallic cobalt was conducted. However in March 2013, a strategic decision was made by the TFM partners to expand the joint venture partnership through the acquisition of the Kokkola cobalt refinery in Finland and related business. The Kokkola cobalt refinery produces a variety of cobalt products from cobalt hydroxide feed, which will increasingly come from Tenke Fungurume in future years. Studies are ongoing to optimize the cobalt hydroxide feed to be sold to the Kokkola refinery.

# 14 MINERAL RESOURCE ESTIMATES

## 14.1 SUMMARY

Mineral Resources for the Tenke-Fungurume Mine have been estimated for 14 separate models to date. By the end of 2013, active mining had been carried out by TFM on 3 of the deposits; Kwatebala, Fwaulu, and Tenke.

### 14.1.1 RESOURCE SUMMARY

The Tenke-Fungurume Mineral Resources with an effective date of 31 December, 2013 are summarized in the table below. A cut-off grade of 1.3% copper equivalent has been used for reporting. The cut-off grade is based on a Cu price of $2.00/lb and Co price of $10.00/lb. It represents a potential economic cut-off based on relative recoveries and estimated average mining and processing costs. Mineral Resources are reported inclusive of Mineral Reserves.

**Table 14-1 Mineral Resource Summary**

| Class | Material Type | Tonnes 000’s | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 108,699.5 | 2.77 | 0.32 | 4.04 |
| | ref. oxide | 229.0 | 1.94 | 0.15 | 2.54 |
| | mixed | 42,940.1 | 3.35 | 0.35 | 4.74 |
| | sulphide | 7,776.8 | 4.29 | 0.33 | 5.61 |
| | leached | 1,103.1 | 0.19 | 0.61 | 2.64 |
| | **Combined** | **160,748.4** | **2.98** | **0.31** | **4.22** |
| **INDICATED** | oxide | 231,076.0 | 2.24 | 0.26 | 3.26 |
| | ref. oxide | 1,057.3 | 1.55 | 0.13 | 2.08 |
| | mixed | 159,768.5 | 2.56 | 0.26 | 3.60 |
| | sulphide | 24,415.8 | 3.09 | 0.22 | 3.99 |
| | leached | 2,193.2 | 0.18 | 0.51 | 2.21 |
| | **Combined** | **418,510.8** | **2.40** | **0.26** | **3.42** |
| **MEASURED & INDICATED** | oxide | 339,775.5 | 2.41 | 0.27 | 3.50 |
| | ref. oxide | 1,286.2 | 1.62 | 0.13 | 2.15 |
| | mixed | 202,708.6 | 2.73 | 0.27 | 3.79 |
| | sulphide | 32,192.6 | 3.38 | 0.25 | 4.39 |
| | leached | 3,296.3 | 0.18 | 0.54 | 2.36 |
| | **Combined** | **579,259.2** | **2.56** | **0.27** | **3.65** |
| **INFERRED** | oxide | 80,496.9 | 1.88 | 0.206 | 2.71 |
| | ref. oxide | 115.4 | 2.51 | 0.12 | 2.98 |
| | mixed | 227,548.1 | 2.00 | 0.25 | 2.99 |
| | sulphide | 31,532.6 | 2.40 | 0.22 | 3.29 |
| | leached | 3,543.5 | 0.12 | 0.50 | 2.12 |
| | **Combined** | **343,236.6** | **1.99** | **0.24** | **2.94** |

## 14.2 INTRODUCTION

This section summarizes the estimation of Mineral Resources for the overall Tenke Fungurume concessions. The Mineral Resources were estimated by staff of FCX and TFM. The Mineral Resource estimates were reviewed by the authors of this report. The current resource models and year of completion are listed in Table 14-2. Six resource models have been updated since the previous technical report of March 2011 and seven new models have been completed.

**Table 14-2 Model Designations**

| Deposit | Model Name | Year |
|---|---|---|
| Kansalawile | KASA 2009a | 2009 |
| Kazinyanga | KANZ 2010a | 2010 |
| Kwatebala | KWAT 2010a | 2010 |
| Katuto | KATO 2011a | 2011 |
| Shinkusu | SHIK 2011a | 2011 |
| Fungurume VI, VI Ext. | FGVI 2012a | 2012 |
| Fwaulu | FWAL 2012a | 2012 |
| Mambilima | MAMB 2012a | 2012 |
| Mudilandima | MUDI 2012b | 2012 |
| Tenke | TENK 2012a | 2012 |
| Zikule | ZIKU 2012a | 2012 |
| Fungurume | FGME 2013a | 2013 |
| Mwadinkomba | MWAN 2013b | 2013 |
| Mwinansefu (Sefu) | SEFU 2013a | 2013 |
| Pumpi | PUMP 2013a | 2013 |

Up to the end of 2006 block model estimations of the Tenke Fungurume deposits utilized conventional grade estimation methods such as Inverse Distance (Kwatebala and Fwaulu) and Ordinary Kriging (Tenke). These block grade estimates were not particularly effective in replicating the mineralized trends observed in the drill hole data. This was due to the inherent methodology and lack of resolution provided by the wide drill hole spacing compared to relatively thin, folded rock units.

In 2007, Isaaks & Company began trial applications of a block interpolation method involving the orientation of data search ellipsoids on a block by block basis in order to simulate local trends. The method has been termed 'Local Anisotropy Kriging' or LAK. All current models use this interpolation method.

The LAK method is a two-stage algorithm with the first stage involving preprocessing of the data and identification of optimum search ellipsoids for each block. The second stage carries out the actual kriging of block grades.

Implementation of the LAK methodology for the Tenke Fungurume deposits required additional customization due to the nature of the ore controls. The methodology has been refined over the past year and presently involves the following steps.

- Create the initial block models and lithologic models using Minesight® software
- Characterize the grade trends within each rock unit using the CONTACT program. Each block within a particular rock unit is tagged with its distance to a rock unit contact.
- Establish nominal 2.5 m thick stratigraphic layers within each unit (blocks and composites).
- Nearest-neighbour assignment of block grades matching layer codes in blocks and composites used to analyze grade profiles within units
- Define optimum orientation of the kriging search ellipsoid using NAYBOR program
- Estimate block grades using the LAK method
- Check global average of all blocks by rock unit and structural zone to ensure there is no global bias
- Import the resulting LAK grade estimates back to the Minesight® model to be used for further evaluation and mine planning.

Two programs were provided by Isaaks & Company for pre-processing of the data:

**CONTACT program**

The CONTACT program identifies relative distance of composites and blocks from the contact with adjacent units. The contact analysis was carried out for RAT, RSF, RSC, and SDB. The composites and blocks were then binned by distance from adjacent units. Layer codes (bins) were assigned by working from upper and lower contacts towards the center of each unit.

Composite codes were edited, when necessary, to better match the layering in the blocks

In most cases the CONTACT software matched layers in blocks and composites reasonably well.

**LAK NAYBOR Program**

The NAYBOR program identifies blocks by layer in a spherical search neighborhood centered on each block. An algorithm fits a plane to the x, y, z coordinates of blocks with matching rock-type and layer codes. A flattened ellipse is defined with search of 60m x 60m along strike and up- and down-dip and 15m across the stratigraphy. The dip direction and dip for each block are stored in the model items DIPAZ and DIP which are, in turn, used to define composite search parameters in the kriging routines.

## 14.3 DATA SOURCES

A summary of all sample data used for the resource models is presented in Table 14-3. The Kwatebala model also included 76 channel samples from trenches and old adits.

**Table 14-3 Sample Data Summary**

| Deposit Model | Drill Holes | m Drilled | Number of Analyses | | | | |
|---|---|---|---|---|---|---|---|
| | | | TCu | ASCu | TCo | ASCo | Ca |
| Kansalawile | 107 | 13,733 | 6,254 | 6,254 | 6,254 | 6,254 | 4,325 |
| Kazinyanga | 53 | 9,325 | 3,885 | 3,883 | 3,881 | 3,885 | 3,884 |
| Kwatebala | 750 | 86,443 | 44,247 | 40,044 | 44,061 | 40,048 | 22,769 |
| Katuto | 105 | 17,483 | 7,075 | 7,074 | 7,074 | 7,074 | 6,888 |
| Shinkusu | 50 | 5,098 | 3,173 | 3,162 | 3,172 | 3,172 | 3,150 |
| Fungurume VI, VI Ext. | 133 | 20,183 | 8,673 | 7,888 | 8,522 | 7,885 | 6,935 |
| Fwaulu | 235 | 36,595 | 14,718 | 13,270 | 14,708 | 13,291 | 13,061 |
| Mambilima | 274 | 53,100 | 24,441 | 24,412 | 24,441 | 24,414 | 21,329 |
| Mudilandima | 91 | 14,320 | 7,346 | 7,345 | 7,345 | 7,345 | 7,346 |
| Tenke | 488 | 66,723 | 26,423 | 24,735 | 26,191 | 24,771 | 19,521 |
| Zikule | 67 | 9,125 | 5,056 | 5,056 | 5,056 | 5,056 | 5,056 |
| Fungurume | 830 | 147,449 | 53,101 | 45,526 | 50,583 | 45,541 | 34,778 |
| Mwadinkomba | 326 | 60,364 | 23,919 | 23,889 | 23,894 | 23,897 | 23,508 |
| Mwinansefu | 105 | 10,642 | 6,119 | 6,119 | 6,119 | 6,118 | 4,043 |
| Pumpi | 265 | 51,133 | 27,874 | 27,871 | 27,878 | 27,876 | 27,343 |
| **Totals** | **3,879** | **601,715** | **262,304** | **246,528** | **259,179** | **246,627** | **203,936** |

## 14.4 MODEL PARAMETERS AND SPATIAL DETAILS

For all models, the block size is set at 5m x 2.5m x 2.5m with the longest axis horizontal along the strike direction. If the dominant orientation is east-west then no model rotation is used. Otherwise the model is rotated such that the x axis is parallel to the principal orientation. The locations and extents of the 14 block models are illustrated in Figure 14-1 and listed in Table 14-4 and Table 14-5. Block parameter codes are common to all models and are listed in Table 14-6.

**Figure 14-1 Model Locations and Extents**

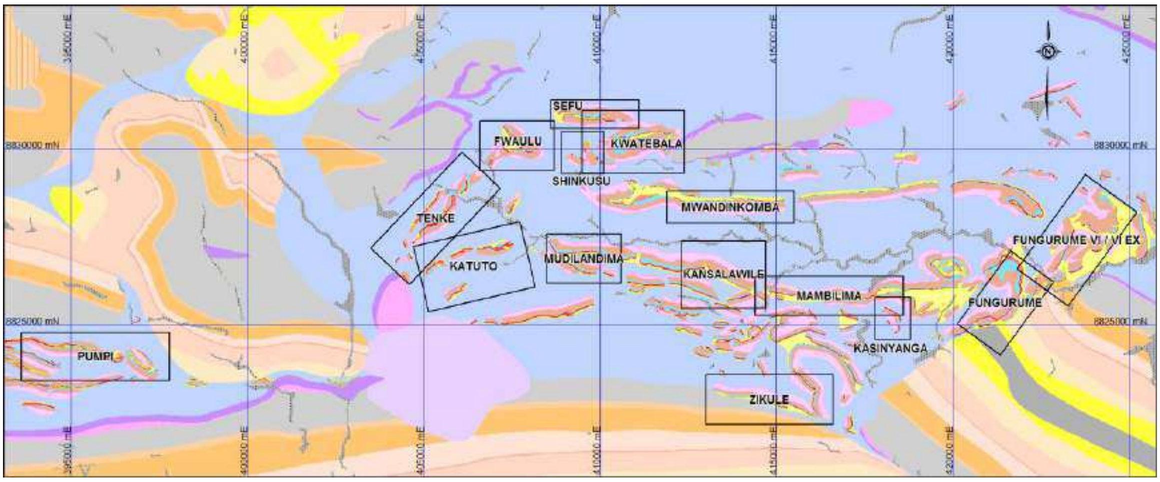


**Table 14-4 Orthogonal Block Model Extents**

| Deposit | Model Name | East (column) | | North (row) | | Elev (level) | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| Kansalawile | KASA 2009a | 412300 | 414700 | 8825500 | 8827400 | 1100 | 1415 |
| Kazinyanga | KANZ 2010a | 417800 | 4188800 | 8824600 | 8825800 | 1100 | 1400 |
| Kwatebala | KWAT 2010a | 409500 | 412400 | 8829300 | 8831100 | 1140 | 1530 |
| Shinkusu | SHIK 2011a | 408900 | 410100 | 8829300 | 8830500 | 1250 | 1460 |
| Fwaulu | FWAL 2012a | 406600 | 408700 | 8829400 | 8830800 | 1100 | 1465 |
| Mambilima | MAMB 2012a | 414400 | 418600 | 8825300 | 8826400 | 950 | 1360 |
| Mudilandima | MUDI 2012b | 408500 | 410600 | 8826200 | 8827600 | 1150 | 1500 |
| Zikule | ZIKU 2012a | 413000 | 416600 | 8822200 | 8823600 | 1200 | 1500 |
| Mwadinkomba | MWAN 2013b | 411900 | 415500 | 8827900 | 8828800 | 1000 | 1450 |
| Pumpi | PUMP 2013a | 363600 | 397800 | 8823450 | 8824800 | 950 | 1600 |

**Table 14-5 Rotated Block Model Extents**

| Deposit | Model Name | Rotation (Degrees) | Origin X | Origin Y | Elev (level) | | Dist X | Dist Y | Dist Z |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | | | |
| Katuto | KATO 2011a | 13 | 405130 | 8825400 | 1100 | 1550 | 3100 | 1900 | 450 |
| Fungurume VI, VI Ext. | FGVI 2012a | 36 | 420129.1 | 8825050 | 900 | 1500 | 1500 | 2550 | 600 |
| Tenke | TENK 2012a | 43.5 | 403500 | 8827200 | 1220 | 1540 | 1500 | 3750 | 340 |
| Fungurume | FGME 2013a | 36 | 421810 | 8826608 | 1160 | 1400 | 1800 | 3300 | 600 |

**Table 14-6 Block Model Parameters**

| Item | Min | Max | Precision | Description |
|---|---|---|---|---|
| TOPOC | 0 | 100 | 1 | Current Topography  as mined. Includes tailings and stockpiles. |
| TOPOO | 0 | 100 | 1 | Original Topography, i.e. miner's pits NOT removed |
| PITRR | 0 | 100 | 1 | Block % within a design pit Reserve Resources (Not used) |
| PITMM | 0 | 100 | 1 | Block % within a design pit Mineralized Material (Not used) |
| TCU | 0 | 40 | 0.01 | Total Copper for mine planning |
| TCUI | 0 | 40 | 0.01 | Inverse-Distance Weighting Total Copper value matching on LAKLR |
| TCUK | 0 | 40 | 0.01 | Kriged Copper Value using LAK |
| TCUNN | 0 | 40 | 0.01 | Nearest-Neighbor Copper Value matching on LAKLR |
| RATCU | 0 | 100 | 1 | Interpolated ratio: Adjusted Acid-Soluble Cu/Total Cu |
| ACU | 0 | 40 | 0.01 | Calculated Acid-Soluble Cu Value = TCu * (RATCu/100) |
| TCO | 0 | 10 | 0.01 | Total Cobalt Value for mine planning |
| TCOI | 0 | 10 | 0.01 | Inverse-Distance Weighting Total Cobalt value matching on LAKLR |
| TCOK | 0 | 10 | 0.01 | Kriged Cobalt Value using LAK |
| TCONN | 0 | 10 | 0.01 | Nearest-Neighbor Cobalt Value matching on LAKLR |
| RATCO | 0 | 100 | 1 | Interpolated ratio: Adjusted Acid-Soluble Co/Total Co |
| ACO | 0 | 10 | 0.01 | Calculated Acid-Soluble Co Value = TCo* (RATCo/100) |
| EQCU | 0 | 150 | 0.01 | Equivalent Copper = Total Copper + (Total Cobalt * 4) |
| CA | 0 | 40 | 0.01 | Kriged Calcium Value using LAK |
| MG | 0 | 40 | 0.01 | Kriged Magnesium Value using LAK |
| FMGAC | 0 | 1000 | 1 | Gangue-Acid Consumption from FMTAC, ACU and ACO |
| FMNAC | 0 | 1000 | 1 | Net-Acid Consumption calculated from model FMGAC and ACU |
| FMTAC | 0 | 1000 | 1 | Total-Acid Consumption calculated from ACU, ACO, CA and MG |
| SG | 0 | 10 | 0.01 | Specific Gravity |
| RTYPM | 0 | 100 | 1 | Modeled  Rock Type |
| ORERK | 0 | 100 | 1 | Code combining rock and ore types, e.g. 42 = oxide RSF; 43=mixed RSF, etc. |
| SZONE | 0 | 29 | 1 | Structural Zone |
| IZONE | 0 | 29 | 1 | Interpolation Zone |
| LAYER | -50 | 50 | 1 | Min and max output from layer program |
| LAKLR | 0 | 9999 | 1 | Combined remapped LAYER field |
| DIPAZ | 0 | 360 | 1 | Estimate of the azimuth of the dip of the strata in a block |
| DIP | -90 | 0 | 1 | Estimate of the magnitude of the dip of strata in a block |
| OTYCU | 0 | 99 | 1 | Copper ore type |
| OTYCO | 0 | 99 | 1 | Cobalt ore type |
| WEATH | 0 | 29 | 1 | Weathering zone |
| WATER | 0 | 100 | 1 | % of block below water table (Not used) |
| NCOMP | 0 | 60 | 1 | Number of composites used in KTCU copper-grade interpolation |
| NDDH | 0 | 25 | 1 | Number of drill holes used in KTCU copper-grade interpolation |
| DISTA | 0 | 500 | 1 | Average distance of all composites used in KTCU grade interpolation |
| DISTC | 0 | 500 | 1 | Distance to closest composite used in KTCU grade interpolation |
| KRVCU | 0 | 5 | 0.01 | Kriging variance from KTCU LAK runs |
| KRVCO | 0 | 5 | 0.01 | Kriging variance from KTCO LAK runs |
| PASSK | 0 | 20 | 1 | Kriging Pass from LAK KTCU runs |
| RCLAS | 0 | 5 | 1 | Resource Class |
| IND1 | 0 | 1 | 0.01 | Indicator item (Not used) |
| IND2 | 0 | 1 | 0.01 | Indicator item (Not used) |
| XTRCU | 0 | 40 | 0.01 | Extra Cu grade item (Not used) |
| XTRCO | 0 | 40 | 0.01 | Extra Co grade item (Not used) |
| BEDRK | 0 | 100 | 1 | % of block that is bed rock, i.e. 0% = soil development; 100% = more-or-less solid rock |
| ORELR | 0 | 9999 | 1 | Combined LAKLR and ore type code |
| ROTY | 0 | 1 | 0.01 | Term used in LAK to denote rotation around Y axis; Set to 0 |

| Item | Min | Max | Precision | Description |
|---|---|---|---|---|
| X2Y | 0 | 1 | 0.01 | Term used in LAK to denote ratio of rotated X-Y axes in search ellipse; Set to 1 |
| Z2Y | 0 | 1 | 0.01 | Term used in LAK to denote ratio of rotated Z to Y axes in search ellipse; Set to 0.33 |
| TURIZ | 0 | 25 | 0.01 | IDW copper estimate, matching only on rock type and interpolation zone (not LAKLR) |
| TORIZ | 0 | 10 | 0.01 | IDW cobalt estimate, matching only on rock type and interpolation zone (not LAKLR) |
| PASSN | 0 | 10 | 1 | NAYBOR Pass |
| CONDH | 0 | 20 | 1 | Number of drill holes used in cobalt LAK interpolations |
| ODSTA | 0 | 600 | 1 | Average distance of all composites used in KTCO grade interpolation |
| ODSTC | 0 | 600 | 1 | Distance to closest composite used in KTCO grade interpolation |
| ORCLS | 0 | 5 | 1 | Resource class based on cobalt LAK interpolations |

## 14.5 LITHOLOGIC MODELS

Stratigraphic units and major structures are interpreted on cross sections, long sections and level plans. The three directions are rectified as the geology is being interpreted. Prior to 2013, the 2.5m benches were coded from the level plans with identical rock type (RTYPM) codes above and below each of the interpreted levels. Figure 14-2 shows an example of the block coding from Kwatebala.

The 2013 models for Fungurume and Pumpi use wireframe solids generated using the MineSight Implicit Modeler (MSIM) to code the blocks. Cross sections, contact points and control points (on long sections and levels) were used as input data for MSIM to complete. The surfaces are modeled using an iterative process, with adjustments and reconciliation of the interpretation in all three dimensions. MSIM calculates surfaces and solids based on the input data. These surfaces are then cut into smaller surfaces representing the individual faults and solids for the rock units. The rock units for each zone are generated independently from one another, allowing for consistency. Examples of the MSIM models for Fungurume and Pumpi are displayed in Figure 14-3 and Figure 14-4.

**Figure 14-2 Kwatebala slices showing block model lithology coded from level plans**

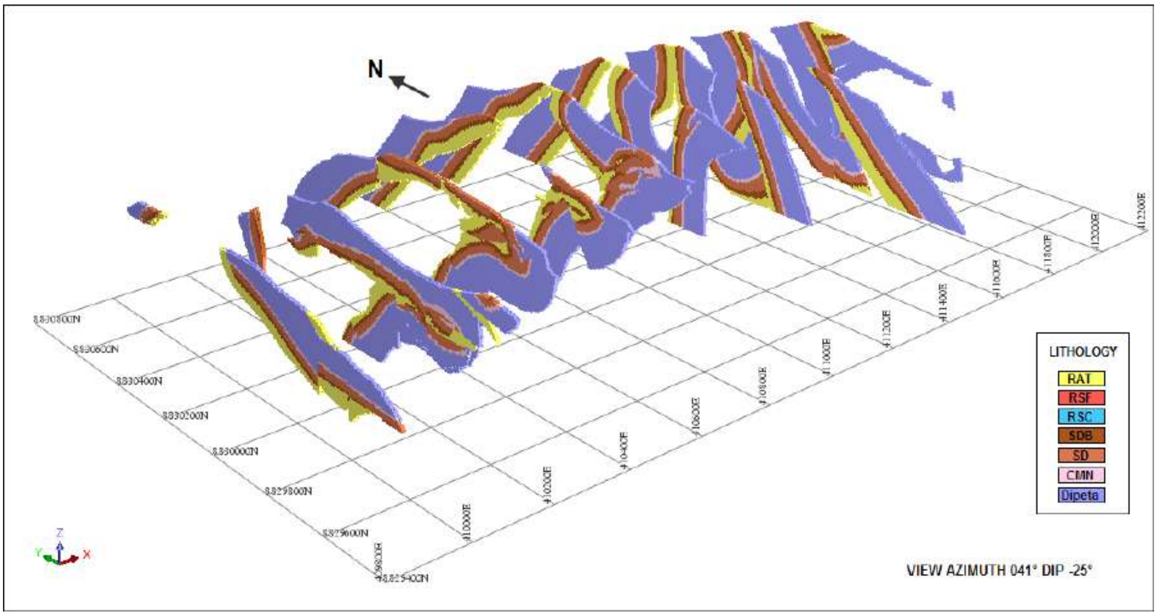


**Figure 14-3 Fungurume Lithologic Solid (MSIM) Models**

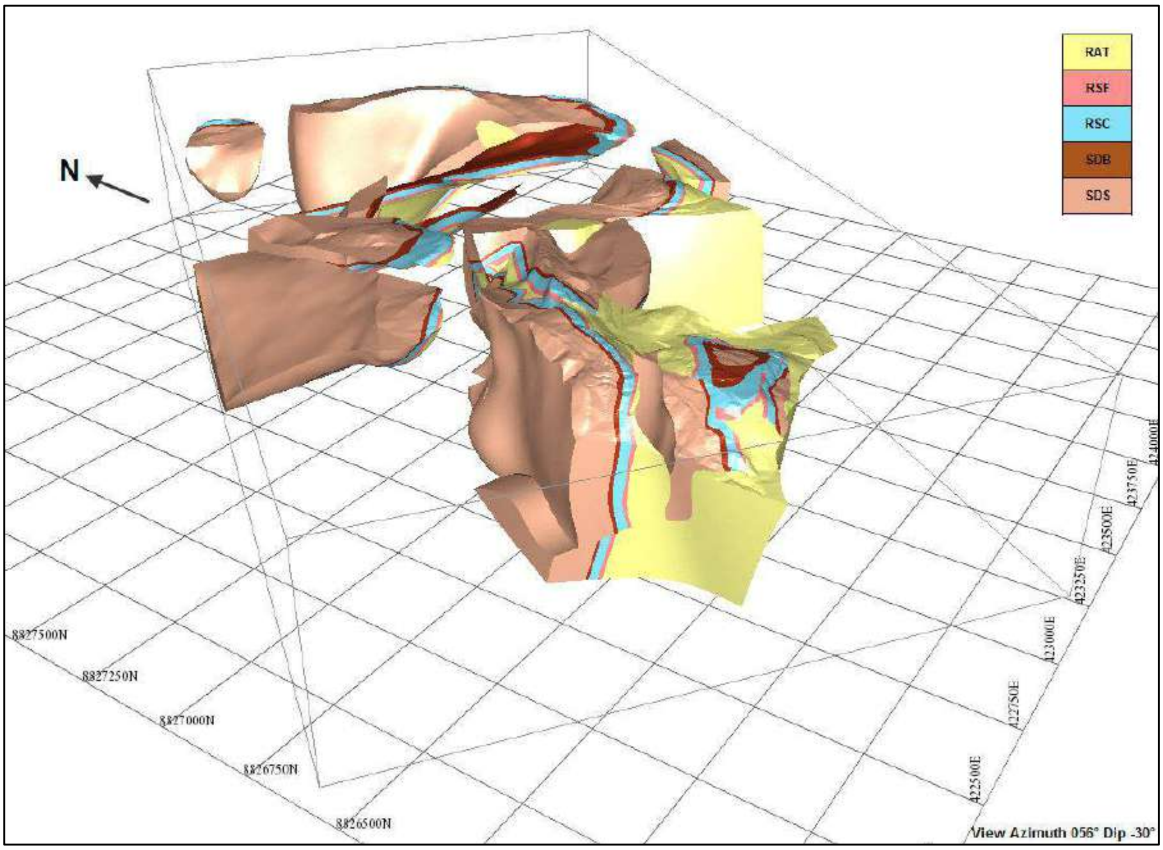
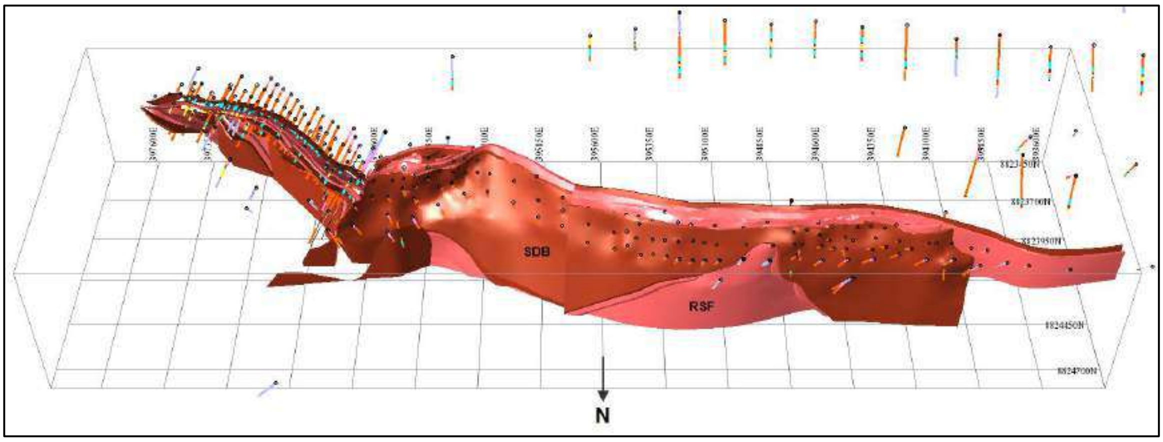


**Figure 14-4 Pumpi Lithologic Solid (MSIM) Models of RSF and SDB Units**



## 14.6 STRUCTURAL ZONE MODELS

Structural zones are modeled to divide the deposits along major faults and fold axes. This has the benefit of facilitating the layering process by separating beds that are offset across structures and also serve as a tool to divide the deposits into distinct grade domains where required. Based on the statistical grade analysis, zones that show a similar grade distribution and close spatial association are regrouped for interpolation. Structural zone codes are stored in model item SZONE and interpolation zones in IZONE.

## 14.7 MATERIAL TYPE MODELS

The leached, oxide, mixed oxide-sulphide, and sulphide zones are interpreted for copper on the geological cross sections. The interpretations are made using the adjusted ratio of acid soluble to total metal for copper (model code RTCUA) where available in the drill holes. The sectional interpretations are used as a guide to construct solids. The solids are then used to code the copper (model code OTYCU) item in the drill hole composites and the blocks. The coding is manually checked for accuracy.

Starting in 2012, an additional material type was included in certain deposit models termed “refractory oxide”. This is a near-surface domain where the ratios suggest a mixed oxide-sulphide regime but no sulphide minerals are recognized in drill logs or core photographs. Black oxides and iron oxide staining may account for low copper acid soluble values, but a thorough investigation will be needed to understand the copper mineralogy of these zones.

Oxide and mixed cobalt ore type shapes are interpreted on geologic cross sections and linked into solids. Blocks and composites are coded from the solids and manually checked for consistency.

## 14.8 MODELING OF THE WEATHERED (LOW CALCIUM) ZONE

Calcium (Ca) analyses examined in cross section show that there is normally a distinct break between a zone of low Ca (<1%) with low acid consumption (<100 kg/tonne) and high Ca with high acid consumption. Often, there is a tenfold increase in Ca grade from the low 0.x % range to multiple percent over a distance of a few meters. In deposits with sufficient Ca analyses, weathered surfaces are modeled from geology sections. Blocks and composites above this surface are coded 1 (for weathered) and blocks below are coded 2 (relatively fresher rock). This surface serves as a hard boundary in Ca interpolation.

## 14.9 MODELING OF THE BEDROCK SURFACE

The contact between relative hard rock and lateritic soil and very strongly weathered rock is important for geomechanical considerations in developing safe slopes. This surface is modeled and used to code the percentage of blocks below the surface as “bedrock” and stored in the code BEDRK as a value between 0 and 100%.

## 14.10 BULK DENSITY

Bulk density (SG item) is measured periodically on drill core and four of the deposits had sufficient measurements throughout to warrant interpolation of model density. Analysis of the data has demonstrated that density has a stronger correlation with calcium content and rock type than it does with elevation or overall metal content. Therefore, when interpolations are run, hard boundaries are used between lithologies and weathered zones. This has resulted in a geologically reasonable estimate of block density where applied. For blocks beyond the search distances, densities are assigned based on regression formulas. Density interpolation has been used in the modeling for Tenke, Fungurume VI, Mambilima and Pumpi.

A relationship between rock types, weathering, and elevation has been established for the different deposits in the district. This relationship shows that in certain circumstances, a good correlation exists for some of the rock types over some range of elevation and weathering type. In cases where there are insufficient data available for interpolation, linear regression equations are used to assign SG in the blocks based on elevation for each combination of rock type and weathering code. In cases where no correlation can be established, the average value by rock type is used. An example of the density assignments for the Sefu model is presented in Table 14-7.

**Table 14-7 Sefu Model Density Assignments**

| Rock Type & Code | Elevation Range | Density Formula |
|---|---|---|
| RAT (11) | All | (-0.0001 * ELEV) + 2.4072 |
| RSF (41) | > 1250 m | (-0.0022 * ELEV) + 5.1544 |
| RSF (41) | <= 1250 m | 2.40 |
| RSC (51) | > 1265 m | (-0.0021 * ELEV) + 5.1544 |
| RSC (51) | <= 1265 m | 2.50 |
| SDB (61) | > 1280 m | (-0.0021 * ELEV) + 5.1921 |
| SDB (61) | <= 1280 m | 2.50 |
| SDS (71) | All | (-0.0017 * ELEV) + 4.6171 |
| CMN (81) | All | S (-0.00001 * ELEV) + 2.4638 |
| Dipeta (91) | All | (-0.0001 * ELEV) + 2.5637 |
| Unknown Rock | All | 2.50 |

## 14.11 EXPLORATORY DATA ANALYSIS

Statistical summaries and cumulative probability plots are generated for the various stratigraphic units by interpolation zone (IZONE). These analyses are used to guide the interpolation strategy, including hard and soft boundaries, thresholds for restricted search distances, etc.

## 14.12 COMPOSITING

Length-weighted composites are generated every 2.5 m, beginning at the hole collar. Composites are not allowed to cross stratigraphic contacts, so partial composites can be generated at these contacts. If the composite length is less than 1.25 m, the partial composite is merged into the preceding composite. If the length is greater or equal to 1.25 m the composite is left as is. Resulting composites are between 1.25 and 3.74 m in length.

## 14.13 VARIOGRAPHY

Correlograms are constructed on layered composites using SAGE2001® software. Correlograms are calculated in the plane of the stratigraphy (rotated x and y), and perpendicular to that plane (rotated z). Two assumptions are made in this analysis:

1. The continuity of grade is approximately the same along strike as it is down-dip.
2. Most holes are drilled across bedding rather than along strike or down dip.

The SAGE software allows pairing of data based on a geologic code. By using LAKLR as the controlling geologic code, all pairs for correlogram calculations must come from the same layer. An omni-directional correlogram controlled by LAKLR is essentially a “down the layer” correlogram. By looking down the layer, better results are obtained than are possible with conventional variography. Based on the first assumption above, the LAKLR constrained correlogram gives the ranges in the rotated strike and dip (or x and y) planes of the stratigraphic units. Based on the second assumption, ranges in the rotated Z direction can be determined by using combined down-hole correlograms.

Based on the similarities and differences seen in statistical analyses of the composites, correlograms were calculated for TCUA, TCOA, RTCUA, RTCOA, SG, and Ca for various combinations of RTYPM, OTYCU (RTCUA), OTYCO (RTCOA), and WEATH (SG and CA). Some groupings do not have adequate pairs to give reasonable correlograms and are therefore combined with other groups. Down-the-layer and down-hole correlograms for each group are combined into a single file for model fitting. These files may be edited to eliminate lags with a large amount of drift, or lags that have insufficient pairs. Experimental correlograms are generally fitted with nested spherical models. A combination of auto and manual model fitting was employed, with the sill being manually set at 1.

## 14.14 GRADE ESTIMATION

Copper and cobalt grades are estimated using LAK and nearest-neighbor assignment. The final resource grades are based on the LAK estimates for copper and cobalt which are stored in the model items TCU and TCO. For most models, grade is normally estimated in only in RAT, RSF, RSC, SDB and sometimes SDS. Some models include separate breccia zones which are also modeled independently. There is often a minor amount of mineralization in the CMN and RGS, but these units are not normally mineralized to a sufficient degree to warrant grade interpolation.

A layering strategy is used within each of the lithologic units to further restrict the projection of grade perpendicular to strike and dip while allowing longer projections in the plane of the stratigraphic units. The number of layers modeled in each unit is based on thickness and the 2.5 m block size. In the RAT and SDS units, only layers that are confirmed to contain significant mineralization are estimated. The number of layers varies somewhat between deposits as follows:

RAT: 11 layers except for Kansalawile which has 10
RSF: 4 to 5 layers
RSC: 8 or 10 layers
SDB: 3 or 4 layers
SDS: 22 to 50 layers (not estimated at Kansalawile, Kazinyanga or Fwaulu)
Dipeta Breccia: 10 layers (only estimated at Fwaulu)
Rat Breccia: 1 layer (only estimated at Fungurume VI and Pumpi)

All of the models use the layers as domain constraints (hard boundaries). Other estimation parameters shared between all of the models include a limit to the number of composites used, the maximum number of composites per drill hole and the maximum search distance. The maximum number of composites used to estimate a single block is eight and a maximum of two composites are permitted from a single hole. The maximum search distance was set at 500 m.

Outlier restrictions were used in all models based on analysis of cumulative probability plots. Cap grades were selected by deposit, rock type, structural zone and, in some cases, material type. Uncapped grades were limited to a search distance of 20 m.

### 14.14.1 ACID-SOLUBLE COPPER AND COBALT GRADE ESTIMATION

Acid-soluble copper and cobalt grade estimates are stored in the items named ACU and ACO, respectively. These values are not interpolated directly. Instead, adjusted acid-soluble copper and cobalt ratios (model items RATCU and RATCO) are interpolated, using groups based on RTYPM, OTYCU, and OTYCO. For grade interpolation, composite RTCUA values are used where TCu is >= 0.08% and RTCOA values are used where TCo is >= 0.1%. This is done because ratios become unreliable when total and acid soluble metal values are near the detection limit. For RATCU, blocks were interpolated with a search radius of 500 m and using RTYPM and OTYCU as hard boundaries. RATCO used the same search radius, with a hard boundary between ore types. Blocks left uninterpolated were assigned an average based on ore type and rock type. After interpolation and assignment of ratios, the acid-soluble metals for each block are calculated as follows:

ACU = TCU * (RATCU/100)

ACO = TCO * (RATCO/100)

### 14.14.2 ESTIMATION OF ACID CONSUMPTION

Total and net acid consumption (FMTAC and FMNAC) are estimated using an equation based on the concentrations of three elements: Cu, Co and Ca. The Ca LAK runs used a 200 m search distance. Kriging is controlled by WEATH and LAKLR for Ca in the un-weathered zone and in the weathered zone, Kriging is controlled by WEATH and RTYPM. Outside the 200m interpolation radius, Ca averages by rock type (RTYPM) have been used for the weathered zone and an average by LAKLR has been used for the un-weathered zone.

The general flow of acid consumption estimation is as follows:

1. Ca values are assigned and interpolated as described above. Values are stored in CA.
2. FMTAC values are calculated on a block by block basis with OTYCU as a constraint, using the relationship between ACu, ACo and Ca as follows:

   For OTYCU 10 and 20: FMTAC = 15.13*ACU + 16.60*ACO + 51.21*Ca + 20.28

   For OTYCU 30 and 40: FMTAC = 14.84*ACU + 48.22*ACO + 43.61*Ca + 9.28
3. The gangue acid consumption (FMGAC), and the net acid consumption (FMNAC), were calculated using the following relationships with total acid consumption (FMTAC):

   FMGAC = FMTAC - 15.43*ACU - 16.64*ACO

   FMNAC = FMTAC – 15.43*ACU*0.7
4. The formula above for FMGAC can result in negative values. In these cases, blocks are assigned an FMGAC value of 0.

### 14.14.3 ESTIMATION OF Mg

Although Mg is not being used to estimate acid consumption, it does have an impact on quicklime consumption in the plant. As a result, Mg is estimated for all models. Mg is interpolated by LAK using LAKLR and WEATH as controls. Blocks not interpolated within a 200 m search distance are left un-interpolated.

## 14.15 RESOURCE CLASSIFICATION

Model classification for all of the current resource models involves a combination of the number of drill holes used to estimate a block and the average composite distance as shown in Table 14-8.

Some blocks have cobalt grades but not copper grades due of the differences in the interpolation schemes for the two metals (i.e. different LAKLR and matching on leached/not leached for TCu). Because of this, the number of drill holes, average distance, and distance to the closest composite from the Co interpolation are stored in the model as ODSTA, ODSTC, and CONDH. In this way, a resource class value (RCLAS) can be assigned independently for the Co estimate and Cu estimate. This procedure was not carried for all models and in those cases blocks with TCo grade but not TCu grade were assigned to the inferred class.

**Table 14-8 Model classification parameters**

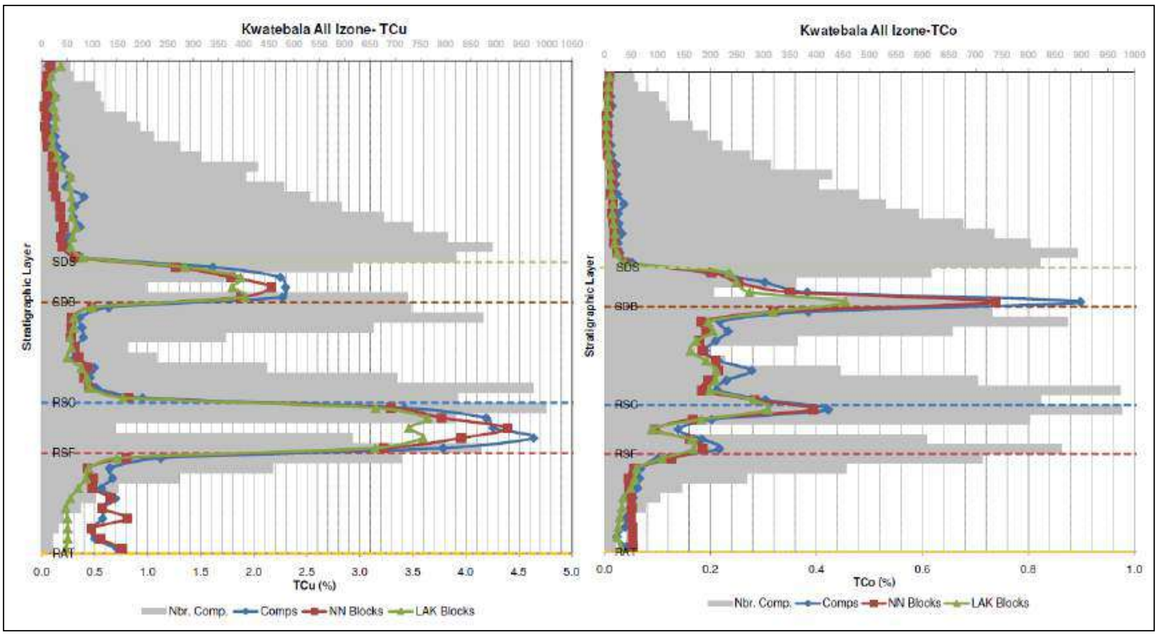
| Class | Min. Avg. Comp Distance (m) | Min. number of Drill Holes |
|---|---|---|
| Measured (1) | 50 | 4 |
| Indicated (2) | 100 | 3 |
| Inferred (3) | 500 | 1 |

## 14.16 MODEL VALIDATION

Block grade estimates are examined in plan and section view to confirm that they correspond to the stratigraphic layering and composite grades.

As a standard part of model validation, results from the LAK models are compared to Nearest Neighbour estimates and composite data by stratigraphic layer to check for bias and possible over-smoothing. Figure 14-5 showing the results for the Kwatebala model is presented as an example.

**Figure 14-5 Kwatebala Model Cu and Co profiles by stratigraphic layer**



## 14.17 REASONABLE PROSPECTS OF ECONOMIC EXTRACTION

A 1.3% Cu equivalent base case cut-off grade has been used to estimate Mineral Resources. A 1.0% total copper cut-off grade has been traditionally used to declare Mineral Resources in the Zambian Copperbelt amenable to extraction by underground mining methods. Geosim believes that there are reasonable prospects for eventual extraction for blocks outside of reserve pits assuming a copper price of $3.00/lb and the use of mechanized mining methods. For sulphide material it is assumed that a concentrate would be produced and a roast/leach or pressure oxidation/leach circuit installed.

Those parts of the Mineral Resources lying below optimized pits used for establishing Mineral Reserves were examined for grade continuity above 1.3% Cu equivalent. Isolated blocks and small clusters that would not likely be incorporated into an underground mining scenario were excluded from resource classification. For this reason the Mineral Resource totals are marginally less than the total block inventories reported by FCX.

## 14.18 MINERAL RESOURCE STATEMENT

The separate Mineral Resource estimates for the 14 models are presented in the tables below at a cut-off grade of 1.3% Copper Equivalent (EQCu) where EQCu=TCu+4*TCo. The effective date is 31 December, 2013.

**Table 14-9 Kansalawile 2009a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 902.3 | 3.28 | 0.13 | 3.81 |
| | mixed | 3.5 | 3.52 | 0.24 | 4.48 |
| | sulphide | | | | |
| | leached | 8.5 | 2.59 | 0.03 | 2.69 |
| | **Combined** | **914.3** | **3.28** | **0.13** | **3.80** |
| **INDICATED** | oxide | 13,321.9 | 2.62 | 0.16 | 3.26 |
| | mixed | 7,027.3 | 2.62 | 0.17 | 3.28 |
| | sulphide | | | | |
| | leached | 117.9 | 0.91 | 0.20 | 1.71 |
| | **Combined** | **20,467.2** | **2.61** | **0.16** | **3.26** |
| **MEASURED & INDICATED** | oxide | 14,224.2 | 2.67 | 0.16 | 3.30 |
| | mixed | 7,030.7 | 2.62 | 0.17 | 3.28 |
| | sulphide | | | | |
| | leached | 126.5 | 1.03 | 0.19 | 1.78 |
| | **Combined** | **21,381.4** | **2.64** | **0.16** | **3.28** |
| **INFERRED** | oxide | 2,942.2 | 1.15 | 0.19 | 1.91 |
| | mixed | 5,889.7 | 2.36 | 0.17 | 3.02 |
| | sulphide | | | | |
| | leached | 7.1 | 0.41 | 0.25 | 1.42 |
| | **Combined** | **8,839.1** | **1.95** | **0.18** | **2.65** |

**Table 14-10 Kazinyanga 2010a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 254.4 | 1.57 | 0.37 | 3.06 |
| | mixed | 97.0 | 1.38 | 0.37 | 2.87 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **351.5** | **1.51** | **0.37** | **3.01** |
| **INDICATED** | oxide | 6,147.2 | 1.45 | 0.33 | 2.78 |
| | mixed | 4,174.3 | 1.53 | 0.28 | 2.67 |
| | sulphide | 1.3 | 1.23 | 0.05 | 1.43 |
| | leached | 274.3 | 0.17 | 0.46 | 1.99 |
| | **Combined** | **10,597.2** | **1.45** | **0.32** | **2.72** |
| **MEASURED & INDICATED** | oxide | 6,401.7 | 1.45 | 0.33 | 2.79 |
| | mixed | 4,271.4 | 1.53 | 0.29 | 2.67 |
| | sulphide | 1.3 | 1.23 | 0.05 | 1.43 |
| | leached | 274.3 | 0.17 | 0.46 | 1.99 |
| | **Combined** | **10,948.7** | **1.45** | **0.32** | **2.73** |
| **INFERRED** | oxide | 1,804.9 | 1.09 | 0.32 | 2.38 |
| | mixed | 2,064.7 | 1.57 | 0.30 | 2.75 |
| | sulphide | 13.5 | 1.62 | 0.11 | 2.07 |
| | leached | 350.0 | 0.09 | 0.42 | 1.78 |
| | **Combined** | **4,233.0** | **1.24** | **0.32** | **2.51** |

**Table 14-11 Kwatebala 2010 Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 27,418.5 | 2.11 | 0.33 | 3.41 |
| | mixed | 3,275.8 | 2.29 | 0.28 | 3.40 |
| | sulphide | 1,415.8 | 2.72 | 0.19 | 3.49 |
| | leached | 411.5 | 0.32 | 0.71 | 3.14 |
| | **Combined** | **32,521.6** | **2.13** | **0.32** | **3.41** |
| **INDICATED** | oxide | 19,490.4 | 1.76 | 0.31 | 2.99 |
| | mixed | 11,992.4 | 1.66 | 0.28 | 2.79 |
| | sulphide | 9,636.6 | 2.58 | 0.21 | 3.41 |
| | leached | 87.3 | 0.32 | 0.62 | 2.79 |
| | **Combined** | **41,206.7** | **1.92** | **0.28** | **3.03** |
| **MEASURED & INDICATED** | oxide | 46,908.9 | 1.96 | 0.32 | 3.24 |
| | mixed | 15,268.2 | 1.79 | 0.28 | 2.92 |
| | sulphide | 11,052.4 | 2.60 | 0.21 | 3.42 |
| | leached | 498.8 | 0.32 | 0.69 | 3.08 |
| | **Combined** | **73,728.3** | **2.01** | **0.30** | **3.20** |
| **INFERRED** | oxide | 956.6 | 1.54 | 0.28 | 2.66 |
| | mixed | 14,204.7 | 0.80 | 0.32 | 2.08 |
| | sulphide | 20,261.6 | 2.31 | 0.22 | 3.19 |
| | leached | 0.0 | 0.00 | 0.00 | 0.00 |
| | **Combined** | **35,422.9** | **1.69** | **0.26** | **2.73** |

**Table 14-12 Katuto 2011a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 195.8 | 1.66 | 0.16 | 2.32 |
| | mixed | 15.7 | 1.81 | 0.04 | 1.98 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **211.4** | **1.67** | **0.15** | **2.29** |
| **INDICATED** | oxide | 9,616.0 | 1.75 | 0.48 | 3.66 |
| | mixed | 3,372.8 | 1.85 | 0.41 | 3.47 |
| | sulphide | | | | |
| | leached | 323.2 | 0.36 | 0.73 | 3.28 |
| | **Combined** | **13,312.0** | **1.74** | **0.47** | **3.60** |
| **MEASURED & INDICATED** | oxide | 9,811.7 | 1.74 | 0.47 | 3.64 |
| | mixed | 3,388.4 | 1.85 | 0.40 | 3.46 |
| | sulphide | | | | |
| | leached | 323.2 | 0.36 | 0.73 | 3.28 |
| | **Combined** | **13,523.4** | **1.74** | **0.46** | **3.58** |
| **INFERRED** | oxide | 5,760.3 | 1.80 | 0.42 | 3.49 |
| | mixed | 7,527.3 | 2.18 | 0.36 | 3.61 |
| | sulphide | | | | |
| | leached | 706.2 | 0.25 | 0.61 | 2.68 |
| | **Combined** | **13,993.8** | **1.93** | **0.40** | **3.52** |

**Table 14-13 Shinkusu 2011a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 1,335.6 | 2.37 | 0.28 | 3.50 |
| | mixed | 219.6 | 3.77 | 0.05 | 3.96 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **1,555.2** | **2.57** | **0.25** | **3.56** |
| **INDICATED** | oxide | 5,065.0 | 2.31 | 0.25 | 3.32 |
| | mixed | 147.2 | 2.70 | 0.19 | 3.45 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **5,212.2** | **2.32** | **0.25** | **3.32** |
| **MEASURED & INDICATED** | oxide | 6,400.6 | 2.32 | 0.26 | 3.36 |
| | mixed | 366.8 | 3.34 | 0.10 | 3.76 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **6,767.4** | **2.38** | **0.25** | **3.38** |
| **INFERRED** | oxide | 3,469.3 | 1.98 | 0.18 | 2.71 |
| | mixed | 498.3 | 1.99 | 0.27 | 3.07 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **3,967.6** | **1.98** | **0.19** | **2.75** |

**Table 14-14 Fungurume VI 2012a Mineral Resource**

| Class | Ore Type | ktonnes | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 2,697.7 | 2.37 | 0.40 | 3.96 |
| | ref. oxide | 0.4 | 2.22 | 0.08 | 2.53 |
| | mixed | 538.4 | 2.72 | 0.42 | 4.41 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **3,236.5** | **2.43** | **0.40** | **4.03** |
| **INDICATED** | oxide | 18,620.3 | 2.23 | 0.34 | 3.60 |
| | ref. oxide | 29.8 | 1.21 | 0.20 | 2.01 |
| | mixed | 5,173.6 | 2.51 | 0.34 | 3.88 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **23,823.6** | **2.29** | **0.34** | **3.66** |
| **MEASURED & INDICATED** | oxide | 21,318.0 | 2.25 | 0.35 | 3.65 |
| | ref. oxide | 30.2 | 1.22 | 0.20 | 2.01 |
| | mixed | 5,712.0 | 2.53 | 0.35 | 3.93 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **27,060.1** | **2.31** | **0.35** | **3.71** |
| **INFERRED** | oxide | 7,275.6 | 2.22 | 0.18 | 2.95 |
| | ref. oxide | 3.4 | 2.25 | 0.09 | 2.61 |
| | mixed | 12,145.3 | 2.07 | 0.20 | 2.89 |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | **19,424.4** | **2.13** | **0.20** | **2.91** |

**Table 14-15 Fwaulu 2012a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| MEASURED | oxide | 5,507.5 | 2.95 | 0.24 | 3.90 |
| | mixed | 1,545.0 | 2.39 | 0.18 | 3.13 |
| | sulphide | 330.7 | 2.99 | 0.12 | 3.48 |
| | leached | | | | |
| | **Combined** | **7,383.3** | **2.83** | **0.22** | **3.72** |
| INDICATED | oxide | 11,822.0 | 2.09 | 0.25 | 3.08 |
| | mixed | 15,694.8 | 1.95 | 0.22 | 2.84 |
| | sulphide | 1,461.9 | 2.50 | 0.21 | 3.35 |
| | leached | | | | |
| | **Combined** | **28,978.8** | **2.04** | **0.23** | **2.96** |
| MEASURED<br>&<br>INDICATED | oxide | 17,329.6 | 2.36 | 0.24 | 3.34 |
| | mixed | 17,239.8 | 1.99 | 0.22 | 2.87 |
| | sulphide | 1,792.7 | 2.59 | 0.20 | 3.37 |
| | leached | | | | |
| | **Combined** | **36,362.1** | **2.20** | **0.23** | **3.12** |
| INFERRED | oxide | 1,881.8 | 2.10 | 0.21 | 2.92 |
| | mixed | 14,480.8 | 1.75 | 0.28 | 2.88 |
| | sulphide | 1,158.3 | 1.39 | 0.33 | 2.70 |
| | leached | | | | |
| | **Combined** | **17,520.9** | **1.77** | **0.28** | **2.87** |

**Table 14-16 Mambilima 2012a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| MEASURED | oxide | 7,027.6 | 2.75 | 0.20 | 3.53 |
| | ref. oxide | 68.7 | 1.75 | 0.20 | 2.54 |
| | mixed | 1,223.8 | 3.08 | 0.14 | 3.64 |
| | sulphide | | | | |
| | leached | 0.3 | 0.04 | 0.35 | 1.44 |
| | **Combined** | **8,320.6** | **2.79** | **0.19** | **3.54** |
| INDICATED | oxide | 35,543.5 | 2.65 | 0.17 | 3.31 |
| | ref. oxide | 296.9 | 1.71 | 0.16 | 2.33 |
| | mixed | 15,940.8 | 2.88 | 0.14 | 3.45 |
| | sulphide | | | | |
| | leached | 66.8 | 0.10 | 0.39 | 1.64 |
| | **Combined** | **51,847.9** | **2.71** | **0.16** | **3.35** |
| MEASURED<br>&<br>INDICATED | oxide | 42,571.1 | 2.67 | 0.17 | 3.35 |
| | ref. oxide | 365.6 | 1.72 | 0.16 | 2.37 |
| | mixed | 17,164.7 | 2.90 | 0.14 | 3.46 |
| | sulphide | | | | |
| | leached | 67.1 | 0.10 | 0.39 | 1.64 |
| | **Combined** | **60,168.5** | **2.72** | **0.16** | **3.37** |
| INFERRED | oxide | 5,661.6 | 2.31 | 0.14 | 2.87 |
| | ref. oxide | 71.9 | 2.97 | 0.11 | 3.40 |
| | mixed | 14,126.9 | 2.53 | 0.17 | 3.23 |
| | sulphide | | | | |
| | leached | 41.9 | 0.11 | 0.38 | 1.62 |
| | **Combined** | **19,902.3** | **2.47** | **0.16** | **3.12** |

**Table 14-17 Mudilandina 2012b Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | | | | |
| | mixed | | | | |
| | sulphide | | | | |
| | leached | 29.9 | 0.07 | 0.46 | 1.90 |
| | **Combined** | **29.9** | **0.07** | **0.46** | **1.90** |
| **INDICATED** | oxide | 13,453.9 | 1.85 | 0.30 | 3.06 |
| | mixed | 1,323.5 | 1.73 | 0.19 | 2.50 |
| | sulphide | | | | |
| | leached | 333.8 | 0.03 | 0.50 | 2.05 |
| | **Combined** | **15,111.2** | **1.79** | **0.30** | **2.99** |
| **MEASURED & INDICATED** | oxide | 13,453.9 | 1.85 | 0.30 | 3.06 |
| | mixed | 1,323.5 | 1.73 | 0.19 | 2.50 |
| | sulphide | | | | |
| | leached | 363.8 | 0.04 | 0.50 | 2.03 |
| | **Combined** | **15,141.1** | **1.79** | **0.30** | **2.99** |
| **INFERRED** | oxide | 16,620.2 | 1.78 | 0.20 | 2.60 |
| | mixed | 9,759.4 | 1.83 | 0.21 | 2.66 |
| | sulphide | | | | |
| | leached | 2,103.6 | 0.07 | 0.47 | 1.93 |
| | **Combined** | **28,483.1** | **1.65** | **0.22** | **2.57** |

**Table 14-18 Tenke 2012a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 25,648.2 | 2.51 | 0.37 | 4.00 |
| | mixed | 5,863.4 | 2.63 | 0.30 | 3.83 |
| | sulphide | 330.0 | 3.89 | 0.41 | 5.52 |
| | leached | 438.5 | 0.10 | 0.63 | 2.60 |
| | **Combined** | **32,280.1** | **2.51** | **0.36** | **3.97** |
| **INDICATED** | oxide | 19,406.9 | 2.39 | 0.30 | 3.59 |
| | mixed | 18,858.7 | 2.62 | 0.25 | 3.62 |
| | sulphide | 844.0 | 5.33 | 0.29 | 6.50 |
| | leached | 145.1 | 0.10 | 0.62 | 2.60 |
| | **Combined** | **39,254.6** | **2.55** | **0.28** | **3.66** |
| **MEASURED & INDICATED** | oxide | 45,055.1 | 2.46 | 0.34 | 3.82 |
| | mixed | 24,722.0 | 2.62 | 0.26 | 3.67 |
| | sulphide | 1,174.0 | 4.92 | 0.33 | 6.22 |
| | leached | 583.6 | 0.10 | 0.63 | 2.60 |
| | **Combined** | **71,534.7** | **2.53** | **0.32** | **3.80** |
| **INFERRED** | oxide | 1,065.8 | 2.42 | 0.21 | 3.27 |
| | mixed | 6,623.0 | 2.33 | 0.32 | 3.60 |
| | sulphide | 36.8 | 5.49 | 0.03 | 5.60 |
| | leached | 232.4 | 0.18 | 0.60 | 2.59 |
| | **Combined** | **7,958.1** | **2.30** | **0.31** | **3.54** |

**Table 14-19 Zikule 2012a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | | | | |
| | mixed | | | | |
| | sulphide | | | | |
| | leached | | | | |
| | **Combined** | | | | |
| **INDICATED** | oxide | 7,183.8 | 2.18 | 0.08 | 2.51 |
| | mixed | 175.6 | 2.09 | 0.06 | 2.34 |
| | sulphide | | | | |
| | leached | 0.1 | 0.10 | 0.31 | 1.34 |
| | **Combined** | **7,359.4** | **2.18** | **0.08** | **2.51** |
| **MEASURED & INDICATED** | oxide | 7,183.8 | 2.18 | 0.08 | 2.51 |
| | mixed | 175.6 | 2.09 | 0.06 | 2.34 |
| | sulphide | | | | |
| | leached | 0.1 | 0.10 | 0.31 | 1.34 |
| | **Combined** | **7,359.4** | **2.18** | **0.08** | **2.51** |
| **INFERRED** | oxide | 8,781.6 | 2.05 | 0.08 | 2.37 |
| | mixed | 3,409.7 | 1.91 | 0.10 | 2.30 |
| | sulphide | | | | |
| | leached | 31.8 | 0.63 | 0.25 | 1.65 |
| | **Combined** | **12,223.1** | **2.01** | **0.09** | **2.35** |

**Table 14-20 Fungurume 2013a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| **MEASURED** | oxide | 21,342.6 | 3.83 | 0.42 | 5.52 |
| | mixed | 27,659.9 | 3.77 | 0.32 | 5.03 |
| | sulphide | 5,522.9 | 4.85 | 0.38 | 6.39 |
| | leached | | | | |
| | **Combined** | **54,525.4** | **3.90** | **0.36** | **5.36** |
| **INDICATED** | oxide | 24,682.6 | 1.81 | 0.39 | 3.36 |
| | mixed | 54,858.7 | 2.95 | 0.33 | 4.25 |
| | sulphide | 5,684.7 | 4.14 | 0.28 | 5.25 |
| | leached | | | | |
| | **Combined** | **85,225.9** | **2.70** | **0.34** | **4.06** |
| **MEASURED & INDICATED** | oxide | 46,025.2 | 2.75 | 0.40 | 4.36 |
| | mixed | 82,518.6 | 3.22 | 0.32 | 4.51 |
| | sulphide | 11,207.6 | 4.49 | 0.33 | 5.81 |
| | leached | | | | |
| | **Combined** | **139,751.4** | **3.17** | **0.35** | **4.56** |
| **INFERRED** | oxide | 6,764.7 | 1.56 | 0.39 | 3.12 |
| | mixed | 73,438.7 | 2.20 | 0.32 | 3.49 |
| | sulphide | 1,816.0 | 3.17 | 0.20 | 3.95 |
| | leached | | | | |
| | **Combined** | **82,019.3** | **2.17** | **0.32** | **3.47** |

**Table 14-21 Mwadinkomba 2013b Mineral Resource**

| Class | Ore Type | ktonnes | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| MEASURED | oxide | 5,473.9 | 3.49 | 0.17 | 4.19 |
| | mixed | 1,372.3 | 3.21 | 0.19 | 3.98 |
| | sulphide | 177.3 | 2.60 | 0.15 | 3.20 |
| | leached | 47.2 | 0.07 | 0.50 | 2.07 |
| | **Combined** | **7,070.8** | **3.39** | **0.18** | **4.11** |
| INDICATED | oxide | 12,010.1 | 3.35 | 0.15 | 3.96 |
| | mixed | 13,321.2 | 2.86 | 0.19 | 3.64 |
| | sulphide | 6,787.4 | 2.79 | 0.19 | 3.55 |
| | leached | 135.9 | 0.10 | 0.50 | 2.08 |
| | **Combined** | **32,254.6** | **3.02** | **0.18** | **3.73** |
| MEASURED & INDICATED | oxide | 17,484.1 | 3.39 | 0.16 | 4.03 |
| | mixed | 14,693.5 | 2.89 | 0.19 | 3.67 |
| | sulphide | 6,964.7 | 2.79 | 0.19 | 3.54 |
| | leached | 183.0 | 0.09 | 0.50 | 2.08 |
| | **Combined** | **39,325.3** | **3.08** | **0.18** | **3.80** |
| INFERRED | oxide | 639.0 | 2.58 | 0.13 | 3.09 |
| | mixed | 2,709.7 | 1.79 | 0.12 | 2.27 |
| | sulphide | 8,064.1 | 2.59 | 0.22 | 3.48 |
| | leached | 13.9 | 0.10 | 0.61 | 2.55 |
| | **Combined** | **11,426.6** | **2.40** | **0.19** | **3.17** |

**Table 14-22 Pumpi 2013a Mineral Resource**

| Class | Material Type | Tonnes 000's | TCu % | TCo % | EQCu % |
|---|---|---|---|---|---|
| MEASURED | oxide | 10,895.2 | 2.66 | 0.15 | 3.26 |
| | ref. oxide | 159.8 | 2.02 | 0.13 | 2.54 |
| | mixed | 1,125.7 | 2.09 | 0.21 | 2.92 |
| | sulphide | | | | |
| | leached | 167.1 | 0.07 | 0.40 | 1.68 |
| | **Combined** | **12,347.9** | **2.57** | **0.16** | **3.20** |
| INDICATED | oxide | 34,712.5 | 2.27 | 0.17 | 2.93 |
| | ref. oxide | 730.6 | 1.50 | 0.12 | 1.99 |
| | mixed | 7,707.6 | 2.19 | 0.17 | 2.89 |
| | sulphide | | | | |
| | leached | 708.8 | 0.06 | 0.46 | 1.89 |
| | **Combined** | **43,859.5** | **2.20** | **0.17** | **2.89** |
| MEASURED & INDICATED | oxide | 45,607.7 | 2.36 | 0.16 | 3.01 |
| | ref. oxide | 890.5 | 1.59 | 0.12 | 2.09 |
| | mixed | 8,833.3 | 2.18 | 0.18 | 2.89 |
| | sulphide | | | | |
| | leached | 875.9 | 0.06 | 0.45 | 1.85 |
| | **Combined** | **56,207.4** | **2.28** | **0.17** | **2.96** |
| INFERRED | oxide | 16,873.5 | 1.90 | 0.16 | 2.53 |
| | ref. oxide | 40.1 | 1.71 | 0.13 | 2.23 |
| | mixed | 60,669.9 | 1.94 | 0.16 | 2.57 |
| | sulphide | 182.4 | 2.15 | 0.01 | 2.21 |
| | leached | 56.6 | 0.05 | 0.57 | 2.33 |
| | **Combined** | **77,822.4** | **1.93** | **0.16** | **2.56** |

## 14.19 FACTORS WHICH COULD AFFECT THE MINERAL RESOURCE ESTIMATE

Areas of uncertainty that may materially impact the Mineral Resource Estimate include:

- Commodity price
- Metal recovery
- Mining and Process costs

There are no other known factors or issues that materially affect the estimate other than normal risks faced by mining projects in the DRC in terms of environmental, permitting, taxation, socio economic, marketing and political factors.

# 15 MINERAL RESERVE ESTIMATES

## 15.1 RESERVE SUMMARY

The Mineral Reserves have been reported based upon smoothed pit designs and Measured and Indicated Resources using metal prices of US$2.00/lb copper and US$10.00/lb cobalt and are effective as of December 31, 2013.

Proven and Probable reserves are summarized in the table below including WIP (Work in Progress) which are considered as Probable reserves.

**Table 15-1 Mineable Reserves Summary**

| Area | Ore t x 1000 | Cu% TCu | Co% TCo | Waste t x 1000 | Recoverable Cu% RCu | Recoverable Co% RCo | Recoverable Cu t x 1000 payable | Recoverable Co t x 1000 payable |
|---|---|---|---|---|---|---|---|---|
| **Summary** | | | | | | | | |
| **Proven** | 52,115.5 | 3.66 | 0.39 | | 3.14 | 0.29 | 1,638.7 | 151.7 |
| **Probable** | 61,323.2 | 3.07 | 0.33 | | 2.66 | 0.25 | 1,632.2 | 155.9 |
| **Subtotal** | **113,438.7** | **3.34** | **0.36** | **698,021.8** | **2.88** | **0.27** | **3,270.9** | **307.6** |
| **WIP Probable** | 30,696.0 | 1.25 | 0.33 | | 1.14 | 0.27 | 349.6 | 84.0 |
| **TOTAL** | **144,134.7** | **2.89** | **0.35** | **698,021.8** | **2.51** | **0.27** | **3,620.4** | **391.6** |

From December 2012, there has been a 4.4% net decrease of in-pit Proven and Probable Mineral Reserve volume with a 1.7% decrease in recoverable copper and 1.8% decrease in recoverable cobalt due to mining during 2013 and changes to resource models and economic parameters. WIP increased by 36.6% as mined lower grade copper ore was placed on to stockpiles. . The overall change of Mineral Reserves including WIP was a 2.2% increase in quantity with a 1.1% increase in payable copper and a 2.5% increase in payable cobalt.

Mineral Reserves are summarized by deposit in the tables below.

**Table 15-2 Mineral Reserves by Deposit Year End 2013**

| Area | Ore t x 1000 | Cu% TCu | Co% TCo | Waste t x 1000 | Recoverable Cu% RCu | Recoverable Co% RCo | Recoverable Cu t x 1000 payable | Recoverable Co t x 1000 payable |
|---|---|---|---|---|---|---|---|---|
| **Kansalawile** | | | | | | | | |
| **Proven** | 681.8 | 3.71 | 0.13 | | 3.27 | 0.10 | 22.3 | 0.7 |
| **Probable** | 5,427.4 | 3.51 | 0.15 | | 3.03 | 0.11 | 164.2 | 5.9 |
| **Sub-total** | **6,109.2** | **3.54** | **0.15** | **40,178.3** | **3.05** | **0.11** | **186.5** | **6.6** |
| **Fungurume** | | | | | | | | |
| **Proven** | 11,820.6 | 4.98 | 0.49 | | 4.16 | 0.31 | 491.8 | 36.1 |
| **Probable** | 3,964.3 | 3.12 | 0.50 | | 2.59 | 0.33 | 102.7 | 13.0 |
| **Sub-total** | **15,784.9** | **4.51** | **0.49** | **65,870.3** | **3.77** | **0.31** | **594.5** | **49.1** |
| **Mambilima** | | | | | | | | |
| **Proven** | 2,765.4 | 3.82 | 0.19 | | 3.38 | 0.15 | 93.6 | 4.0 |
| **Probable** | 10,291.5 | 3.67 | 0.15 | | 3.25 | 0.10 | 334.6 | 10.6 |
| **Sub-total** | **13,056.9** | **3.71** | **0.16** | **111,140.2** | **3.28** | **0.11** | **428.2** | **14.6** |
| **Kanzinyanga** | | | | | | | | |
| **Proven** | 73.8 | 1.92 | 0.47 | | 1.63 | 0.34 | 1.2 | 0.2 |
| **Probable** | 1,151.4 | 1.61 | 0.40 | | 1.37 | 0.30 | 15.8 | 3.4 |
| **Sub-total** | **1,225.2** | **1.63** | **0.41** | **8,700.0** | **1.39** | **0.30** | **17.0** | **3.7** |
| **Mudilandima** | | | | | | | | |
| **Proven** | 4.1 | 0.08 | 0.76 | | 0.05 | 0.63 | 0.0 | 0.0 |
| **Probable** | 4,954.6 | 2.13 | 0.43 | | 1.89 | 0.36 | 93.9 | 17.8 |
| **Sub-total** | **4,958.8** | **2.13** | **0.43** | **40,940.6** | **1.89** | **0.36** | **93.9** | **17.8** |
| **Mwadinkomba** | | | | | | | | |
| **Proven** | 2,734.3 | 3.98 | 0.21 | | 3.43 | 0.16 | 93.9 | 4.5 |
| **Probable** | 4,458.2 | 3.89 | 0.19 | | 3.37 | 0.15 | 150.1 | 6.7 |
| **Sub-total** | **7,192.5** | **3.93** | **0.20** | **65,919.8** | **3.39** | **0.15** | **244.0** | **11.1** |
| **Zikule** | | | | | | | | |
| **Proven** | - | - | - | | - | - | - | - |
| **Probable** | 64.2 | 4.50 | 0.28 | | 3.72 | 0.20 | 2.4 | 0.1 |
| **Sub-total** | **64.2** | **4.50** | **0.28** | **1,041.7** | **3.72** | **0.20** | **2.4** | **0.1** |
| **Kato L3K** | | | | | | | | |
| **Proven** | 6.9 | 1.60 | 1.02 | | 1.35 | 0.86 | 0.1 | 0.1 |
| **Probable** | 3,359.2 | 2.05 | 0.64 | | 1.80 | 0.53 | 60.3 | 17.9 |
| **Sub-total** | **3,366.1** | **2.05** | **0.64** | **29,147.9** | **1.79** | **0.53** | **60.4** | **18.0** |

| Area | Ore t x 1000 | Cu% TCu | Co% TCo | Waste t x 1000 | Recoverable Cu% RCu | Recoverable Co% RCo | Recoverable Cu t x 1000 payable | Recoverable Co t x 1000 payable |
|---|---|---|---|---|---|---|---|---|
| **Pumpi** | | | | | | | | |
| **Proven** | 3,761.0 | 3.74 | 0.19 | | 3.23 | 0.15 | 121.5 | 5.8 |
| **Probable** | 5,309.5 | 3.23 | 0.19 | | 2.74 | 0.15 | 145.4 | 8.2 |
| **Sub-total** | **9,070.5** | **3.44** | **0.19** | **43,941.0** | **2.94** | **0.15** | **266.8** | **14.0** |
| **Fwaulu** | | | | | | | | |
| **Proven** | 2,795.6 | 3.89 | 0.27 | | 3.24 | 0.22 | 90.7 | 6.0 |
| **Probable** | 2,867.9 | 2.95 | 0.28 | | 2.44 | 0.22 | 69.8 | 6.4 |
| **Sub-total** | **5,663.5** | **3.41** | **0.27** | **26,946.8** | **2.83** | **0.22** | **160.5** | **12.5** |
| **Fungurume VI** | | | | | | | | |
| **Proven** | 992.5 | 3.11 | 0.51 | | 2.66 | 0.38 | 26.4 | 3.8 |
| **Probable** | 5,756.6 | 2.95 | 0.48 | | 2.56 | 0.37 | 147.2 | 21.3 |
| **Sub-total** | **6,749.0** | **2.98** | **0.49** | **42,195.0** | **2.57** | **0.37** | **173.6** | **25.1** |
| **Shinkusu** | | | | | | | | |
| **Proven** | 277.3 | 3.27 | 0.71 | | 2.90 | 0.56 | 8.0 | 1.6 |
| **Probable** | 1,093.9 | 2.95 | 0.57 | | 2.59 | 0.46 | 28.3 | 5.0 |
| **Sub-total** | **1,371.2** | **3.01** | **0.60** | **14,130.2** | **2.65** | **0.48** | **36.4** | **6.6** |
| **Tenke** | | | | | | | | |
| **Proven** | 13,547.4 | 3.24 | 0.46 | | 2.83 | 0.36 | 384.0 | 48.2 |
| **Probable** | 7,698.2 | 3.09 | 0.39 | | 2.72 | 0.30 | 209.2 | 23.4 |
| **Sub-total** | **21,245.6** | **3.19** | **0.43** | **124,304.1** | **2.79** | **0.34** | **593.2** | **71.7** |
| **Kwatebala** | | | | | | | | |
| **Proven** | 12,654.9 | 2.75 | 0.40 | | 2.41 | 0.32 | 305.3 | 40.7 |
| **Probable** | 4,926.2 | 2.50 | 0.41 | | 2.20 | 0.33 | 108.3 | 16.1 |
| **Sub-total** | **17,581.1** | **2.68** | **0.40** | **83,566.1** | **2.35** | **0.32** | **413.6** | **56.8** |
| **Summary** | | | | | | | | |
| **Proven** | 52,115.5 | 3.66 | 0.39 | | 3.14 | 0.29 | 1,638.7 | 151.7 |
| **Probable** | 61,323.2 | 3.07 | 0.33 | | 2.66 | 0.25 | 1,632.2 | 155.9 |
| **Sub-total** | **113,438.7** | **3.34** | **0.36** | **698,021.8** | **2.88** | **0.27** | **3,270.9** | **307.6** |

Reserve parameter changes between December 2012 and 2013 are summarized as follows:

- Combined base mining cost changes resulting in an 8% increase at the entrance bench
- Approximately 25% reduction in ore and waste ex-pit haulage costs
- Approximately 7% reduction in low grade ex-pit haulage costs
- Increase in throughput rate at the process plant from 14,000 tpd to 14,500 tpd
- Overall processing operating cost increase of 1%
- Increase in G&A cost of 3%
- Increase in tailings annuity of 21%%
- Overall copper cost increase of 5%
- Overall cobalt cost increase of 175%
- Acid cost reduction of 3.5%

## 15.2 GENERAL DESIGN CRITERIA

### 15.2.1 PRODUCTION RATE

The following targets were set for mine design:

| | |
|---|---|
| Overall Mine Production Rate | 53 million tpa |
| Milling Rate | 14,500 tpd |
| Copper Production | 208,000 tpa |
| Cobalt Production | 15,000 tpa |

### 15.2.2 BLOCK MODEL DILUTION

Dilution and losses of mineralized material are of significant importance in all mining operations. At Tenke Fungurume it is further highlighted because processing costs and relative strip ratios are high and so are ore values.

- Mineralized zones are:
  - Long and narrow
  - Typically 10 m to 15 m wide
  - Faulted and folded
  - Copper and Cobalt may have inversely proportional relationship
  - Contacts between ore and waste may be relatively sharp
- Block dimensions
  - Blocks are 5 m x 2.5 m x 2.5 m

Model dilution has been applied for the purposes of mine planning. Process grades have been reduced 5% to account for anticipated grade dilution.

## 15.3 PIT OPTIMIZATION

### 15.3.1 GENERAL

The pit optimization has been carried out using Minesight® for all deposits. A Lerchs Grossman algorithm was used to maximize the gross value of the pit.

As in earlier pit limit analyses FCX developed an optimized pit limit with the following sequence of steps:

- Prepare a geological block model including resource classification
- Perform slope stability analyses to determine pit sector slope angles
- Forecast metal prices and future operating costs
- Set discount rates for the mining sequence and economic analyses
- Establish maximum allowable sinking rates
- Determine metallurgical recoveries for the processes
- Calculate the block model net values
- Determine the economic pit limits using Lerchs Grossman algorithms

### **15.3.2** BLOCK MODELS

The resource block models used for pit optimization are described in the resource section. Measured and Indicated resources only have been used for pit optimization.

### **15.3.3** WALL SLOPES

The following default guidelines were used to develop pit designs and also provide a basis for pit optimization:

- 38 degree inter-ramp slope angle and a 33 degree overall slope angle
- Double 7.5 m benches to 15 m interval between berms
- Adjust slope for low strength RAT

The default design parameters above are applied to all deposits in the absence of specific geotechnical data. Typicallly, for mining within budget forecast periods, area specific geotechnical studies lead to the development of unique slope design recommendations for the individual depoists.

### **15.3.4** METAL PRICES

The metal prices for copper and cobalt used to define final pit limits were US$2.00/lb and US$10.00/lb respectively.

### **15.3.5** OPERATING COSTS

Operating costs for G&A and processing were based upon 4th quarter 2013 FCX updates of expected costs.

Mining costs were estimated by FCX Engineering staff. Ore mining costs were calculated based on a combination of drilling and blasting and fragmentation with the surface miner, loading with front-end loaders and hauling with 45 and 85 tonne trucks. These fleets mine all of the ore material plus low-grade. All ore mined will be stockpiled. Operating costs for ore re-handling by a front-end loader at the breaker and transfer chute to the mill were also estimated.

Mining costs for both ore and waste are incremented with depth. In-pit base mining costs were estimated for all pits. Ore haulage costs from each deposit to the plant site at Kwatebala were estimated and added to the process costs for block value calculations.

Waste mining costs were calculated based on conventional open pit bench mining including drilling and blasting. Loading and haulage costs are based on front-end loaders, hydraulic excavators, shovels and 85 tonne haul trucks. The smaller 45t truck fleet are now being phased out resulting in decreases in haulage operating costs.

### **15.3.6** SUSTAINING CAPITAL

Sustaining capital was input as a cost to the pit optimization routine to ensure that the last pit increment can support all direct operating costs and sustaining capital. Since ongoing capital expenditures occur throughout the mine life, an annuity is calculated for each category of sustaining capital to represent the discounted present value of this cost. This present value cost is assigned to the quantity mined and processed or metal recovered as appropriate.

Sustaining capital has been allocated for mining and plant equipment and tailings dam construction.

### 15.3.7 DISCOUNTING

The discount applied to ore and waste blocks was calculated based on the project discount rate and the vertical advance rate of the mine. The projected vertical advance rate was "***equivalent***" to 18, five meter benches per year with an annual discount rate of 12%. This resulted in an annual discount rate of 0.67% per 5 m bench/year.

### 15.3.8 PROCESS RECOVERY

Copper and cobalt processing recoveries, based upon plant historic data, applied for pit optimization are as follows:

- 97% of acid soluble copper
- 94% of acid soluble cobalt

As stated in the sections above process grades include 5% mining dilution.

### 15.3.9 PIT LIMIT DETERMINATION

The parameters, discussed in the sections above, applied to generate the ultimate pit limits are summarized in the table below with a comparison to 2012 year end parameters and relative changes. The biggest relative changes since 2012 are as follows:

- No cobalt metal will be produced on site in the future
    - Cobalt average sales price has increased
    - Cobalt average costs have increased
- Base mining costs have increased
- Waste haulage costs have decreased

## Table 15-3 Pit Optimization Parameters

| **Year** | | **2012** | **2013** | **Change** |
|---|---|---|---|---|
| **Basic Design Parameters** | **Units** | **Reserve** | **Reserve** | **2013-2012** |
| **Realized Metal Prices** | | | | |
| Copper | $/lb-Cu | 2.000 | 2.000 | - |
| Copper Premium | $/lb-Cu | 0.025 | 0.025 | - |
| Copper - Sales Price | $/lb-Cu | **1.980** | **1.989** | **0.009** |
| Copper - Sales Price | $/lb-tn | **4,365.15** | **4,386.07** | **20.92** |
| Cobalt Metal & 2013 Final Product Kokkola | $/lb-Co | 10.000 | 10.000 | - |
| Cobalt Hydroxide & 2013 Cobalt Premium Kokkola | $/lb-Co | 6.500 | 1.000 | - 5.500 |
| Cobalt - Average Sales Price | $/lb-Co | **7.911** | **11.000** | **3.090** |
| Cobalt - Sales Price | $/lb-tn | **17,440** | **24,251** | **6,811** |
| **Process Recovery** | | | | |
| Copper Recovery | % of AsCu | **97.00%** | **97.00%** | **0.00%** |
| Copper Dilution/Metal Loss | % of AsCu | **5.00%** | **5.00%** | **0.00%** |
| Ultimate Copper Recovery of AsCu | % of AsCu | **92.15%** | **92.15%** | **0.00%** |
| Cobalt Recovery | % of AsCo | **94.00%** | **94.00%** | **0.00%** |
| Cobalt Dilution/Metal Loss | % of AsCo | **5.00%** | **5.00%** | **0.00%** |
| Ultimate Cobalt Recovery of AsCo | % of AsCo | **88.58%** | **89.30%** | **0.72%** |
| **Discounting** | | | | |
| Annual Discount Rate | % | 12.0% | 12.0% | 0.0% |
| Average Vertical Advance Rate | bench/yr/PB | 18.0 | 18.0 | - |
| Annual Discount Rate Per Bench | % | 0.67 | 0.67 | - |
| Bench Height | meters | 2.50 | 2.50 | - |
| Advisory Fee & ICA Tax for Operating Cost and G&A | % | 0.00% | 1.54% | 1.54% |
| Advisory Fee & ICA Tax for Capital Cost | % | 0.00% | 0.92% | 0.92% |
| Advisory Fee & ICA Tax for Marketing | % | 0.00% | 0.38% | 0.38% |
| **Mining Rate** | **kmtpd** | **147.5** | **145.3** | **-2.2** |
| Base Mining Costs | $/dmt-mined | 2.110 | 2.605 | 0.495 |
| Oxide Pit Dewatering Costs | $/dmt-mined | - | - | - |
| Mine Equipment Capital Annuity | $/dmt-mined | 0.850 | 0.600 | - 0.250 |
| G&A Assigned to Mining | $/dmt-mined | - | - | - |
| Advisory Fee for Mining Cost | $/dmt-mined | 0.030 | 0.040 | 0.010 |
| Advisory Fee for Capital Cost | $/dmt-mined | 0.010 | 0.006 | - 0.004 |
| **Total Mining @ Pit Exit** | **$/dmt-mined** | **3.000** | **3.251** | **0.251** |
| **Haulage Increment/bench** | $/dmt-mined | **0.010** | **0.004** | **-0.006** |
| **Advisory Fee for Mining Cost** | $/dmt-mined | 0.000 | 0.000 | 0.000 |
| **Total Haulage Increment** | **$/dmt-mined** | **0.010** | **0.004** | **-0.006** |
| **Ore Hauling Costs** | | | | |
| Kwatebala | $/dmt-milled | 0.630 | 0.340 | - 0.290 |
| Tenke | $/dmt-milled | 2.124 | 0.753 | - 1.371 |
| Fwaulu | $/dmt-milled | 0.939 | 0.502 | - 0.437 |
| Mwadinkomba | $/dmt-milled | 1.593 | 0.844 | - 0.749 |
| Kansalawile | $/dmt-milled | 2.895 | 2.626 | - 0.269 |
| Pumpi | $/dmt-milled | 3.813 | 3.552 | - 0.261 |
| Fungurume | $/dmt-milled | 3.936 | 3.638 | - 0.298 |
| Mambilima | $/dmt-milled | 3.147 | 2.871 | - 0.276 |
| Kazinyanga | $/dmt-milled | 3.645 | 3.343 | - 0.302 |
| Kato L3K | $/dmt-milled | 2.322 | 2.045 | - 0.277 |
| Shinkusu | $/dmt-milled | 0.783 | 0.420 | - 0.363 |
| FGVI Extension | $/dmt-milled | 5.219 | 4.728 | - 0.491 |
| Mudilandima | $/dmt-milled | 3.328 | 2.924 | - 0.404 |
| Sefu | $/dmt-milled | | 0.411 | 0.411 |
| KM-485 | $/dmt-milled | | 2.967 | 2.967 |
| Mwad Anticline | $/dmt-milled | | 0.644 | 0.644 |
| **Low Grade Hauling Costs** | | | | |
| Kwatebala | $/dmt-milled | 1.459 | 1.328 | -0.131 |
| Tenke | $/dmt-milled | 1.919 | 1.755 | -0.164 |
| Fwaulu | $/dmt-milled | 1.714 | 1.578 | -0.136 |
| Mwadinkomba | $/dmt-milled | 1.714 | 1.539 | -0.175 |
| Kansalawile | $/dmt-milled | 2.800 | 2.665 | -0.135 |
| Pumpi | $/dmt-milled | 3.701 | 3.575 | -0.126 |

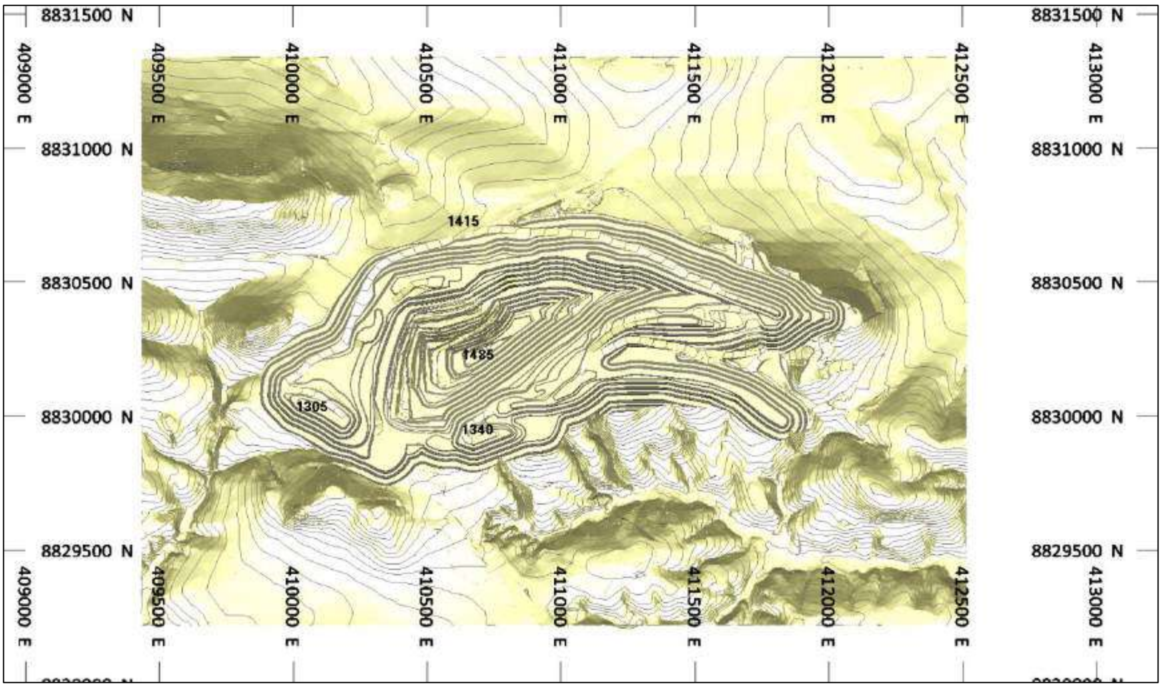
| Year | | 2012 | 2013 | Change |
|---|---|---|---|---|
| **Basic Design Parameters** | **Units** | **Reserve** | **Reserve** | **2013-2012** |
| **Processing Costs** | | | | |
| Throughput | KTPD Base | 14.000 | 14.500 | 0.500 |
| Long-Term Stockpile Re-Handling Costs | $/dmt-mined | - | - | - |
| Mill Stockpile Rehandling Cost | $/dmt-milled | 0.313 | 0.533 | 0.220 |
| Crush & Mill | $/dmt-milled | 3.848 | 4.074 | 0.226 |
| Leach - CCD | $/dmt-milled | 2.752 | 3.497 | 0.745 |
| Tailings Neutralization & Pump Costs | $/dmt-milled | 6.987 | 6.731 | - 0.256 |
| Lab & Tech Services | $/dmt-milled | 4.711 | 3.953 | - 0.758 |
| Advisory Fee for Processing Costs | $/dmt-milled | 0.286 | 0.288 | 0.002 |
| **Total Cost** | **$/dmt-milled** | **18.896** | **19.076** | **0.180** |
| **Site-Wide G&A** | | | | **0.0000** |
| **G&A Costs** | $/dmt-milled | **18.800** | **19.274** | **0.474** |
| Advisory Free for G&A | $/dmt-milled | **0.290** | **0.296** | **0.006** |
| **Total Site-Wide G&A** | $/dmt-milled | **19.090** | **19.570** | **0.480** |
| **Tailings Dam Construction** | | | | |
| **Tailings Annuity** | $/dmt-milled | **1.640** | **1.986** | **0.347** |
| Advisory Fee for Capital Cost | $/dmt-milled | **0.015** | **0.018** | **0.003** |
| **Total Tainlings Dam Construction Cost** | $/dmt-milled | **1.655** | **2.005** | **0.350** |
| **Copper Costs** | | | | |
| Copper Annuity | $/lb-Cu | 0.010 | 0.005 | - 0.005 |
| SX-EW Costs | $/lb-Cu | 0.091 | 0.106 | 0.015 |
| Operations Management Fee | $/lb-Cu | 0.020 | 0.020 | - |
| Marketing Fee | $/lb-Cu | 0.027 | 0.027 | - |
| Export Duties | $/lb-Cu | 0.028 | 0.031 | 0.003 |
| Local Fund and Exchange Controls | $/lb-Cu | 0.010 | 0.010 | 0.000 |
| Royalties | $/lb-Cu | 0.037 | 0.037 | 0.000 |
| Advisory Fee for Capital Cost | $/lb-Cu | 0.000 | 0.000 | - 0.000 |
| Advisory Fee for Operating Cost | $/lb-Cu | 0.002 | 0.002 | 0.000 |
| **SubTotal Cost/lb-Cu** | **$/lb-Cu** | **0.226** | **0.238** | **0.012** |
| Copper Cathode Freight Cost | $/lb-Cu | 0.101 | 0.093 | - 0.008 |
| Secuity & Escort | $/lb-Cu | - | - | - |
| Agency Fee | $/lb-Cu | - | - | - |
| Advisory Fee for Operating Cost | $/lb-Cu | 0.002 | 0.001 | - 0.000 |
| **Total Cost/lb-Cu** | **$/lb-Cu** | **0.328** | **0.333** | **0.005** |
| **Cobalt Costs** | | | | |
| Cobalt Hydroxide Cost | $/lb-Co | 0.920 | 1.055 | 0.135 |
| Cobalt Hydroxide to Metal Cost | $/lb-Co | 0.490 | 3.380 | 2.890 |
| Wt. Average Cobalt Cost | $/lb-Co | 1.120 | 4.435 | 3.315 |
| Advisory Fee for Cobalt Cost | $/lb-Co | 0.020 | 0.016 | - 0.004 |
| **Subtotal** | $/lb-Co | **1.140** | **4.451** | **3.311** |
| Cobalt Annuity | $/lb-Co | 0.197 | 0.036 | - 0.162 |
| Operations Management Fee | $/lb-Co | 0.079 | 0.065 | - 0.014 |
| Marketing Fee | $/lb-Co | 0.104 | 0.085 | - 0.018 |
| Export Duties | $/lb-Co | 0.064 | 0.085 | 0.021 |
| Local Fund and Exchange Controls | $/lb-Co | 0.038 | 0.030 | - 0.007 |
| Royalties | $/lb-Co | 0.149 | 0.118 | - 0.031 |
| Advisory Fee for Capital Cost | $/lb-Co | 0.002 | 0.000 | - 0.001 |
| Advisory Fee for Operating Cost | $/lb-Co | 0.002 | 0.002 | 0.000 |
| **SubTotal Cost/lb-Co** | **$/lb-Co** | **1.7739** | **4.8729** | **3.0990** |
| Cobalt Metal Freight Cost | $/lb-Co | 0.131 | - | - 0.131 |
| Security & Escort | $/lb-Co | - | - | - |
| Agency Fee | $/lb-Co | - | - | - |
| Cobalt Hydroxide Freight Cost | $/lb-Co | 0.405 | 0.444 | 0.039 |
| Security & Escort | $/lb-Co | - | - | - |
| Agency Fee | $/lb-Co | - | - | - |
| Average Cobalt Freight Cost | $/lb-Co | 0.295 | 0.444 | 0.150 |
| Advisory Fee for Operating Cost | | 0.005 | 0.004 | - 0.000 |
| **Total Cost/lb-Co** | **$/lb-Co** | **2.0729** | **5.3214** | **3.2485** |
| **Acid Cost** | | | | |

## 15.4 MINE DESIGN AND PIT DEVELOPEMENT

Based upon the pit optimization work undertaken at Kwatebala, Fungurume, Fwaulu, Kansalawile, Mambilima, Mwandinkomba, Pumpi, Tenke, Fungurume VI, Kazinyanga, Kato L3K, Shinkusu, Zikule and Mudilandima smoothed pit designs were completed including haulage roads. Examples of the final pit limits are shown in the figures below.

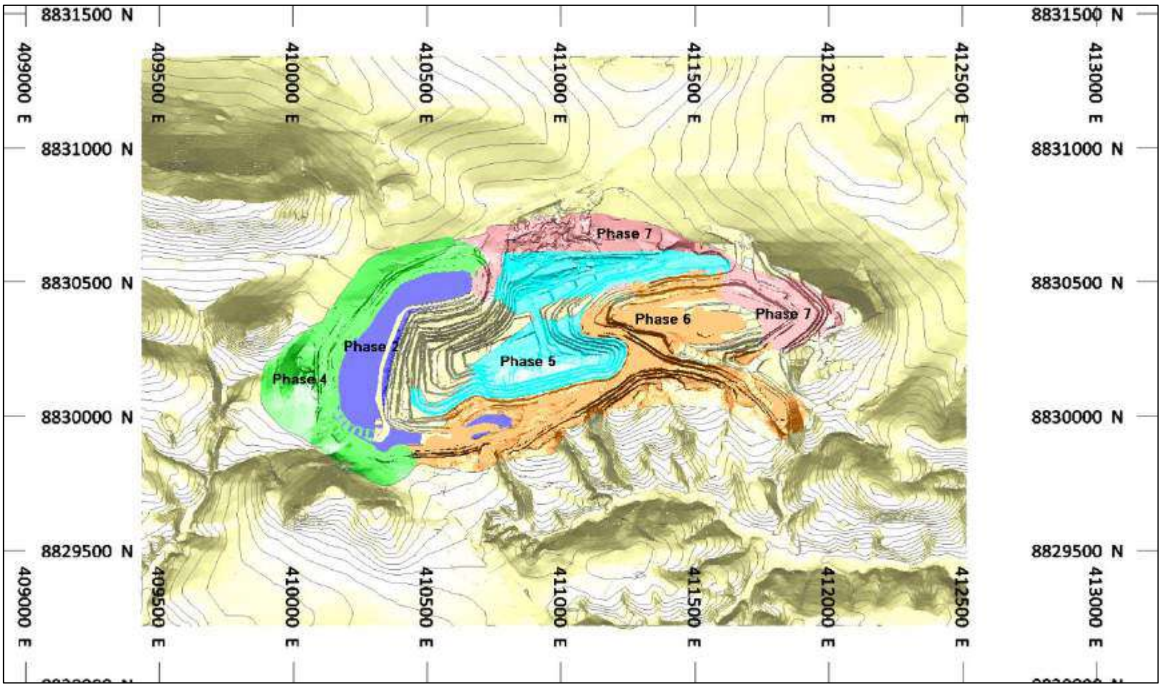
The Kwatebala updated pit design, shown in Figure 15-1, includes five remaining development phases. The pit is approximately 2,350 m long and 950 m wide. Haulage roads exit on the north side of the pit towards the ore and waste stockpiles.

**Figure 15-1 Kwatebala Pit Design**



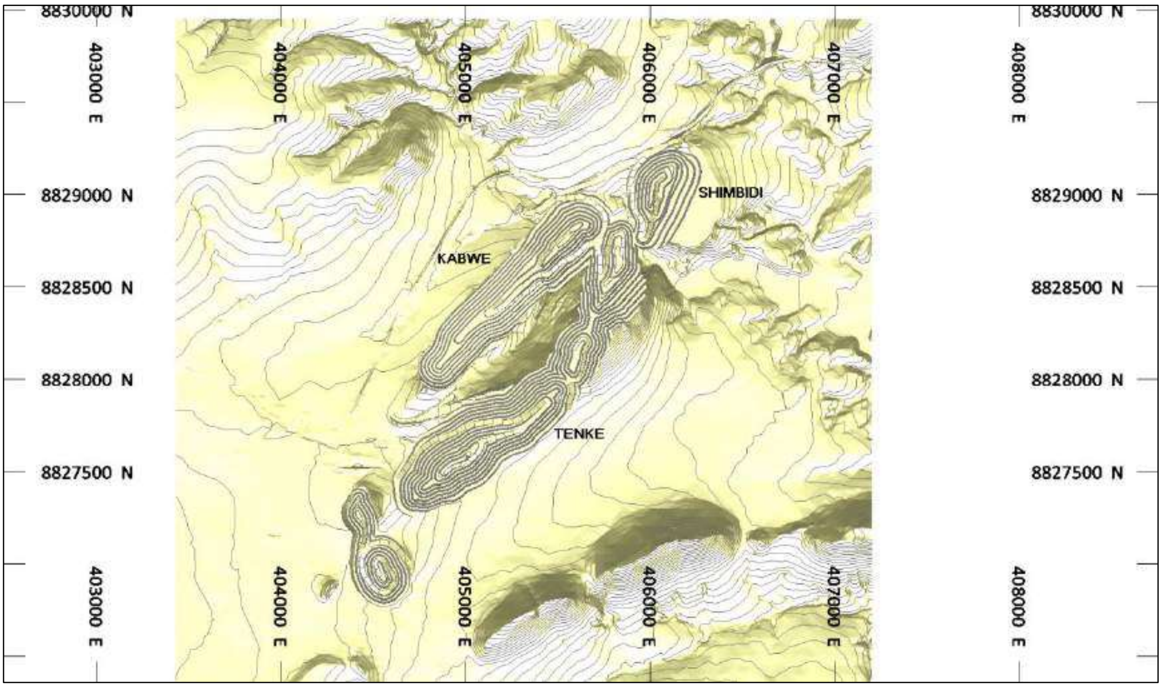
The phase development sequence for the remaining Phases is shown in the figure below.

**Figure 15-2 Kwatebala Pit Phase Development**



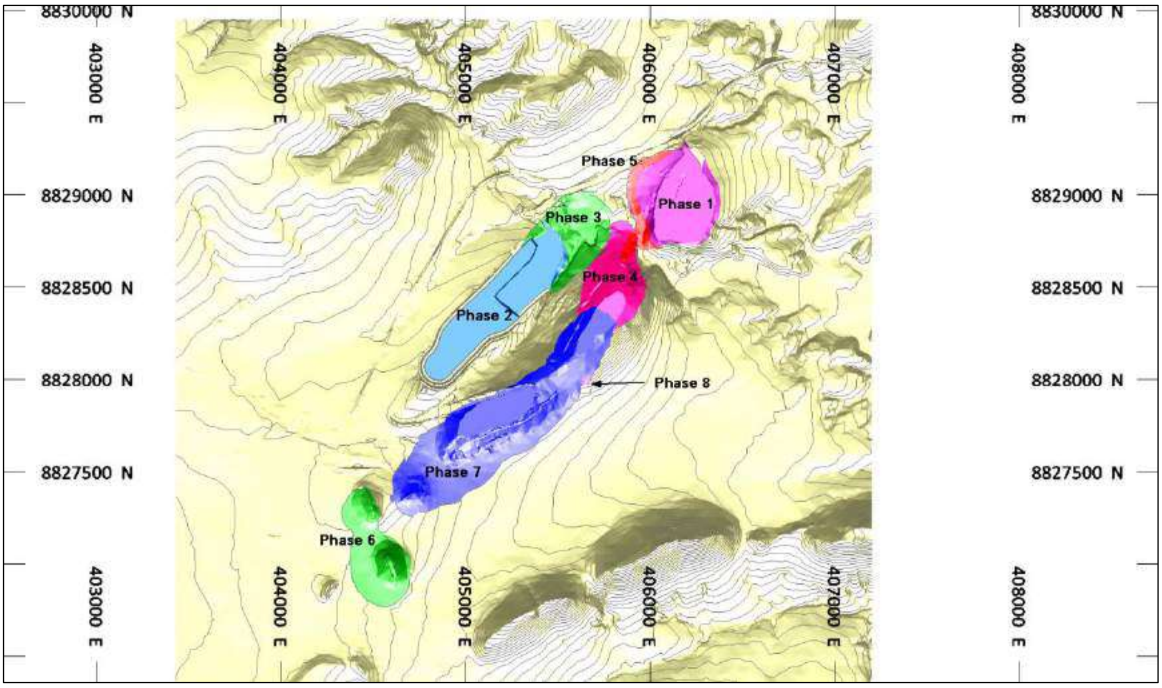
The Tenke pit design is shown in Figure 15-3 below. The mined area is approximately 2,900 m by 800 m wide.

**Figure 15-3 Tenke Pit Design**



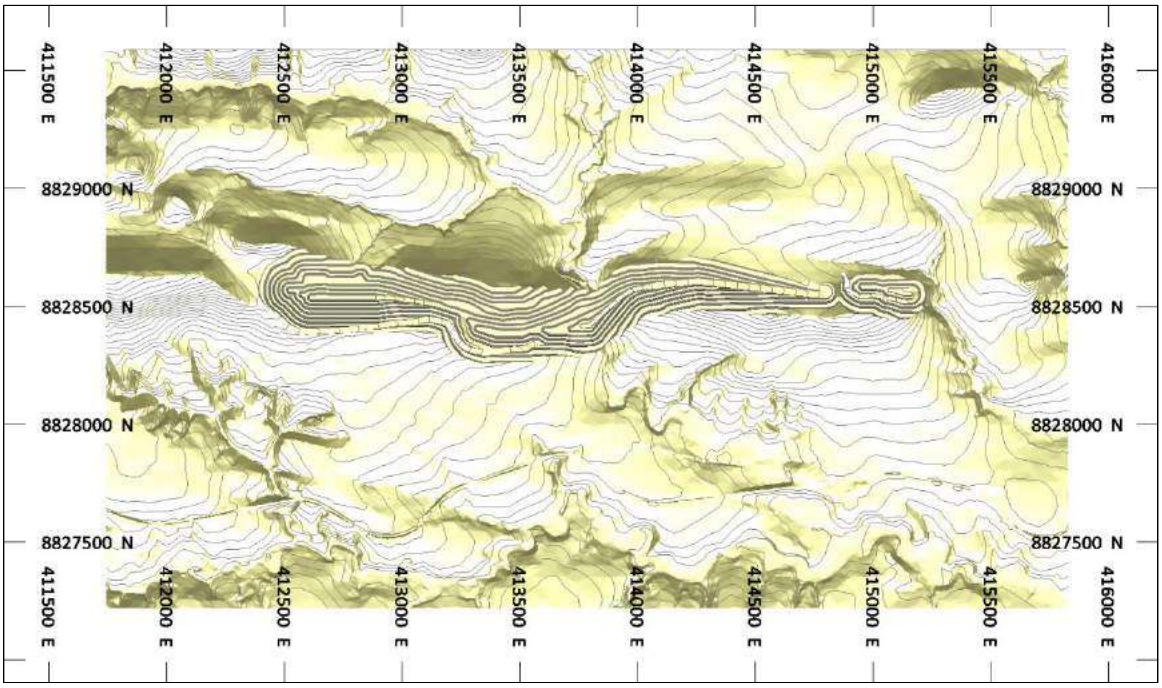
The Tenke deposits are mined in eight development phases. Key mining areas at Tenke include Shimbidi, Tenke and Kabwe. The phase development sequence is shown in the figure below.

**Figure 15-4 Tenke Pit Phase Development**



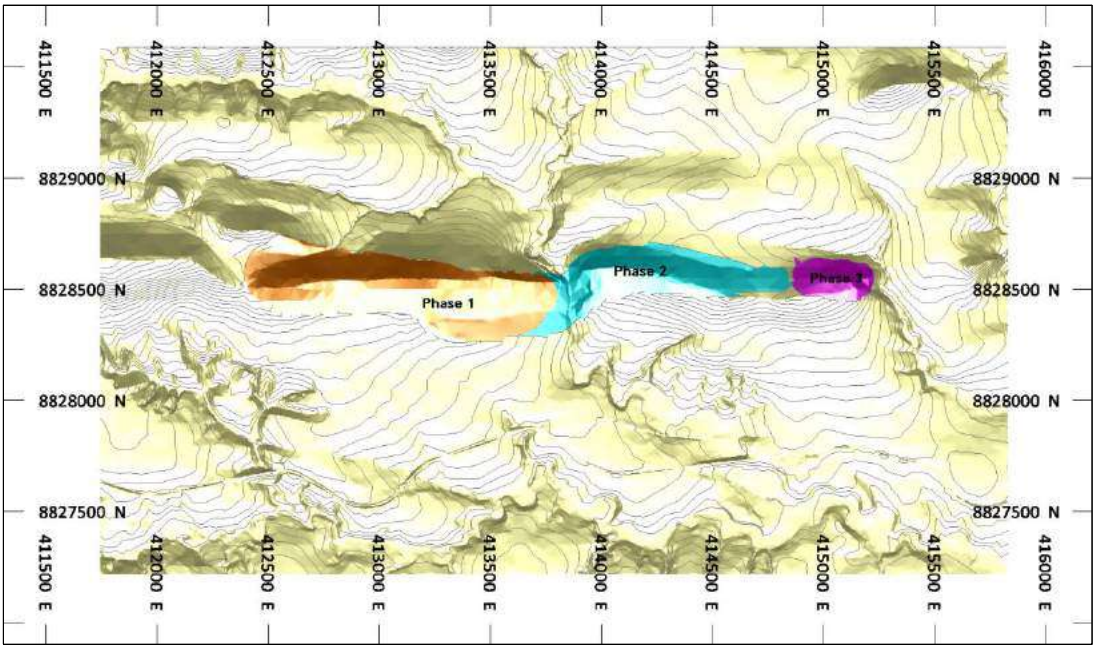
The Mwadinkomba pit design is shown in Figure 15-5. The mined area will be approximately 2,800 m by 300 m.

**Figure 15-5 Mwadinkomba Pit Design**



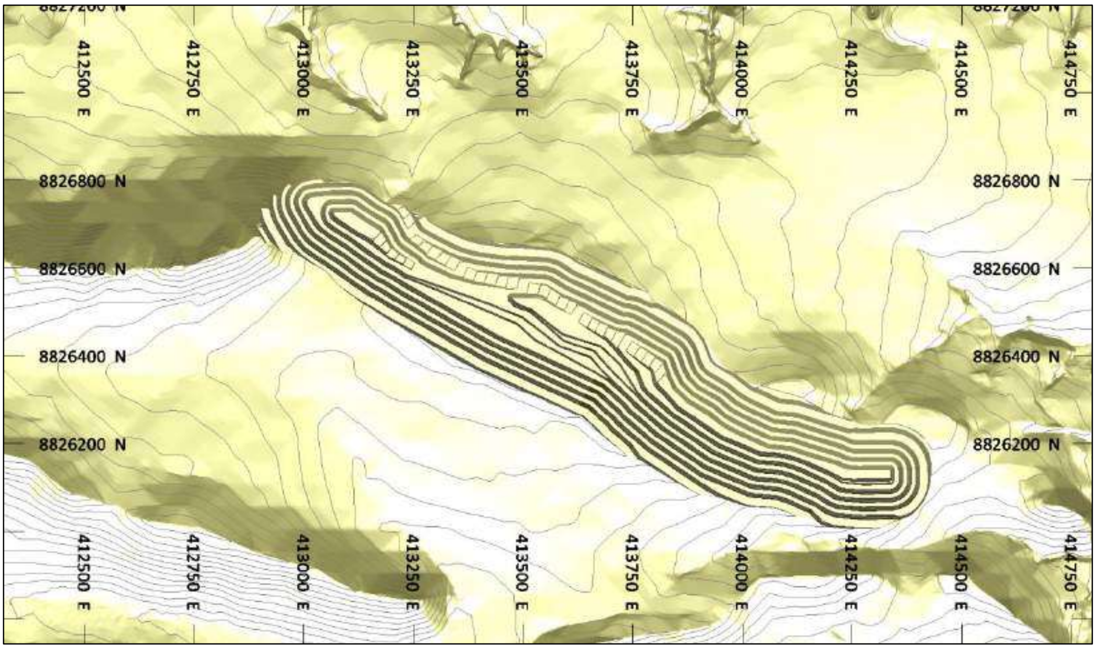
Mwadinkomba will be developed in three pit phases. The phase development sequence is shown in the figure below.

**Figure 15-6 Mwadinkomba Pit Phase Development**



The Kansalawile pit design is shown in Figure 15-7. The pit is approximately 1,600 m long by 325 m wide and will be developed in a single phase.

**Figure 15-7 Kansalawile Pit Design**



The Fwaulu pit design is shown in Figure 15-8. The main pit is approximately 100 m long by 580 m wide. It will be developed in 8 phases as shown in Figure 15-9.

**Figure 15-8 Fwaulu Pit Design**

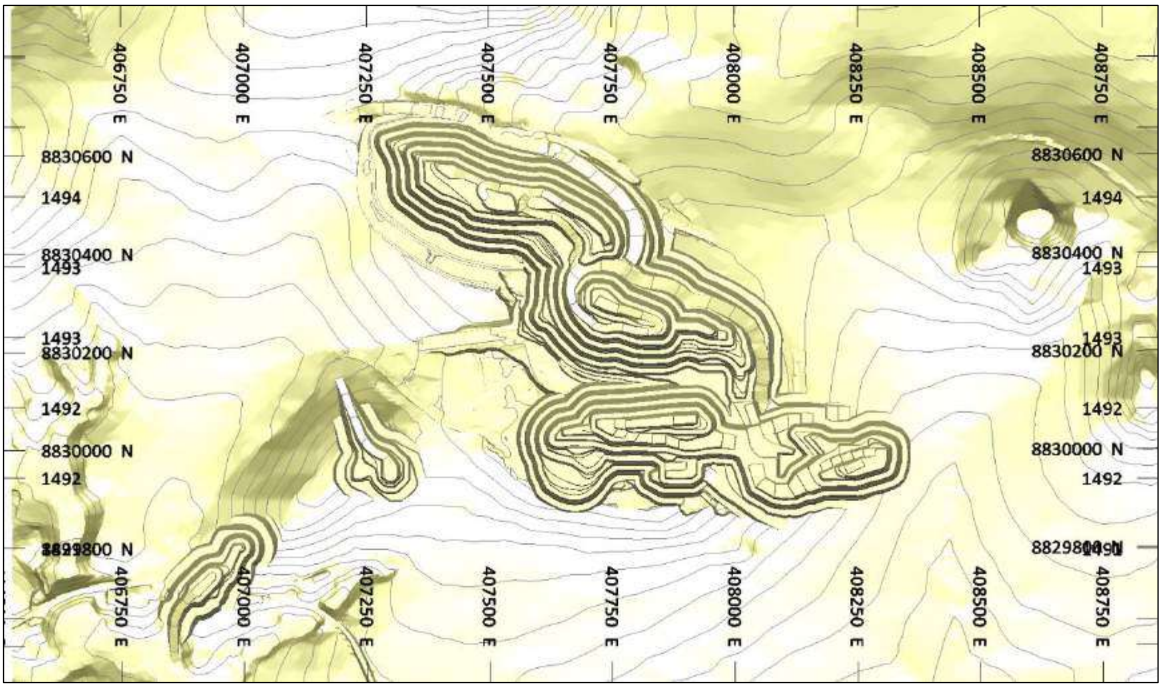
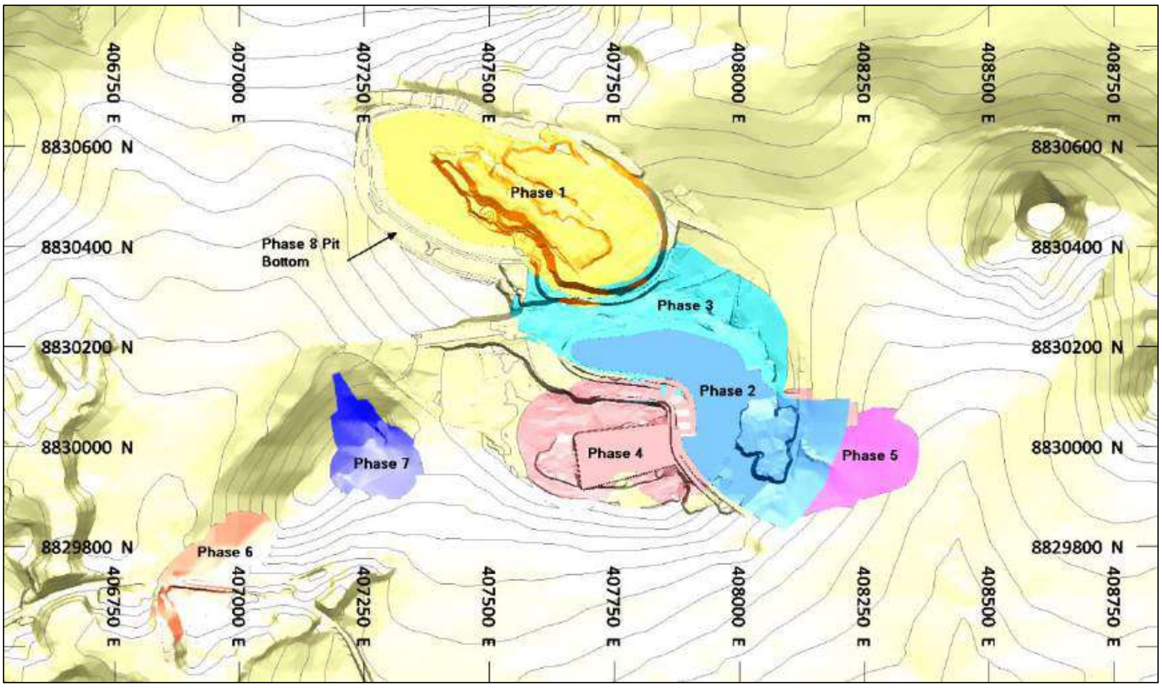


**Figure 15-9 Fwaulu Pit Phase Development**



The Mambalima pit design and development phases are shown in the figures below. The pit will be approximately 3,500 m long by 350 m wide and will be developed in 5 phases.

**Figure 15-10 Mambalima Pit Design**

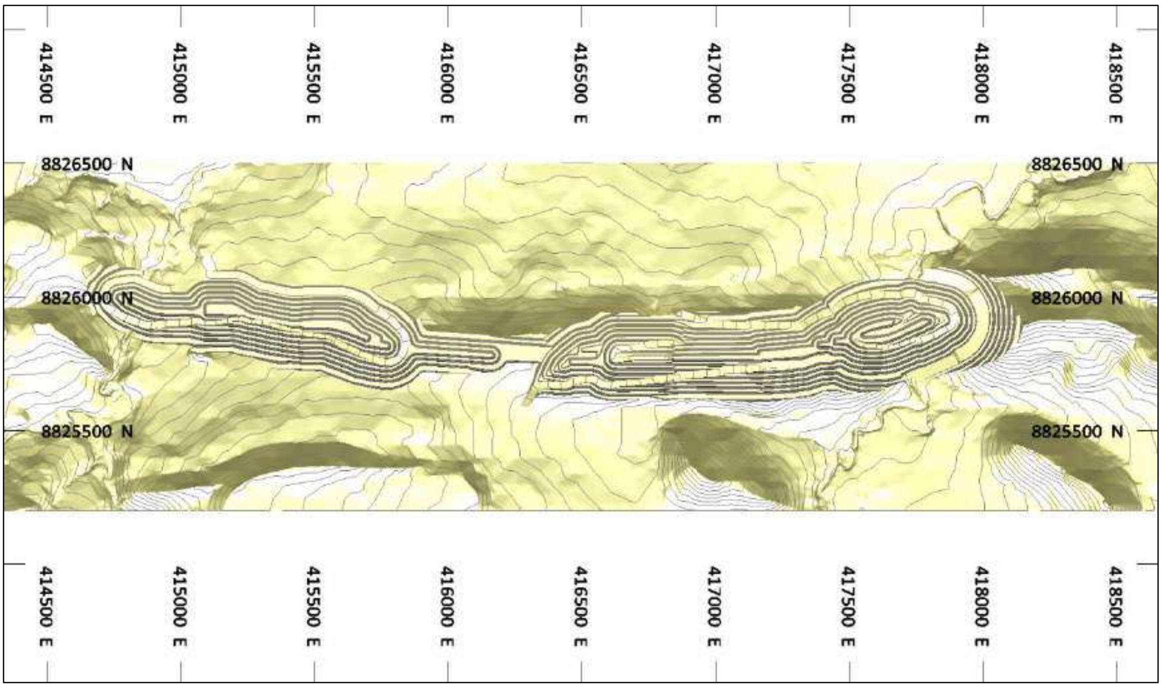
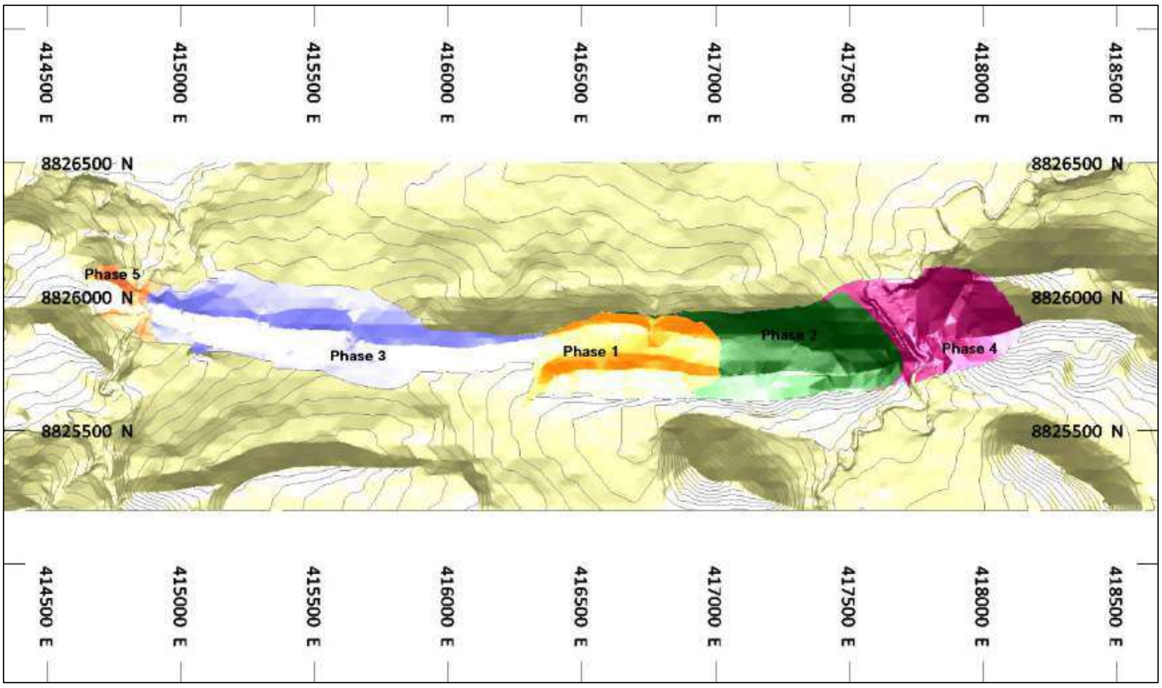


**Figure 15-11 Mambalima Pit Phases**



The Fungurume pit design and development phases are shown in Figure 15-12 and Figure 15-13. The deposit will be mined in 8 development phases.

**Figure 15-12 Fungurume Pit Design**

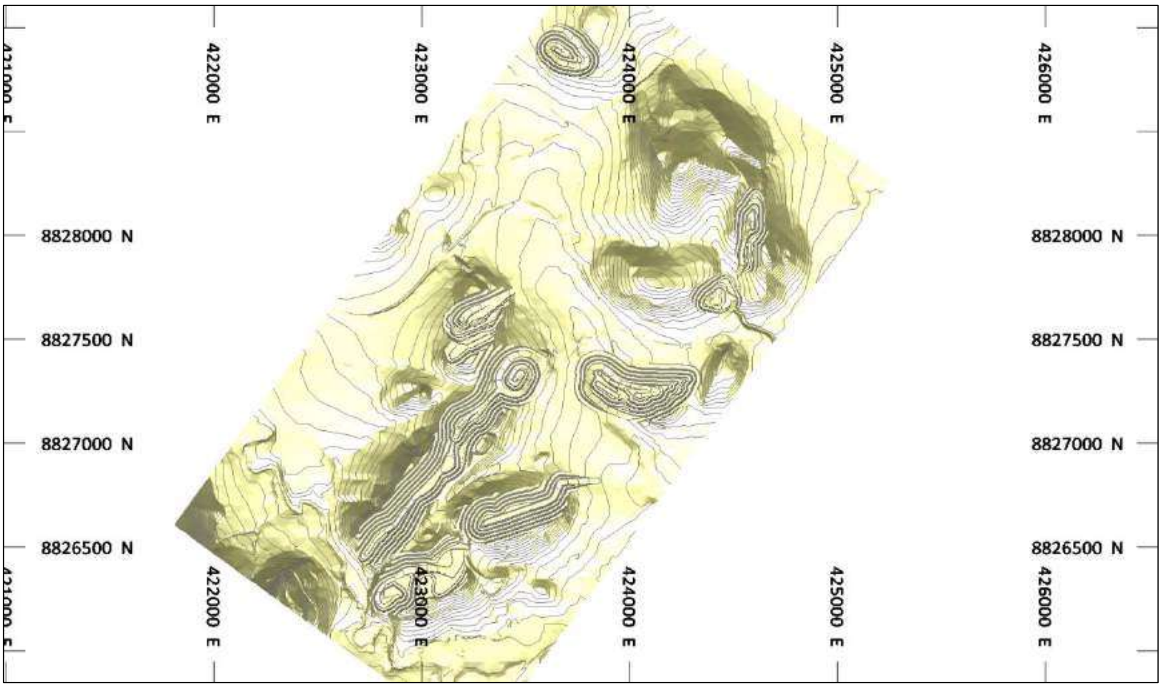
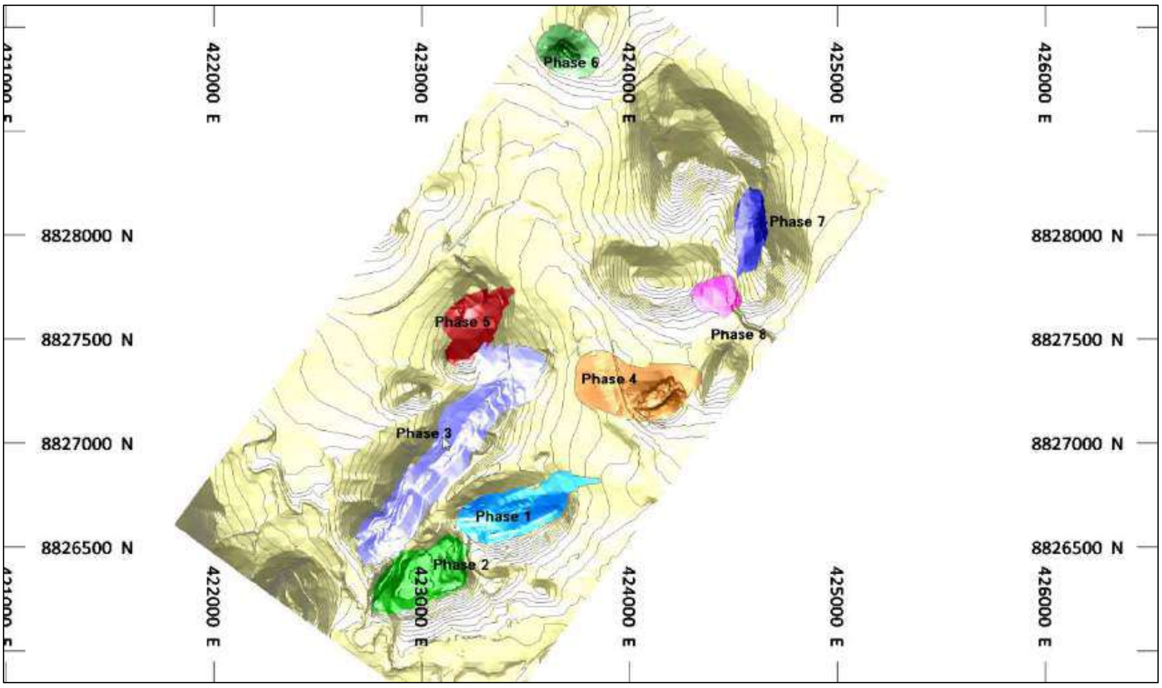


**Figure 15-13 Fungurume Pit Phases**



The Pumpi pit design and development phases are shown in Figure 15-14 and Figure 15-15. Pumpi will be mined three phases at surface and one phase to depth.

**Figure 15-14 Pumpi North and East Pit Design**

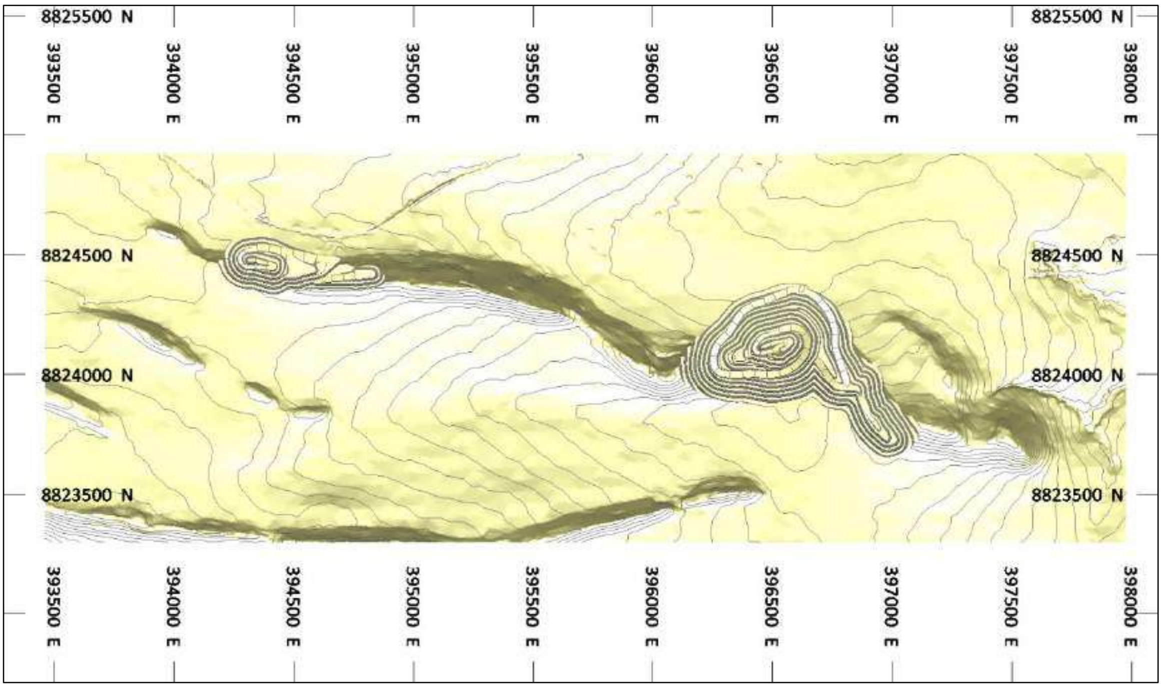
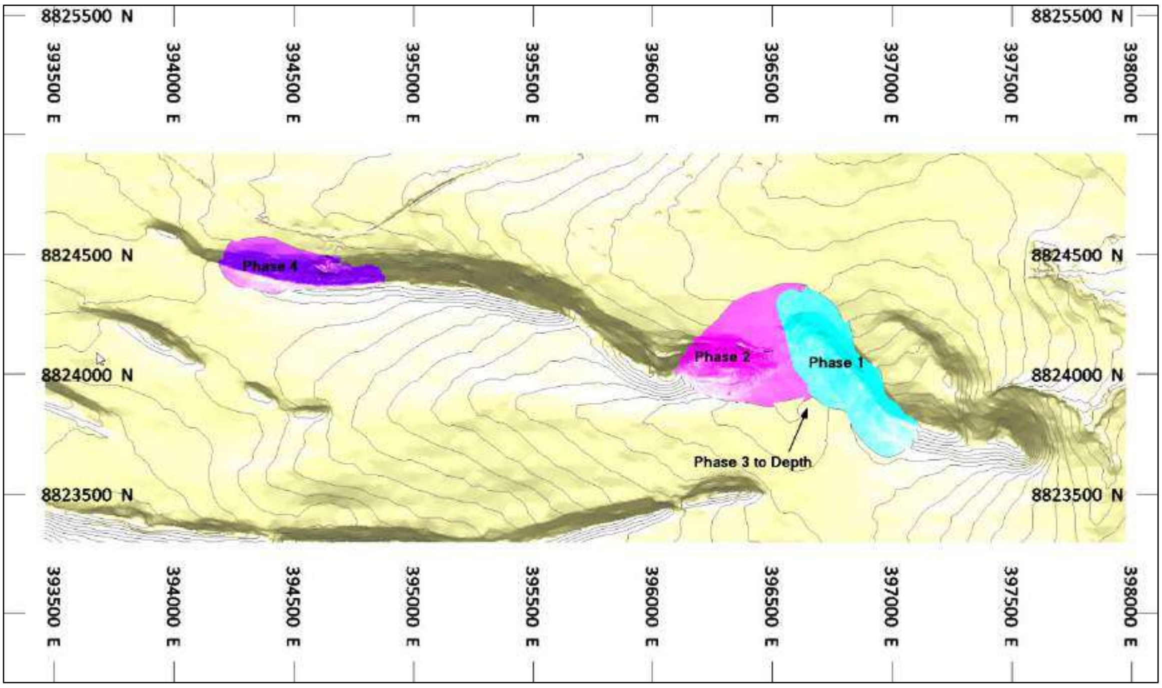


**Figure 15-15 Pumpi Pit Phases**



The Fungurume VI pit design and development phases are shown in Figure **15-16** and Figure 15-17. The deposit will be mined in four development phases.

**Figure 15-16 Fungurume VI Design**

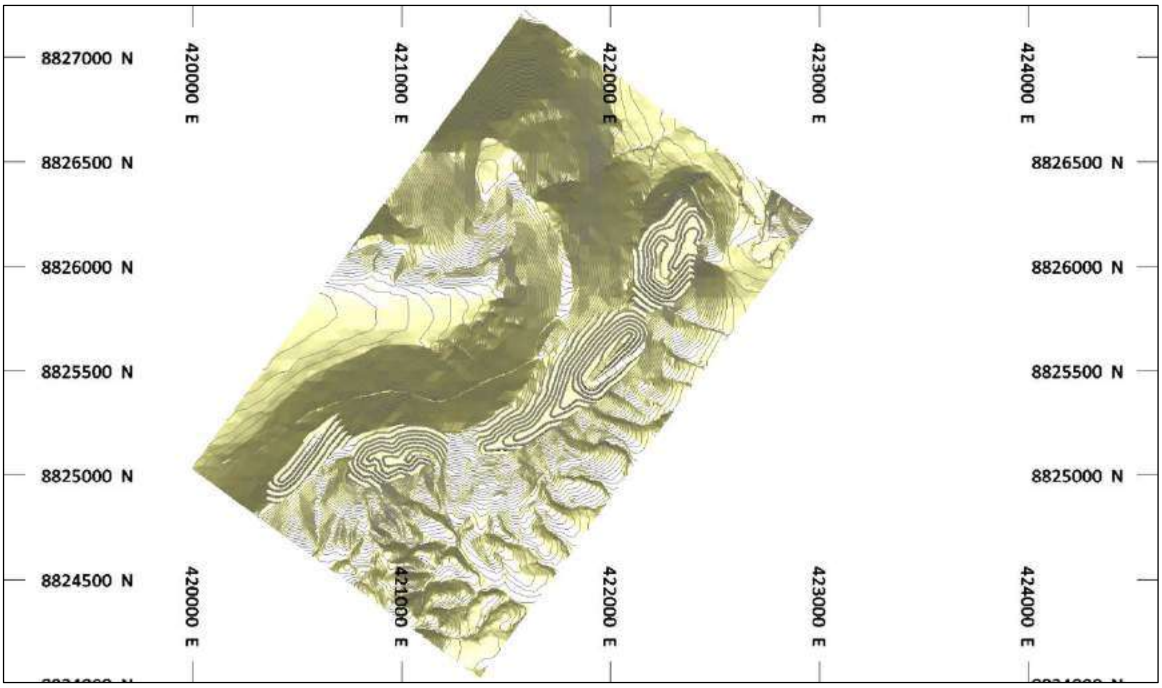
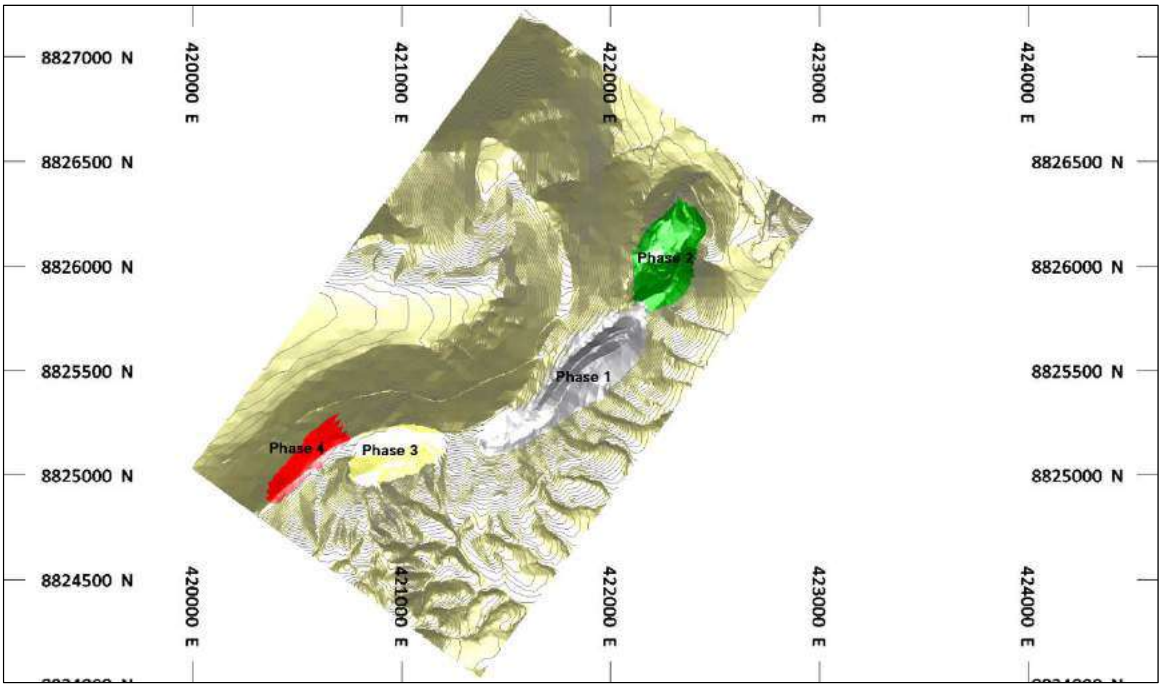
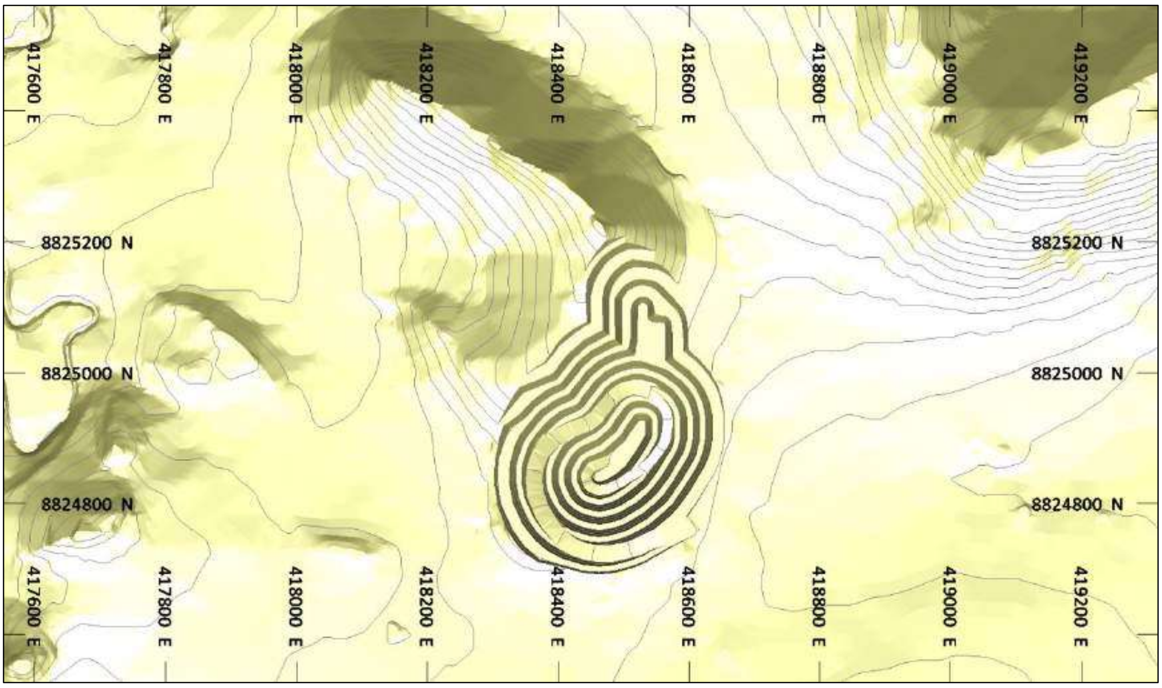


**Figure 15-17 Fungurume VI Pit Phases**



The Kazinyanga pit design is shown in Figure 15-18. The pit is approximately 500 m across and will be mined in a single phase.

**Figure 15-18 Kazinyanga Design**



The Zikule pit design and development phases are shown in Figure 15-19 and Figure 15-20.

**Figure 15-19 Zikule Pit Design**

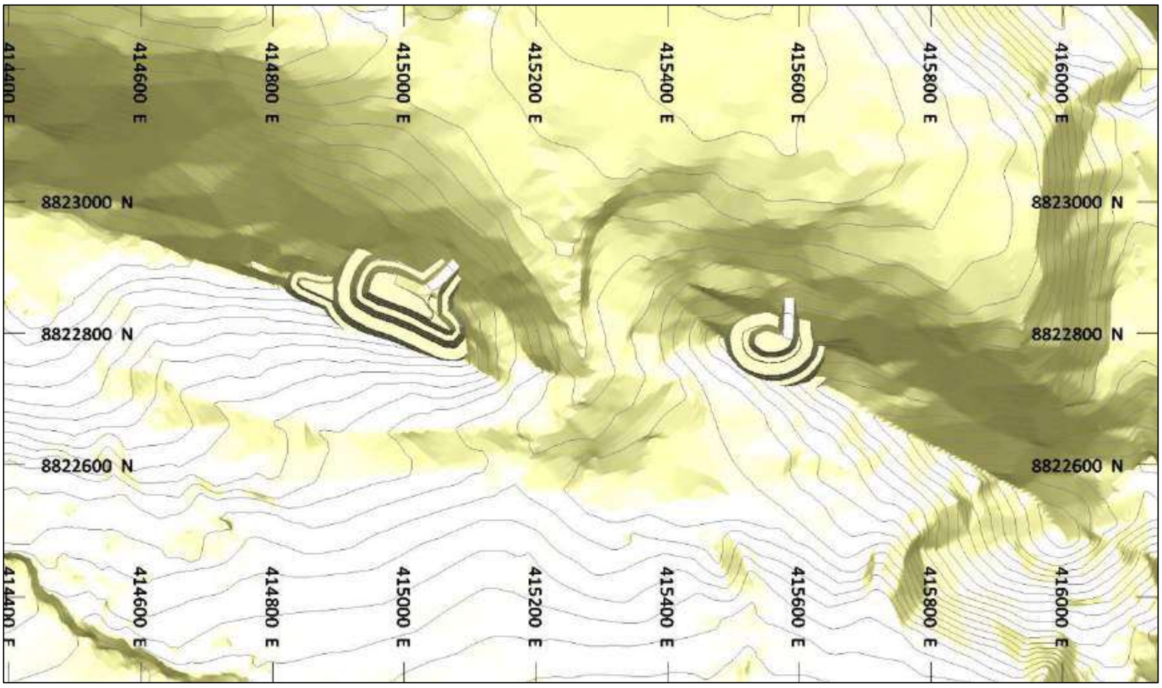
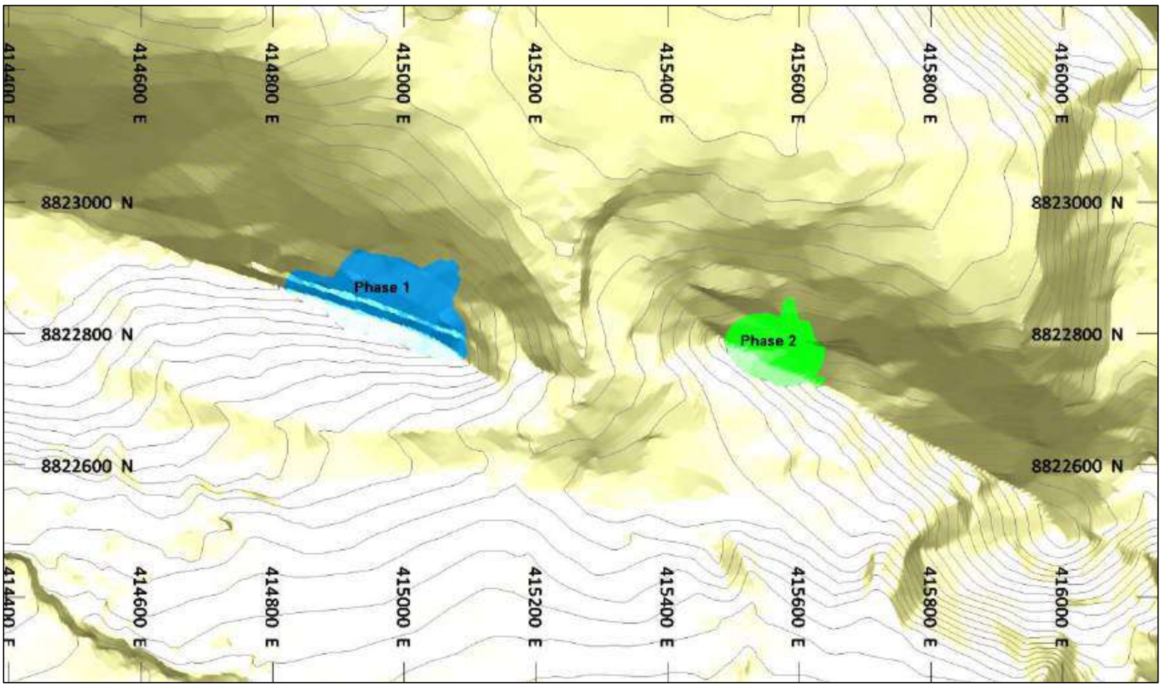


**Figure 15-20 Zikule Pit Phases**



The Kato pit design and development phases are shown in Figure 15-21 and Figure 15-22.

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**Figure 15-21 Kato Pit Design**

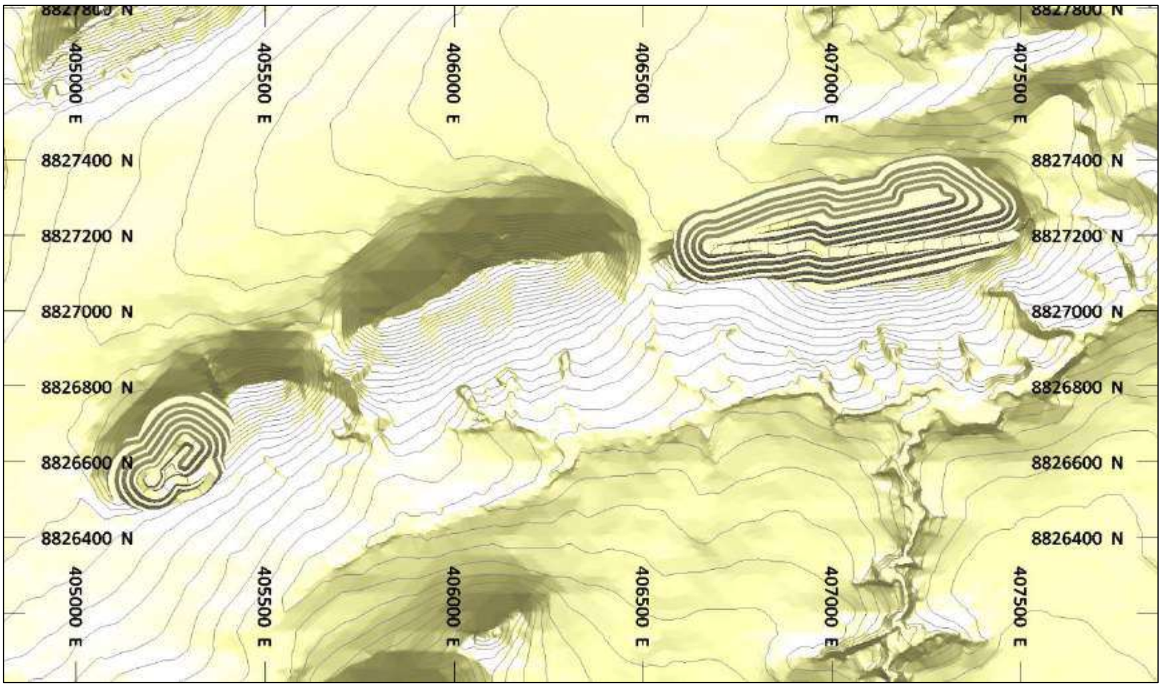
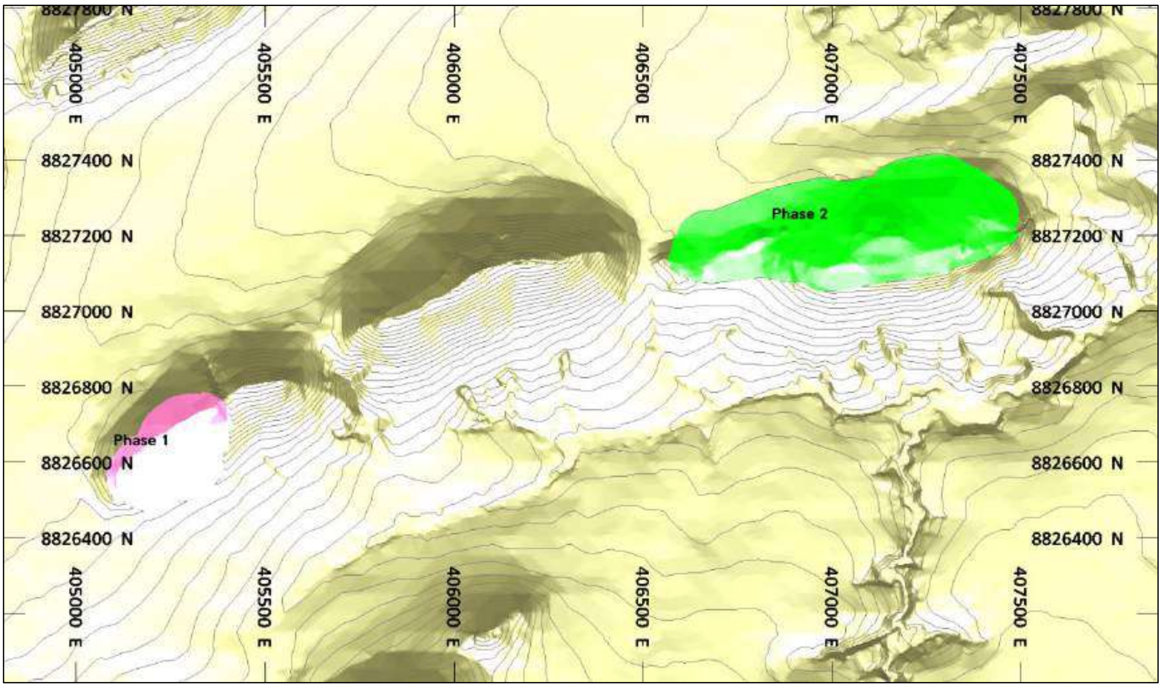
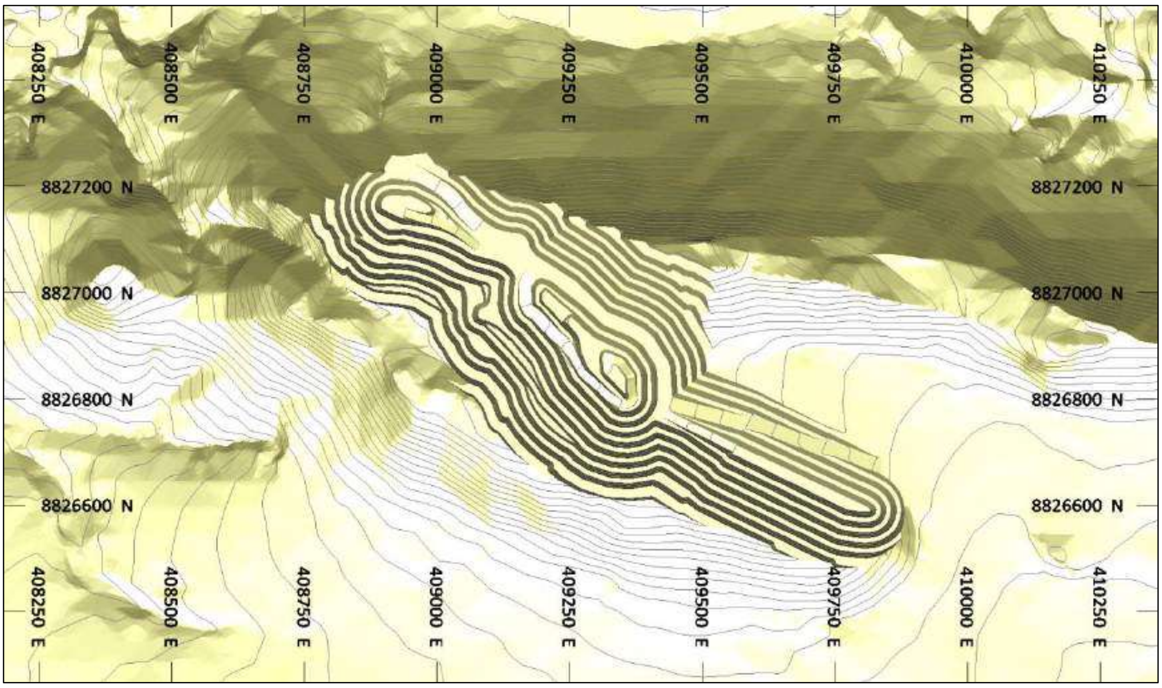


**Figure 15-22 Kato Pit Phases**



The Mudilandima pit is shown in **Figure 15-23** below. It will be 1250 m long and 460 m wide and will be mined as a single phase.

**Figure 15-23 Mudlandima Design**



## 15.5 DISCUSSION

The mineable reserve estimate was based upon a set of economic parameters, geotechnical design criteria and metallurgical recovery assumptions. Changes in these assumptions will impact the in-pit reserve estimate. In general, increases in operating costs, reductions in revenue assumptions or reductions in metallurgical recovery may result in increased cut-off grades, reductions in in-pit reserves and increasing strip ratios. The converse is also true. Reductions in operating costs, increases in revenue assumptions or increase in metallurgical recovery may result in reduced cut-off grades and increases in reserves.

# 16 MINING METHODS

## 16.1 GENERAL

### Mine Production

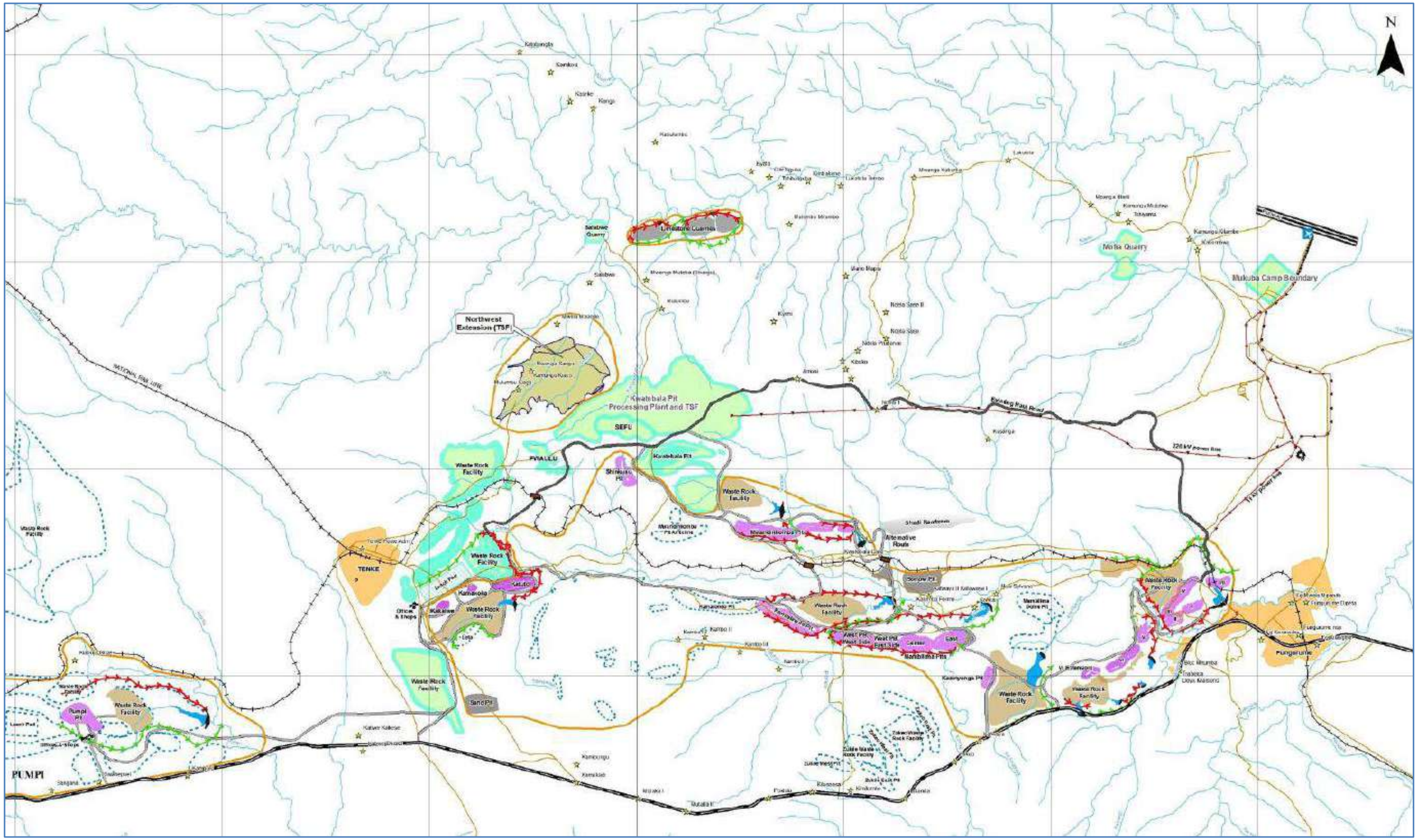
The 2013 TFM Mineral Reserves were used to develop the current mine plan. The principal objectives of this plan are to provide 208,000 tpa recoverable copper and approximately 15,000 tpa recoverable cobalt to the process facility through 2022 followed by a steady decline in metal output as head grades decrease. The current mine plan is an open pit operation for 17 years, 2014 through 2030, followed by reclaim and processing of stockpiled lower grade material for another 11 years for a total mine life of 28 years 2014 through 2041. A total of 144.1 million tonnes with an average grade of 2.89% TCu and 0.35% TCo will be processed including stockpile material reclaimed. Total waste mined will be 698.0 million tonnes.

### Mine Operations

The mine is currently in operation as a conventional open pit operation. Waste mining started with 5.0 m benches but now takes place on 7.5 m benches using 16.5 $m^3$ shovels, 12.2 $m^3$ and 6.3 $m^3$ wheel loaders and 85 t and 45 t trucks. Waste is drilled and blasted. Ore is identified and then broken in 0.625 m deep slices using continuous surface miners. The broken ore is excavated using wheel loaders and loaded into 45 and 85 t trucks. The average daily mining rate during continuous operations will be 144,000 tpd.

The Mineral Reserves have been estimated using long term metal prices of US$2.00/lb for copper and US$10.00/lb for cobalt. The mine plan and reserve estimate have been made using the current resource models for Kwatebala, Tenke, Fwaulu, Mwadinkomba, Kansalawile Mambalima, Fungurume, Pumpi, Shinkusu, Kato L3K, Kazinyanga, Fungurume VI, Mudilandima and Zikule. Deposit locations are shown in Figure 16-1.

**Figure 16-1 Location of Deposits**



## 16.2 MINE CONCEPT AND METHODOLOGY

Selective mining of the high grade ore is a key element of success for the operation. The ore is located in relatively thin seams and in some locations the seams are significantly faulted, folded and overturned. To minimize ore dilution and ore losses, the ore is broken in very thin (0.625 m) cuts using a surface miner. A surface miner is a track-mounted machine with a large rotating drum and hardened steel picks that break the rock in-situ. A new model chainless drive Vermeer is shown in Figure 16-2. The ore is broken to minus 150 mm in size and front-end loaders are used to load 45 t or 85 t haul trucks. High-grade ore is delivered to stockpiles near the mill feed chute. Loaders are then used to produce an ore blend from these stockpiles. A declining cut-off grade strategy has been applied to provide the highest grade ore to the mill and lower grade ores to low grade ore stockpiles. Processing of stockpile material will occur later in the mine life.

**Figure 16-2 Surface Miner (November 2013 Site Visit)**

Waste mining will be carried out using conventional drill, blast, load and haul unit operations. Currently, 7.5 meter benches are mined with 16.5m3 hydraulic excavators and Caterpillar 992 front-end loaders to Caterpillar 777 haul trucks.

Figure 16-3  Hydraulic Excavator Mining Waste

## 16.3 PRODUCTION SCHEDULE

The Kwatebala, Tenke, Fwaulu, Mwadinkomba, Kansalawile Mambalima, Fungurume, Pumpi, Shinkusu, Kato L3K, Kazinyanga, Fungurume VI, Mudilandima and Zikule deposits are expected to be mined over a period of 17 years between 2014 and 2030. After 2030, low-grade stockpiles will be progressively reclaimed and processed extending the operational life to 28 years, through 2041. Annual scheduled mining quantities from the open pit operations and WIP stockpiles between 2014 and 2041 are shown in the Figure 16-4 and table below.

**Figure 16-4 Mine Material Movement Schedule**

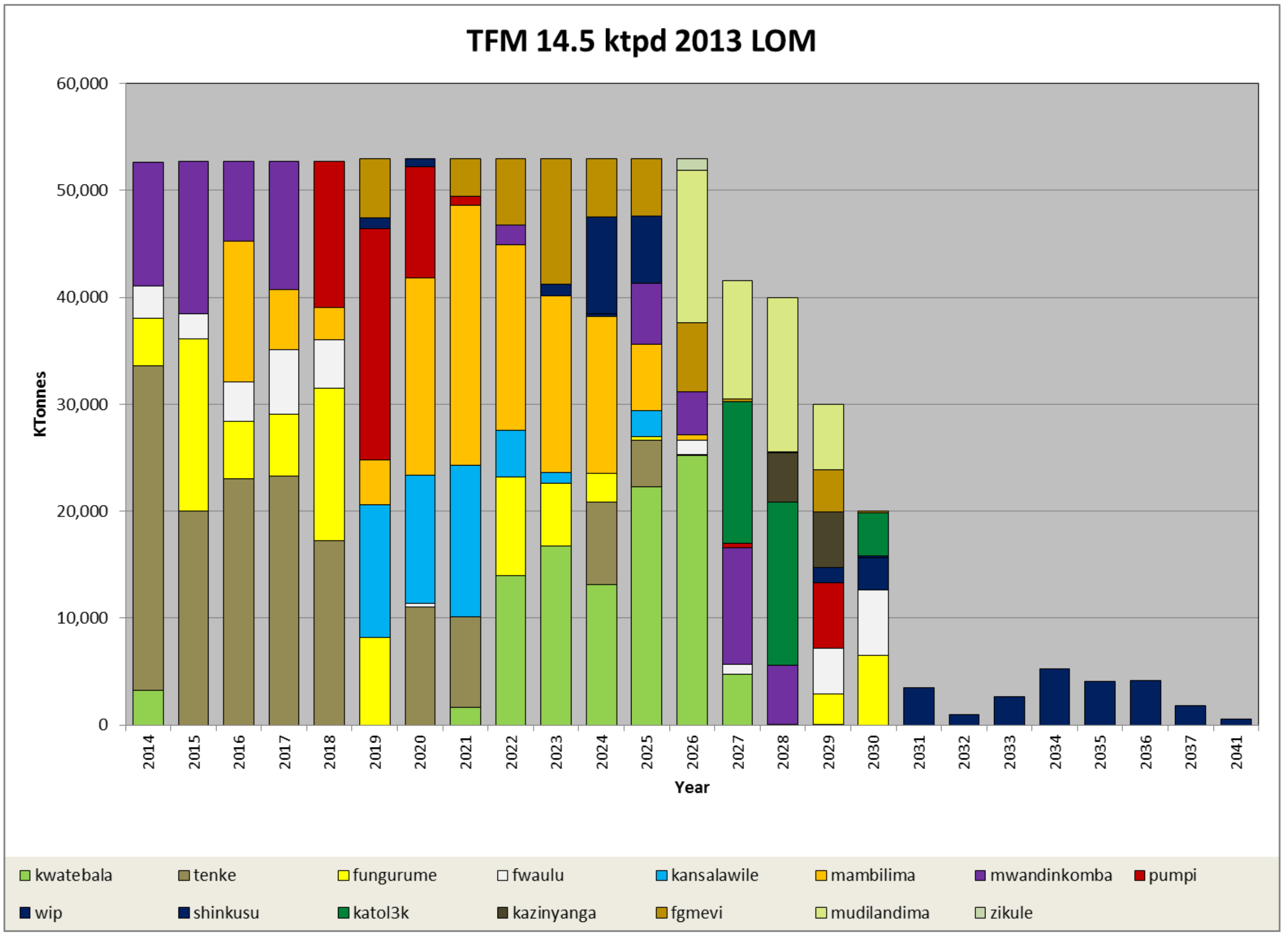


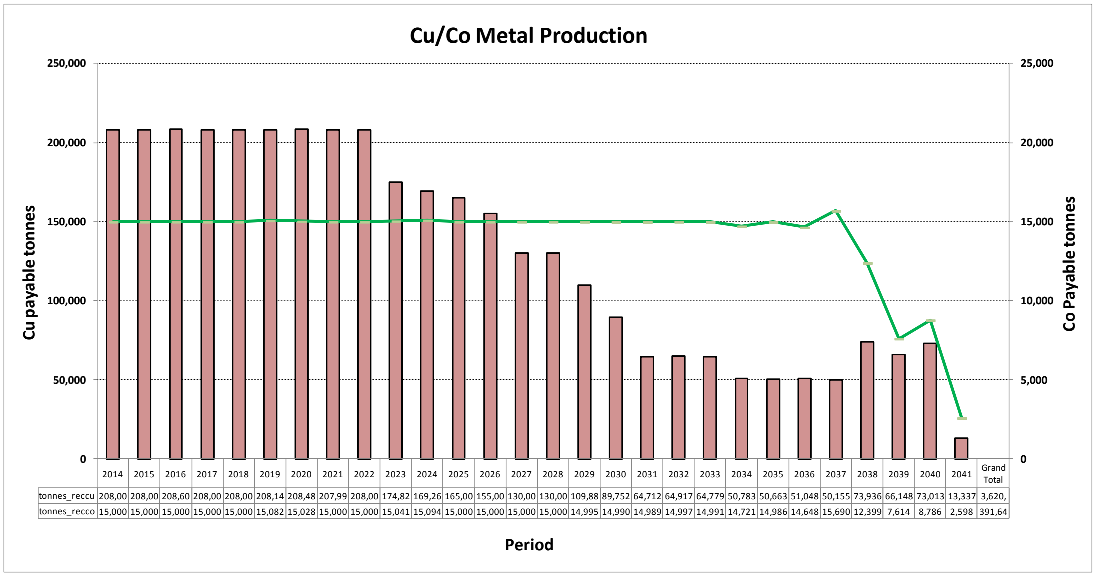
**Table 16-1 Production Schedule**

| Year | Total Mined | Waste Mined | Ore Mined | Ore Mill (ktonnes) | Payable Cu (tonnes) | Payable Co | Rec Cu (%) | Rec Co (%) |
|---|---|---|---|---|---|---|---|---|
| 2014 | 52,600 | 44,898 | 7,702 | 5,292 | 208,000 | 15,000 | 3.93 | 0.28 |
| 2015 | 52,700 | 44,429 | 8,271 | 5,293 | 208,000 | 15,000 | 3.93 | 0.28 |
| 2016 | 52,700 | 44,302 | 8,398 | 5,307 | 208,600 | 15,000 | 3.93 | 0.28 |
| 2017 | 52,700 | 45,276 | 7,424 | 5,293 | 208,000 | 15,000 | 3.93 | 0.28 |
| 2018 | 52,700 | 43,922 | 8,778 | 5,293 | 208,000 | 15,000 | 3.93 | 0.28 |
| 2019 | 51,995 | 45,498 | 6,498 | 5,293 | 208,141 | 15,082 | 3.93 | 0.28 |
| 2020 | 52,254 | 45,870 | 6,384 | 5,307 | 208,481 | 15,028 | 3.93 | 0.28 |
| 2021 | 52,993 | 45,718 | 7,276 | 5,293 | 207,999 | 15,000 | 3.93 | 0.28 |
| 2022 | 53,000 | 44,340 | 8,660 | 5,293 | 208,000 | 15,000 | 3.93 | 0.28 |
| 2023 | 51,902 | 45,130 | 6,771 | 5,293 | 174,824 | 15,041 | 3.30 | 0.28 |
| 2024 | 52,755 | 45,706 | 7,049 | 5,307 | 169,260 | 15,094 | 3.19 | 0.28 |
| 2025 | 53,000 | 46,214 | 6,786 | 5,292 | 165,000 | 15,000 | 3.12 | 0.28 |
| 2026 | 53,000 | 45,845 | 7,155 | 5,292 | 155,000 | 15,000 | 2.93 | 0.28 |
| 2027 | 41,604 | 36,986 | 4,618 | 5,292 | 130,000 | 15,000 | 2.46 | 0.28 |
| 2028 | 40,000 | 35,308 | 4,692 | 5,307 | 130,000 | 15,000 | 2.45 | 0.28 |
| 2029 | 28,558 | 24,602 | 3,955 | 5,292 | 109,881 | 14,995 | 2.08 | 0.28 |
| 2030 | 16,999 | 13,977 | 3,022 | 5,293 | 89,752 | 14,990 | 1.70 | 0.28 |
| 2031 | - | - | - | 5,292 | 64,712 | 14,989 | 1.22 | 0.28 |
| 2032 | - | - | - | 5,307 | 64,917 | 14,997 | 1.22 | 0.28 |
| 2033 | - | - | - | 5,292 | 64,779 | 14,991 | 1.22 | 0.28 |
| 2034 | - | - | - | 5,293 | 50,783 | 14,980 | 0.96 | 0.28 |
| 2035 | - | - | - | 5,293 | 50,663 | 15,188 | 0.96 | 0.29 |
| 2036 | - | - | - | 5,307 | 51,048 | 14,853 | 0.96 | 0.28 |
| 2037 | - | - | - | 5,292 | 50,155 | 15,778 | 0.95 | 0.30 |
| 2038 | - | - | - | 5,293 | 73,936 | 12,399 | 1.40 | 0.23 |
| 2039 | - | - | - | 5,293 | 66,148 | 7,614 | 1.25 | 0.14 |
| 2040 | - | - | - | 5,307 | 73,013 | 8,786 | 1.38 | 0.17 |
| 2041 | - | - | - | 1,136 | 13,337 | 2,626 | 1.17 | 0.23 |
| **Total** | **811,460** | **698,021** | **113,439** | **144,135** | **3,620,430** | **392,429** | **2.51** | **0.27** |

From 2014 to 2022, the recoverable copper target is 208,000 tpa with high grade copper ore selectively fed to the plant to fully utilise it's capacity, while low grade ore is stockpiled for future treatment. The cobalt production during the same period is targeted to average 15,000 tpa and will continue at this level until 2037 as low grade copper but higher grade cobalt ore is recovered from the WIP stockpiles..

While processing low copper grade ore stockpiles, production will average approximately 61,000 tpa of copper and 13,400 tpa of cobalt for the full years operated. The annual scheduled metal production of total copper and cobalt is shown in the figure below.

**Figure 16-5 Metal Production Forecast**



| | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| tonnes_reccu | 208,00 | 208,00 | 208,60 | 208,00 | 208,00 | 208,14 | 208,48 | 207,99 | 208,00 | 174,82 | 169,26 | 165,00 | 155,00 | 130,00 |
| tonnes_recco | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,082 | 15,028 | 15,000 | 15,000 | 15,041 | 15,094 | 15,000 | 15,000 | 15,000 |

| | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| tonnes_reccu | 130,00 | 109,88 | 89,752 | 64,712 | 64,917 | 64,779 | 50,783 | 50,663 | 51,048 | 50,155 | 73,936 | 66,148 | 73,013 | 13,337 | 3,620, |
| tonnes_recco | 15,000 | 14,995 | 14,990 | 14,989 | 14,997 | 14,991 | 14,721 | 14,986 | 14,648 | 15,690 | 12,399 | 7,614 | 8,786 | 2,598 | 391,64 |

## 16.4 MINE OPERATION AND EQUIPMENT

### 16.4.1 MINING METHOD

Mining is currently concentrated in the Kwatebala, Tenke and Fwaulu Pits with development in Mwadinkomba and Fungurume pits. Mining at Tenke Fungurume has historically been carried out on benches of 5 m or 10 m height advancing top down in the various development phases. Recently, the bench height has been increased to 7.5 m and 15 m height. Bench operating surface widths are generally quite generous with the narrowest areas having a width of 30 m. Ore is generally broken using a continuous surface miner and excavated using a wheel loader. Waste and some low grade ore is drilled and blasted and excavated using either hydraulic excavators, front shovels or wheel loaders. Ore and waste is hauled in 85 t and 45 t capacity off-road end dump trucks. Long haul trucks will be introduced to haul ore from some of the more distant deposits. The smaller trucks are generally being phased out in favour of larger units. The mine operates on a three eight-hour shift, seven days per week schedule.

**Figure 16-6 Kwatebala Pit Perspective (November 2013 Site Visit)**

The mine operations sequence begins by identifying ore and waste. A rock saw is used to make a 10 cm wide cut across the strike of the ore zones. Samples are sent to the laboratory where acid soluble grades and gangue acid consumption are determined. The assays are used to develop an ore control model from which the ore zones can be designated. Surveyors stake the outlines of the ore zones in the field after the surface miner has fragmented the rock.

Ore zones are mined first using the surface miner. High-grade ore is delivered to stockpiles near the mill feed chute. A two month stockpile of this high-grade ore is maintained and loaders provide an optimized blend to the mill. The two month stockpile also allows the mine to develop in an orderly fashion without "chasing" ore in the phase to meet short-term demands.

Waste mining generally follows ore removal. Blastholes have been drilled 6 m deep on a 5 m by 5 m pattern or 11 m deep on a 6 m by 6 m pattern. A third party contractor primes and loads the holes for blasting. Originally Cat 988 front-end loaders loading into 45 tonne capacity Cat 772 haul trucks were employed to load and haul the waste. Larger Cat 992 front-end loaders and 100 tonne capacity Cat 777 haul tracks have been introduced to supplement the original fleet and increase waste stripping rates.

### 16.4.2 MINE EQUIPMENT

FCX maintains a global alliance with Caterpillar that provides preferred pricing on capital, parts, and services in exchange for committing to purchase only Caterpillar equipment where Caterpillar shares the market with other manufacturers of like equipment. With the exception of the surface miners and drills all equipment is Caterpillar. However, even the surface miner undercarriage and engine are of Caterpillar origin.

The major mining equipment is divided into two fleets, one for ore and one for waste, with appropriate support equipment for both.

Ore is mined by Vermeer surface miners cutting 0.625m flitches. There are currently 5 Vermeers operating with combined capacity of 12,000 tpd. Some ore is also drilled and blasted to make up the required mill feed. Fragmentation can be an issue with ore at the breaker station. Waste rock is conventionally drilled and blasted using a fleet of Atlas Copco, Furukawa and Pantera drill rigs. The current trend in drilling is a movement away from small drills and 131 mm holes to DM-45's hammer drills and 165/175 mm diameter holes. There are currently four DM-45's in the fleet with an additional unit to be added in 2014.

The current loading and hauling fleet consists of Caterpillar 988 6.4 $m^3$ capacity front-end loaders, 18 - Caterpillar 772 45 tonne capacity haul trucks, Caterpillar 992 12.5 $m^3$ capacity front end loaders and 32 - Caterpillar 777 85 tonne haul trucks. As part of the 14,000 tpd expansion, a larger waste mining fleet consisting of Bucyrus RH120E 16.5 $m^3$ face shovels, Bucyrus RH90C 11$m^3$ excavator and Cat 777 85 tonne haul trucks was introduced. This fleet delivers improved waste mining productivity. Recent additions include Caterpillar 6030 front shovels. Overland haul trucks, with 50 tonne capacity, are used to deliver ore from the outlying deposits to the mill stockpile. The haul truck fleet requirements were determined by calculating cycle times required to deliver materials to their respective destinations. Equipment replacement schedules were used to develop life of mine capital requirements.

**Table 16-2** lists the major mine equipment required to achieve the long range mine plan, the average operating hours per year and replacement hours for each fleet.

Production support equipment consists of track and rubber tire dozers, motor graders, water trucks, fuel/lube trucks and a small fleet to support the Mofya quarry operation. The support fleet includes Cat D8R track dozers, Cat D10N track dozers, Cat 824G rubber tire dozers, Cat 14M motor graders, Cat 16M motor graders, Cat 740 fuel/lube trucks, miscellaneous hydraulic excavators, Cat 772 and Cat 777 water trucks equipped with Mega 11,000 gallon and 20,000 gallon tanks respectively.

**Table 16-2 : Major Equipment Fleet and Operational Parameters**

| Equipment | Maximum Fleet size | Average Operating hours/year | Scheduled Replacement (Hours) |
|---|---|---|---|
| CAT 772 Haul Truck, 45 t | 29 | 5,600 | 60,000 |
| CAT 777 Haul Truck, 90 t | 33 | 5,600 | 60,000 |
| Mercedes Haul Truck, 50 t | 22 | 5,600 | 60,000 |
| Grizzly Feeder | 5 | 5,600 | N/A |
| CAT 988 Front End Loader | 17 | 5,600 | 35,000 |
| CAT 992 Front End Loader | 2 | 5,270 | 35,000 |
| RH120E Front Shovel | 8 | 6,670 | 35,000 |
| RH90C Front Shovel | 1 | 6,670 | 35,000 |
| T1255 Surface Miner | 5 | 4,030 | 20,000 |
| ROC L8 Drill | 4 | 5,600 | 30,000 |
| DM45 Drill | 5 | 5,600 | 33,075 |
| CAT D8R Track Dozer | 8 | 4,710 | 30,000 |
| CAT D10N Track Dozer | 6 | 4,720 | 35,000 |
| CAT 824G-RTD Rubber Tired Dozer | 5 | 4,720 | 35,000 |
| Rock Saw Drill/Excavator | 4 | 2,550 | 20,000 |
| CAT 14M Grader | 3 | 4,710 | 45,000 |
| CAT 16M Grader | 5 | 4,710 | 45,000 |
| CAT 345 Hydraulic Excavator | 2 | 4,730 | 35,000 |
| CAT 772 Water Truck | 2 | 4,740 | 60,000 |
| CAT 777 Water Truck | 2 | 4,740 | 60,000 |

### 16.4.3 DESIGN CRITERIA

Block model specific gravity estimates were based on core testing and vary as a function of lithology and relative elevation. The average in-situ bulk density of the ore and waste is 2.26 t/m$^3$. The loose density was based on an estimated swell factor of 30 percent for all material types.

Moisture content of mined rock was assumed to be 7 percent by weight.

All equipment operating costs and capital costs were based on in-house data and vendor quotes. Equipment is maintained by a dealer or dealer representative through a maintenance and repair contract (MARC).

Physical Availability is calculated as [Available (Operating) Time / Scheduled (Planned) Production Time]. A physical availability of 80% was utilized for all Caterpillar equipment, 80% for RH120E and RH90C shovels, 70% for surface miners and 80% for blast hole drills.

Heavy rainfall from December to March can cause cessation of operations for several hours each day. Total operating days per year were reduced to 343 days.

Utilization of Availability is defined as [operating time / (operating time + operational delays)]. Excluding surface miners, an 85% utilization of availability was applied to all equipment during normal mine production. Surface miner utilization was set at 70%.

Asset efficiency is calculated as [Controllable Availability * Utilization of Availability]. The maximum asset efficiency is 68%.

The maximum annual available equipment operating hours will be 5,598 hours per year calculated using this formula: (343 days/year * 3 shifts/day * 8 hours/shift * Asset Efficiency).

Historically, the ROC L8 has had an average blast hole drill penetration rate of 40 m per operating hour, on 5 m bench height blast pattern size of 5 m x 5 m, total drill depth of 5.5 m including sub-drilling and stemming of 3.0 m. The DM45 was estimated to have an average blast hole drill penetration rate of 40 m per operating hour, blast pattern size of 6.1 m x 6.1 m, total drilled depth of 12.2 meters on a 10 m bench including sub-drilling and stemming of 6.22 m. Bench heights have now been increased with corresponding changes in pattern sizes.

Explosives usage was planned for 100% of the waste material. Emulsion will be the primary blasting agent. Programmable detonators and 400 g boosters will be the initiating accessories for all blasting. It was assumed that blasting occurs in 60% of the ore zones, mostly within the low grade.

The Cat 988 and Cat 992 loader bucket fill factors were estimated to be 85%, while the RH120E and RH90C bucket fill factor was estimated to be 95%.

Loaded and empty haul truck cycle times were estimated using the Caterpillar equipment performance handbook.

The surface miner productivity is currently 500 tph. The controllable availability is 70% and utilization is 70% for a combined overall asset efficiency of 70% x 70% = 49%.

Parameters used to determine major equipment requirements are listed in Table 1-15.

**Table 16-3: Major Equipment Operating Parameters**

| | Mechanical Availabiity | Utilization | Scheduled Days per Year | Hrs per yr |
|---|---|---|---|---|
| **Trucks** | 0.80 | 0.85 | 343 | 5,600 |
| **Loaders** | 0.80 | 0.80 | 343 | 5,270 |
| **Shovels** | 0.90 | 0.90 | 343 | 6,670 |
| **Surface miners** | 0.70 | 0.70 | 343 | 4,030 |
| **Drills** | 0.80 | 0.85 | 343 | 5,600 |

### 16.4.4 MINE SERVICES AND INFRASTRUCTURE

The mine maintenance facilities consist of a shop complete with overhead crane and equipment repair bays. The shop bays were sized to accommodate Cat 777 haul trucks. There is a wash area, an area for fuel and oil tanks and facilities for contractors. There is a large staging and lay-down yard adjacent to the main shop.

The general maintenance shop is located within the truck shop. The electrical system is wired for 480 volt welding machines, but most welding is performed in the field. The mechanics, welders, and mine electricians share the shop. The maintenance shop was expanded with additional bays to accommodate the larger mining fleet.

A change house is located next to the truck shop. This change house accommodates all of the mine operations and maintenance personnel.

A mine office building is located next to the change house and accommodates all mine management, mine geology, mine engineering, surveyors and ore control personnel.

As mining progresses to the satellite deposits the mine haul road network will be extended. Stormwater dams will be constructed downstream of pits and waste dumps. Diversion ditches will be excavated for both impacted and non-impacted water flows. Stream crossings will be constructed as required. Railroad crossings will be erected for access to the Tenke deposits and near the village of Kwatebala Gar for access to the deposits on the south side of the Dipeta River. Each deposit's individual mine development infrastructure cost has been estimated and the timing of the investment is keyed to the production schedule.

One fuel tank farm will be installed at Mambilima, Fungurume and Pumpi to optimize the fuel/lube delivery system for the mine. The fuel/lube trucks will be loaded with fuel and lube from the tank farm. This process will reduce the travel time taken by fuel/lube trucks and mine equipment.

A satellite maintenance shop will be erected at each distant deposit to cover simple routine maintenance and emergency repairs.

The mining fleet is all diesel powered and therefore requires no high voltage power lines to the mine. Dewatering pumps will be located in-pit and will be powered by diesel generators.

### 16.4.5 ORGANIZATION AND WORKFORCE

The mine organization for the life of mine plan was based on the existing TFM personnel structure. The mine manpower requirements were based on the mine production schedule. Total equipment hours were used to determine the staffing levels for operation of all mining equipment. The mine department's major functional areas include geology, ore control, short and long range mine planning, operations and administration. Mine personnel total 1,172 including 14 expatriates as of December 2013. Operations personnel work a three shift, 24 hours, seven days per week schedule. Mine maintenance is currently administered by TFM's centralized maintenance department. Contractors perform equipment maintenance and provide down-the-hole blasting services. Salaried personnel include the mine manager, mine superintendent, operations supervisors, geologists and mining engineers. Hourly personnel include equipment operators, ore control tallymen, surveyors and general labourers.

### 16.4.6 RESOURCE RECONCILIATION

Reconciliation of the short range model (SRM) and material sent to the process plant has consistently shown a trend of more tonnes at a lower Cu grade and higher Co grade than the long range model (LRM) predicted. This reconciliation trend varies by deposit with Kwatebala being the most consistent and Tenke being the least. The quarterly forecast is made using a dilution factor of 12% applied to the LRM to compensate for the reconciliation trends.

These reconciliation trends are thought to be due to a number of factors including the following:

- Geologic controls of mineralization are not being adequately accounted for in the SRM and ore control when compared to the LRM.
- Ore routing decisions in the field are sometimes made without all the assay data due to delays in the lab turnaround time. To compensate the mine geologists use the assays from the previously mined level above.
- The LRM model grades are undiluted and may have to be modified to account for the dilution (mining methods, ore control polygons and other sources) once the SRM model is up to standard.

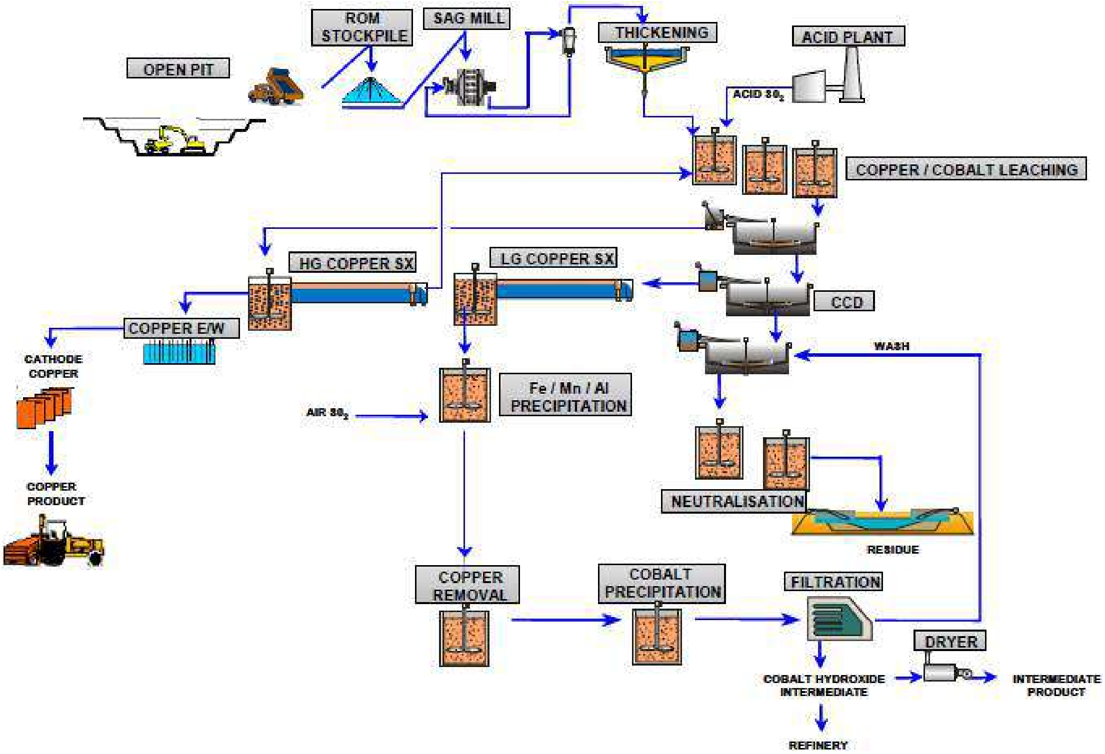
Further improvements to the SRM are planned during 2014. Work will focus on sample quality, geologic mapping of features that control and displace mineralization, and the integration of these attributes into the grade estimation procedure. An initial aspect of this project was conducted at Shimbidi (Tenke area) in the first quarter of 2014 where reverse circulation (RC) drill samples were taken to evaluate sample quality relative to those obtained from trenches. The results of the test program are being analyzed. Prior sample quality evaluations were performed in 2013 to compare the results of core to RC drilling. This test was designed to address a potential issue of poor core recovery in the RSC unit causing a grade bias. Twenty-two core holes were twinned with RC holes at Kwatebala and Tenke. Statistical results showed no significant variability.

# 17 RECOVERY METHODS

The Phase 2 Expansion of the processing plant was substantially completed in 2013 and increased the nameplate throughput of the plant to 14,000 dry metric tonnes per day of ore to produce 195,000 mtpa copper cathode. In the full year 2013, throughput averaged over the nameplate capacity at approximately 14,900 tpd and 210,000 tpa copper cathode was produced.

The general flow sheet is shown in the figure below.

**Figure 17-1 Copper Circuit and Cobalt Purification**



## 17.1 GRINDING

Run-of-mine (ROM) ore is delivered by haul truck to the ROM pad. Front-end loaders feed a blend of ore to a mobile crusher which feeds a ROM bin from where it is conveyed to a single stage SAG mill. The SAG mill operates in closed circuit with a cluster of hydrocyclones.

Key Phase 2 Expansion additions in the grinding area included a mobile crusher ahead of the SAG mill feeder, which increased the speed and braking capacity of the SAG feed conveyor, and the introduction of a pebble crusher to the SAG mill circuit to achieve the desired grind size.

The addition of a ball mill is planned for the grinding circuit for 2017. This is in anticipation of harder ores with depth and as part of "front-end" optimization.

## 17.2 LEACHING AND COUNTER CURRENT DECANTATION

The ground slurry is thickened, pumped to the first of five leach tanks and mixed with sulphur dioxide ($SO_2$), sulphuric acid ($H_2SO_4$) and raffinate to achieve a leach feed pulp. Copper and cobalt leach extractions are achieved in the leach operation. The leached slurry is thickened and the overflow is clarified and pumped to the high-grade (HG) pregnant leach solution (PLS) pond. After cooling the HG PLS is re-clarified to remove residual colloidal silica and suspended solids, and then pumped to the HG solvent extractions circuit.

Thickener underflow is pumped to the counter-current decantation (CCD) circuit to recover dissolved copper and cobalt values from the leached solids. CCD 1 overflow is clarified and pumped to the low-grade (LG) pregnant leach solution (PLS) pond. The washed solids from CCD 5 are pumped to the neutralization circuit.

The completed Phase 2 Expansion included new desanding pumps and upgrades to the leach feed thickener, the leach discharge thickener and the CCD underflow pumps. New conventional raked clarifiers on the HG and LG PLS streams were also installed.

## 17.3 NEUTRALIZATION

CCD 5 underflow, excess CCD wash solution, and iron residue slurry are neutralized using slaked lime. Slaked lime is added to precipitate magnesium and trace heavy metals. The final neutralized slurry is pumped to the lined tailings storage facility.

The Phase 2 Expansion included the addition of a third neutralization tails pump and related modifications to the neutralization tanks.

## 17.4 SOLUTION EXTRACTION AND ELECTROWINNING

The solvent extraction facility consists of a single circuit comprising six extraction and four stripping stages. The HG circuit has four extraction stages, the LG circuit has two extraction stages and the common organic stream is stripped in four stages.

The Phase 2 Expansion included four new mixer-settlers, three new tri-canters, a new clay filter and a new crud filter. The four mixer settlers have been installed in a new building at the same elevation and to the immediate south of the existing mixer settler building.

Copper is extracted from the PLS solution using an organic extractant. The copper is subsequently stripped from the organic phase to produce strong electrolyte. The strong electrolyte is then filtered to remove any entrained organic solvent, prior to electrowinning. The LME Grade A cathodes are removed, washed, stripped, weighed and dispatched using semi-automatic and fully automatic stripping machines. The stainless steel cathode blanks are returned to the cells for re-use.

The Phase 2 Expansion completed a 100% extension to the existing EW tankhouse including an additional 280 cells, with two rectiformers, two high speed stripping machines, four electrolyte filters, a cooling tower with associated heat exchangers and three cranes. The new tankhouse is an eastern extension of the existing tankhouse and cranes are able to travel across both buildings. The fully expanded tankhouse has a nameplate capacity of 270,000 tpa copper cathode. Full year production in 2013 was 210,000 t copper cathode.

The potential for higher production is dependent on ore grades, front-end debottlenecking of the plant, as well as possible copper recovery from low grade ores by heap leaching. Investigations to optimize production are ongoing.

Figure 17-2  Extended Tankhouse (November 2013 Site Visit)

Figure 17-3  Extended Tankhouse - Part of Phase 2 Expansion (November 2013 Site Visit)

**Figure 17-4 New Automated Stripping Machine (November 2013 Site Visit)**

The HG raffinate and electrolyte bleed are combined in the HG raffinate pond and are returned to the leach circuit to reduce fresh $H_2SO_4$ consumption and to achieve the desired pulp density.

## 17.5 FE/AL/MN (FAM) REMOVAL

LG raffinate from the solvent extraction is neutralized using limestone. Sulphur dioxide and air are sparged into agitated tanks to precipitate iron, aluminum and manganese under oxidizing conditions. Limestone is added to each of the tanks for pH control. The resultant slurry is thickened and filtered to recover the cobalt solution. The filter cake, containing predominantly gypsum, iron and aluminum hydroxides, is repulped and pumped to the neutralization circuit.

As part of the Phase 2 Expansion, the FAM agitators, FAM thickener feed, and underflow pumps were upgraded.

## 17.6 COPPER PRECIPITATION

Milk of lime is added to the solution from the FAM removal circuit to precipitate the remaining soluble copper. Sulphur dioxide and air are sparged into the agitated tanks to promote the precipitation of any remaining manganese. The slurry is thickened and the solids are returned to the leaching circuit for recovery of the precipitated copper.

As part of the Phase 2 Expansion, the copper precipitation tank agitators, thickener feed, and underflow pumps were upgraded.

## 17.7 COBALT PRECIPITATION

Milk of magnesia is added to the solution from the copper precipitation circuit to produce cobalt hydroxide. Two stages of precipitation are used to improve the purity of the hydroxide precipitate and consequently reduce the consumption of magnesia. Magnesia is added in the first stage of precipitation whereas milk of lime is added in the second stage of precipitation. The thickened cobalt hydroxide from first stage precipitation is filtered and bagged as a wet product for export or flash dried and bagged as a dry product for export. Thickened solids from the second stage of precipitation are recycled to the FAM circuit. The cobalt-free solution is predominantly used as CCD wash solution, with the excess reporting to the neutralization circuit.

The Phase 2 Expansion included upgrades to the cobalt thickener feed and underflow pumps, but did not increase the tank capacity.

# 18 PROJECT INFRASTRUCTURE

## 18.1 ROADS

The existing road system constructed and upgraded during the original TFM Mine has proven to be adequate to support the expanded facility.

## 18.2 AIRSTRIP

TFM constructed a 1,650 m long paved airstrip, suitable for medium sized aircraft, to the northeast of Fungurume. A TFM charter operates a regular 30 minute flight between Lubumbashi airport and the site.

## 18.3 POWER

The power supply to the plant site is provided via a high voltage overhead line from the Fungurume substation to the switchyard at the plant site. The power distribution around the plant is at 33 kV, 11 kV, 220 V, 380 V and 690 V as necessary for the operation of equipment. Power is also supplied to the permanent village from the Fungurume substation via a separate overhead line.

The Fungurume substation has been upgraded to provide a reliable power supply to TFM. TFM electrical load has been interconnected to the Fungurume substation in the Katanga grid, which is supplied by hydroelectric power. La Société Nationale d'Electricité (SNEL) is the state owned electric utility company serving the region and also exporting power to Zambia and South Africa. The Katanga grid receives 125 MW power from the Inga grid (1,800 MW installed generation capacity) through a DC link (500 MW inverter capacity). To satisfy the local load and the export to Zambia, the Katanga grid utilizes the following installed hydro-generation capacity (465 MW):

Nseke: (4 X 65 MW – 3 units currently operating, Unit #2 currently dismantled and undergoing rebuild); 120/220 kV step-up; installed in 1956

Nzilo: (4 X 25 MW – 2 operating); 120 kV; installed in 1952

Mwadingusha: (3 X 10 MW & 3 X 12 MW – 3 operating); installed in 1928 and one additional unit added in 1953

Koni: (3 X 12 MW – 2 operating); installed in 1953

Smaller hydroelectric generation is connected to the 120 kV subsystem

The Katanga grid has two subsystems: 220 kV (Kolwezi SCK) and 120 kV (Kolwezi R.O.). Kolwezi R.O. connects to the Nzilo generation (120 kV). Kolwezi SCK connects to the Inga DC link and Nseke 220 KV stepped up voltage. Kolwezi R.O and Kolwezi SCK are connected by 220/120 kV transformers. Fungurume substation is approximately 100 km from Kolwezi TFM is connected to Fungurume with a 17 km transmission line. The local Tenke load is served by both the 120 kV line from Kolwezi R.O. and the 120 kV system stepped down from the three 220 kV transmission lines from Kolwezi SCK. The 120 kV local system is interrupted when the power is needed to support the export requirements.

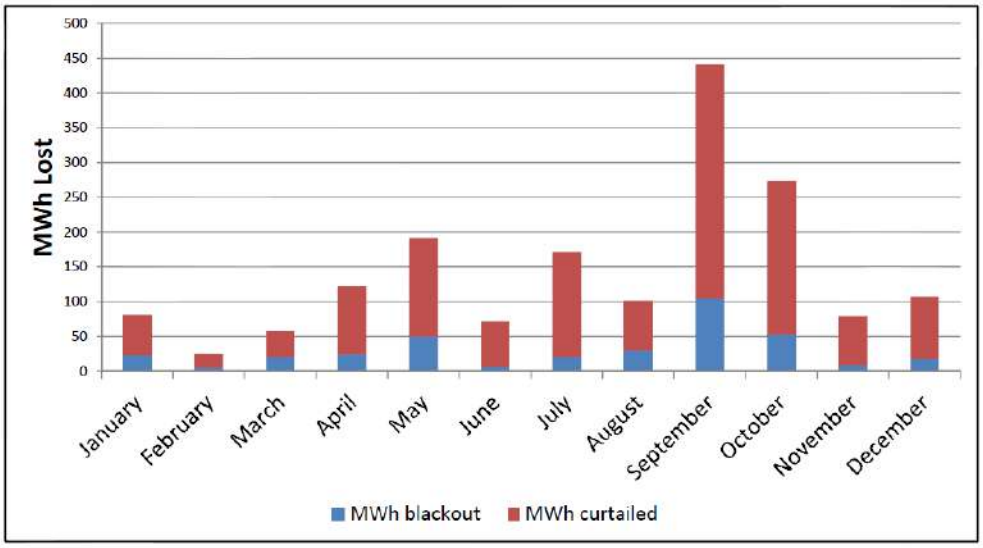
TFM has signed a long term contract with Société National d'Électricité Limitée (SNEL) for supply of electricity from SNEL`s Nseke Power Station located west of the Tenke concessions towards Kolwezi. A separate contract includes provisions for TFM to loan SNEL the funds required to recondition the hydro electric station and increase generating capacity from three to four 65 megawatt units, as well construct new local transmission lines to service the mine and neighboring communities. The costs for this work will be repaid to TFM through a credit against future electricity charges. The initial phase of reconditioning the power station and construction of power lines was completed during the second quarter of 2009. The first generating unit refurbishment was completed in January 2011 and a second has since been completed. Currently, three units are up and running. Unit #2 is currently completely dismantled. The program to complete the refurbishment of all the units is targeted for completion in 2015.

The N'Seke project loan through December 31, 2013 was $152 million plus interest and repayments and SNEL oversight. The current projection is for a $250 million loan with oversight provided by TFM and completion by the end of 2015.

TFM has secured five agreements with SNEL: a long-term purchased power agreement (PPA) to set the price TFM will pay for power, two finance agreements to finance improvements to the power system infrastructure, a maintenance agreement to ensure system reliability and an administration agreement to implement the finance and maintenance agreements.

With the Phase 2 Expansion completed the current power demand for Tenke Fungurume is approximately 90-92 MW. The existing contract with SNEL is for a supply of up to 100 MW with an additional 100 MW available within a 2 year notice period. TFM has notified SNEL of its desire to increase its contractual right for an additional 100 MW of power for a total demand of 200 MW. TFM is currently in power supply discussions with SNEL as power supply reliability continues to cause operating difficulties at the plant. The distribution of lost power impacts during 2013 are shown in Figure 18-1.

**Figure 18-1 Power Impacts - Lost MWh 2013**



Power disruptions and curtailments are a regional issue faced by most mining operations in Katanga and the DRC. Foreign investments in new and refurbishment of power generation and associated infrastructure in Katanga and DRC have increased in recent years and this trend is expected to continue. Katanga also draws power from the Southern African with power being routed via Zambia.

## 18.4 WATER SUPPLY

The raw water supply is from wells within a reasonable distance of the mine site and plant. Appropriately spaced wells in three sub-catchments surrounding Kwatebala will sustain the mining and plant processes, with standby capacity. The three well-field areas in order of preference or convenience are near the plant site, south of Kwatebala and northwest of the TSF.

Raw water is pumped from the well fields to the fire and raw water dams. Fire water is reticulated throughout the plant site. Raw water is used throughout the processing plant for reagent make-up and cooling water.

Process water and gland seal water is from the TSF tailing decant water, leach feed thickener overflow and run-off storm water collected from the waste rock stockpiles and plant site with make-up water supplied from the wells installed at Kwatebala.

Filtered raw water is used to produce potable and demineralized water. Potable water is used for drinking water and safety shower requirements in the processing plant. Demineralized water is used in the cobalt refinery and for steam generation in the acid plant and electric boilers.

Potable water is also supplied to and reticulated throughout, the permanent village located north of Fungurume. The water for this application is from independent wells located at Fungurume.

## 18.5 DAMS

A single polyethylene lined firewater dam overflows into a neighboring polyethylene lined raw water dam.

## 18.6 WASTE DUMPS AND STOCKPILES

Waste dump and stockpile locations for the fourteen deposits are located based on multiple factors including:

- Minimization of haulage distance
- Maximizing distance from farmlands
- Flowing water (streams and rivers) to decrease the amount of contact water that will have to be sent to the storm water ponds
- Storm water pond locations
- Ability to share waste dumps and stockpiles.

## 18.7 TAILINGS STORAGE

The tailings storage facility (TSF) consists of a cross-valley storage site, contained by mine rock and native earth embankments, and is located to the north west of the plant site. The entire impoundment area is lined with an HDPE liner. The TSF is being constructed in stages with a first phase completed ahead of the production start and a second stage completed in mid-2010. The TSF is supplemented by a Return Water Dam (RWD). A small initial RWD was constructed which was then absorbed by the expanded TSF and a second permanent RWD became operational.

The TSF design has embraced the corporate policy of aiming for a “zero discharge” solution. The basins of the TSF and RWD have been lined with composite liners, comprising thick high density polyethylene (HDPE) geomembranes, overlying a layer of conditioned and compacted in-situ clayey silt. A thicker geomembrane is used on the upstream faces of embankments and the steeper sections of the basins, where the stresses on the liner are likely to be higher. An under-liner drainage system has been incorporated into the design, reducing the potential for uplift pressures on the liner. The under-liner drainage will also serve as a long term monitoring facility to check for liner leakage.

Further expansions of the existing TSF are planned by raising and extending the dam walls and advancing the placement basin to the north of the current footprint. The current location and configuration will provide containments sufficient for the full known reserves. Conceptual location studies over the concession area have also been carried out to identify future tailings sites to meet potentially expanded production scenarios.

## 18.8 SULPHURIC ACID PLANT, $SO_2$ PLANT, AND STEAM GENERATION

Sulphuric acid for use in the leach circuit is produced by burning imported sulphur. Waste heat from the acid plant is utilized for raising steam. Electric boilers are available on standby to meet the heating requirements of the acid plant during start-up or during a prolonged shutdown.

The existing acid plant (AP1) with a new boiler and inter-economizer has achieved a nameplate capacity of 825 tpd. A second new acid plant (AP2) is under construction and will have a capacity of 1,400 tpd. The second plant is scheduled to be commissioned in 2016.

## 18.9 UTILITIES

Compressed air and instrument quality air are reticulated throughout the plant site. Low-pressure blowers provide the air requirements for the Fe/Al/Mn removal and Cu precipitation circuits.

# 19 MARKETING STUDIES AND CONTRACTS

## 19.1 MARKET AND CONTRACTS

**Copper**

The copper cathode produced by Tenke Fungurume is sold as part of the overall FCX copper marketing program with sales based on arm’s length terms. The quality of TFM copper cathode product has shown steady improvement which has helped grow TFM's reputation in the markets. TFM remains focused on higher quality requirements, in particular for copper rod manufacturing customers.

**Cobalt**

Cobalt hydroxide is sold either under multiyear frame contracts or on the spot market. In March 2013, the TFM partners acquired the Kokkola cobalt refinery in Finland and related business in order to enhance TFM's cobalt marketing position, product portfolio and product development capabilities.

The acquisition provides direct end-market access for the cobalt hydroxide production at Tenke. Since the acquisition, the business based in Finland has been renamed Freeport Cobalt Oy.

# 20 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT

## 20.1 ENVIRONMENTAL

### 20.1.1 LEGAL AND POLICY FRAMEWORK

The original Kwatebala ESIA issued in 2007, the Phase 2 Expansion Project Addendum issued in March, 2011, and the Oxide Expansion Project ESIA issued in March 2013 were prepared in accordance with best international practice, in general conformance with the policies and guidelines of the World Bank Group, as well as the environmental quality standards of the DRC. In addition, the projects outlined in the ESIAs were planned and conducted in accordance with the Equator Principles. These principles are derived from the International Finance Corporation's (IFC) Performance Standards established in 2006, and revised on an ongoing basis. As a member of the International Council on Mining and Metals (ICMM), FCX is also committed to implementing the ICMM Sustainable Development Framework. This framework includes a commitment to implement the ICMM 10 Sustainable Development Principles, report performance against these principles using the Global Reporting Initiative (GRI) G3 indicators, and undergoing an external assurance process.

The Expansion Project Addendum can be viewed through "Downloadable Reports" on FCX's web site http://www.fcx.com/operations/africatenke.htm.

### 20.1.2 BASELINE CONDITIONS, IMPACTS AND MITIGATION

Data for the baseline conditions at the Kwatebala mine and the plant site were collected between 2005 and 2008 which supplemented data collected by SRK in 1997 and 1998. A summary of the baseline conditions is included in the original ESIA, the Phase 2 Expansion Project Addendum and the Oxide Expansion Project ESIA.

Mitigation measures to protect and enhance the physical, biological (particularly endemic flora) and social resources of the project area, as well as potential impacts, are described in detail in the original ESIA and the Phase 2 Expansion Project Addendum.

Key environmental issues include:

- Identification of and mitigation of impacts to special flora indigenous to high copper and cobalt mineralized areas of the Katangan copper belt including the successful relocation of certain special plants from the Kwatebala area to a protected flora reserve area.
- Construction of the first fully membrane lined base metals tailings impoundment facility on the African continent to ensure the highest practical emission standards are maintained.
- Protection of natural watercourses with drainage plans and sediment control
- Special waste impoundment areas for long term environmental protection.

### 20.1.3 ACTION PLANS

Action plans were proposed in the Phase 2 Expansion Addendum to manage the predicted impacts on people and the environment. These action plans will prevent negative impacts as well as mitigate or compensate for unavoidable impacts. The action plans will pursue positive impact enhancement, particularly those actions in alignment with sustainable development goals. The action plans outline the environmental monitoring, reclamation and closure requirements for the Phase 2 Expansion.

### 20.1.4 ISO 14001-2004 CERTIFICATION

On January 21, 2013 ISO 14001-2004 Certification was received following a December 2012 audit. This is an environmental management standard that specifies a set of environmental management requirements for environmental systems. The purpose of this standard is to help organizations to protect the environment, to prevent pollution and to improve their environmental performance.

## 20.2 SOCIAL

### 20.2.1 LEGAL & POLICY FRAMEWORK

TFM continues to plan and conduct social development activities related to its ongoing project in accordance with the Equator Principles, as derived from the International Finance Corporation's (IFC) Performance Standards, applicable DRC law and the Amended and Restated Mining Convention (ARMC), and all FCX corporate policies.

### 20.2.2 KEY ISSUES IDENTIFICATION AND MITIGATION

TFM's ESIAs contain strategies, based on current experience, to enhance positive and reduce negative social impacts. These strategies include continuous improvement of health and safety, socio-economic effects on communities as well as other impacts related to the workforce, such as migration into the Tenke and Fungurume communities and training.

### 20.2.3 EMPLOYMENT AND SOCIAL DEVELOPMENT PROJECTIONS

As of December 2013, TFM employed approximately 3,400 full time personnel and 3,900 contractors.

According to an economic impact assessment commissioned by TFM, both directly and indirectly TFM accounts for 5 percent of all formal employment in the DRC's private sector. This was equivalent to nearly 18,000 jobs in 2013.

TFM implements a number of social development investments, including an annual contribution of 0.3% of net revenue to the TFM Social Community Fund. Social and community benefits from the project development include assistance with agriculture, education, community health, clean water, electricity and resettlement housing.

Specific projects which have benefitted the communities in the concession are as follows:

- Over 90 potable water village wells constructed in the concession and five in the greater region, and construction of an urban water distribution system for Tenke Fungurume.
- Constructed six schools and refurbished one, serving over 12,000 students in resettlement villages and the urban centers of Tenke and Fungurume.

- Relocation of 374 households from three villages near the Kwatebala plant site followed by relocation of 70 households due to expansion of the mine to the Tenke-Fwaulu ore deposits. Preparations for a third resettlement project related to the Oxides Expansion Project is underway.
- A Community Health Action Plan to reduce preventable diseases such as malaria, HIV/AIDS, and cholera. Other community health programs focus on mother and child health, sanitation and potable water; as well as the establishment of a 30-bed interim referral hospital in Fungurume and construction of a new clinic in Tenke, two rural health centers, and the provision of a mobile clinic.
- Comprehensive malaria control program implemented with indoor residual spraying and distribution of over 45,000 insecticide-treated bed nets, resulting in a 71% decline in community malaria rates from 2007 to 2012.
- Establishment of a community grievance management system, including an Independent Mediation Committee to independently and impartially resolve grievances through mediation and dispute resolution.
- Development of an urban growth management plan for Fungurume and Tenke to assure that future growth occurs in a sustainable manner and reduces potential future impacts from mine expansion.

Furthermore, TFM Social Community Fund projects include:

- Construction of seven new schools and rehabilitation of an existing school, including provision of furniture
- Rehabilitation of agricultural access and urban roads
- Drilling of clean water wells
- Construction of health facilities in uncovered health areas within the Fungurume Health Zone
- Donation of an ambulance and hearse to the Fungurume Health Zone
- Construction and equipment of community centres
- Innovative pilot projects for fish farming, maize production and riverside vegetable gardening

In addition to the benefits to the local communities, the project has invested in provincial infrastructure both to support an effective mining operation and to provide rebuilding support to the DRC. This includes a projected US$250 million investment, by the end of 2015, in renovating the regional hydro-electric power station at N'seke, including installation of two transformers and the replacement and upgrade of transmission lines and substations.

TFM has invested more than $3 billion in its copper and cobalt operations in Katanga Province of the DRC. It is the largest private investment in the country's history. From the start of construction which began in 2006 to the end of 2013, TFM has paid more than $890 million in taxes, royalties, duties, and other payments to the DRC.

### 20.2.4 ACTION PLANS TO MITIGATE NEGATIVE SOCIO-ECONOMIC IMPACTS

The potential negative impacts of construction for the expansion of operations are being mitigated through the Environmental and Social Management System (ESMS). The ESMS has been designed to appropriately prevent, mitigate, manage and monitor the environmental and social impacts of the project from construction through post-closure including responsive measures for an emergency.

The ESMS includes a Social Action Plan which includes:

- Community Development Plan (CDP) to provide a framework for effective local development
- Social Management Plan (SMP) to address the key socio-economic issues raised in the ESIA
- Cultural Heritage Plan (CHP) to minimize impacts to archaeological, historical and cultural resources
- Resettlement Action Plan (RAP) to ensure that any required resettlement is carried out to international standards.

Detailed reports dated 2009 and 2012, which include TFM's framework on land access, compensation, and resettlement policy can also be found on FCX's company website, under "Downloadable Reports". In addition, resettlement required for new mining areas as part of the Oxide Project is discussed in detail in the Oxide Project ESIA from August 2013.

## 20.3 MANAGEMENT OF WASTE

Management of wastes will include dedicated facilities for tailings, waste rock, and domestic, industrial and hazardous waste.

Objectives for waste management will be for:

- Waste reduction, recycling, reuse and composting, and onsite treatment, as applicable
- Safe waste storage to minimize the negative impacts to the environment (air, surface water, groundwater).

Solid wastes will be classified and sorted according to their characteristics as recyclable, clean landfill, compostable, or hazardous. All hazardous waste will be transported off site.

Extension of the Kwatebala tailings storage facility (TSF) to the northwest are in progress and constitute a significant part of TFM's annual sustaining capital investments. The extended TSF will be operated consistent with the approach used for the existing TSF. The extended TSF will be lined and will receive the milled, leached and neutralized mineral residue from the processing plant. The decanted water will be returned to the plant via the existing return water dam.

## 20.4 WATER MANAGEMENT

The tailings facility is lined with an impermeable liner and tailing water is recycled to the processing plant. Storm water runoff from waste rock stockpiles, low grade ore stockpiles and the plant site are collected and recycled to the processing plant. Surplus water is evaporated or used for dust control on roads within the plant site area to result in a net neutral water balance.

Water management is discussed in detail in the original ESIA and the Phase 2 Expansion Project ESIA Addendum. Successful operation and water management practices have been documented and applied in detail in the Oxide Project ESIA in August 2013.

## 20.5 MONITORING

Environmental monitoring requirements are outlined in the ESIA Action Plans. These monitoring activities document compliance with the ESIA commitments, as well as measure environmental impacts to verify compliance with appropriate regulatory or guidance thresholds.

Monitoring programs are included in each of the action plans including: socio-economic impact, soil, air quality, noise and vibration, surface water resources and sediments, groundwater resources, sewage, mine waste and ore stockpiles, domestic, industrial, hazardous and medical waste, material handling, flora and biodiversity.

An environmental monitoring network has been established to define baseline conditions and to monitor environmental impacts for the plant site and current mining activities. A comprehensive monitoring program has been implemented to track waste volumes and types; assess surface and groundwater conditions, up gradient and down gradient, of each major facility and assess the integrity of the leachate collection systems, diversion berms and monitoring systems. At the end of 2013, the monitoring system includes 162 monitoring sites (80 wells).

The existing network will also define impacts for plant expansions and additional monitoring stations will be established for mine expansion areas as detailed in the Oxide Project ESIA of August 2013.

## 20.6 PERMITS

### 20.6.1 MINE EXPANSION

In 2005 TFM received from the DRC Government, an Amended and Restated Mining Convention (ARMC). This sets forth the contractual framework for the operation of the project, the holding of mining rights, the tax, customs and para-fiscal regimes, the financial and exchange system, the personnel and social investments, and the environmental protection regime. In addition, TFM has received authorization from the Provincial Governor to occupy land inside the mining perimeter necessary for mining activities.

### 20.6.2 PROCESS PLANT EXPANSION COMPLETED

In order to address an increase in the plant's capacity TFM required an amendment to the existing ESIA, including the DRC version. The scoping phase of the public participation process was initiated on April 14, 2010, based on a 16,000 tpd scenario. Consultation meetings were held to solicit comments and suggestions from stakeholders and provide conceptual information on the proposed expansion.

Preparation of the Plant Expansion ESIA Addendum began with a draft report in August 2010. Following another round of open houses in November/December 2010, the final Addendum was completed and submitted to the DRC government (in French) in March 2011**.**

### 20.6.3 OXIDE PROJECT

As part of ongoing development of the Mineral Resources within TFM's mining concession, TFM intends to expand its mining operations to include some of the oxide deposits in the Fungurume Hills, North and South Dipeta and Pumpi regions of the concession as well as expanding the tailings storage facility (TSF) near the existing Kwatebala plant. This expansion is defined as the Oxide Project as detailed in the 2013 ESIA, which is being implemented to ensure that the environmental and social consequences of the project are fully understood and that potential impacts are adequately managed.

TFM committed to obtaining all necessary permits and authorization to proceed with the Oxide Project as well as to comply with applicable international treaties and agreements to which the DRC is signatory, including treaties that protect biodiversity, endangered species, various ecosystems and monitoring of greenhouse gas emissions.

It should be noted that the Oxide Project ESIA includes definition of future heap leach facilities in addition to the currently permitted Tenke heap leach facility. The design and location of these future facilities have not been determined and will need to be addressed through a future addendum to the Oxide Project ESIA.

### 20.6.4 TAILINGS STORAGE FACILITY EXPANSION

The original ESIA identifies 115 million tonnes as the tailings design capacity and includes expansions to the southwest towards the Fwaulu deposit. The LOM tailing storage requirements is estimated at 157 million tons. The Amended ESIA assessed expansions of the existing tailing storage facility (TSF) beyond those included in the original ESIA (i.e., northwest extension) and, if necessary, the construction of a new TSF. An alternative site selection study for tailing storage facilities prepared by MWH in December 2008 was included in the Amended ESIA.

For the Oxide Project, no significant differences in the nature of the tailings materials from the different pit areas are expected. Oxide Project tailings that will go into the Northwest Extension TSF will be a blend of processed ore from the Oxide Project pits, Kwatebala pit, and Tenke and Fwaulu pits.

The Oxide Project ESIA provides detailed descriptions of ongoing work and studies on the northwest TSF expansion as well as future sites in consideration.

### 20.6.5 STATUS OF PERMITS

Based on the Amended ESIA, the DRC Government – Mining Environment Protection Department issued a Letter of No Objection on June 27, 2011, which allowed the Phase 2 Expansion to proceed and be substantially completed in 2013.

Based on the Oxide Project ESIA, the DRC Government - Mining Environment Protection Department issued a Letter of No Objection in late 2013, which legally permits TFM to mine the Fungurume to Pumpi deposits.

TFM is currently working on an amendment to the Oxide Project ESIA, which will include relocation of the Fungurume waste dump, three additional monitoring wells, addition of a haul road in the Dipeta Valley, lined leach pad at Kwatebala, spent leach material storage, expansion of landfills and leachate pond, and an increase in the existing acid plant size. The footprint of the new acid plant targeted for completion in 2016 will also been included in the amendment.

It should also be noted that TFM received ISO Certification 14001-2004 on January 21, 2013, after the audit completed in December 2012 reported no major non-conformances.

## 20.7 CLOSURE

The reclamation and closure plan is described in detail the EISA documents. The main objectives of the reclamation and closure plan are to ensure the long-term physical and chemical stability of the project, where possible restore the project site conditions to allow post-closure beneficial use and to protect humans and wildlife from any hazards. This plan will also present necessary post-closure treatment, maintenance and monitoring required following the completion of closure measures.

The reclamation and closure plan has been developed for the mining of ore bodies at Kwatebala, Tenke, Fwaulu, and the future mining areas described in the Oxide Project ESIA, with their associated processing facilities and other infrastructure. The development of this closure plan is ongoing and will evolve over the life of mine as additional ore bodies are mined and processing facilities enlarged. The most recent updates to the closure plan can be found in the Oxide Project ESIA, dated August 2013.

The overall objective of the closure and reclamation plan is to reinstate the mosaic of agricultural land and miombo woodland taking in to account the unavoidable mining disturbances. More specific objectives include:

- Physical stabilization: Making stable and secure the surface infrastructure and mining related disturbances and/or residue facilities.
- Health and Safety: Limiting the health and safety threats to humans and domestic animals using the reclaimed mine site following closure.
- Land Capability: The re-instatement over as large as possible area of an equivalent pre-mining land capability to facilitate the return to pre-mining land use.
- Aesthetic Quality: The reclaimed mine site's aesthetic quality will be improved by a variety of landscaping and re-vegetation initiatives.
- Biodiversity: Lands designated for biodiversity conservation will be reclaimed, as much as feasible, such that the pre-mining land capability for biodiversity will be reinstated over time.

### 20.7.1 SURFACE INFRASTRUCTURE AND DISTURBED AREAS

Upon closure of the site TFM will recycle, remove, or demolish surface infrastructure relating to the project and reclaim disturbed areas. Surface infrastructure includes the process plant components, overland conveyors, power lines, infrastructure at mine sites and quarries. Buildings and process components will be removed and the concrete demolished. Disturbed areas include open pits, waste rock facilities, remaining low-grade ore stockpiles, and the surface infrastructure foot prints.

Access roads, haul roads and access ramps will be rehabilitated. Pit perimeters will be back shaped, slopes modified and security fencing installed. The upper perimeter of waste rock dumps will be landscaped and outer slopes vegetated with native species.

### 20.7.2 TAILING STORAGE FACILITY (TSF)

The components of the TSF closure include:

- Treatment/management of TSF and RWP supernatant
- Construction of a durable, chemically stable cover system of waste rock and topsoil to reduce wind erosion, prevent animals burrowing into the tailings and facilitate re-vegetation with native species.
- Construction of a storm water management system to route clean storm water runoff from the cover system off of the TSF facility and to maintain positive drainage. Rock fill on embankment slopes will limit erosion.
- RWP geo-membrane will be completely removed and disposed
- RWP embankment will be removed, and slopes graded to blend in to the surrounding native topography.

### 20.7.3 STORM WATER PONDS

At closure, storm water ponds will be decommissioned and dewatering operations will cease.

Groundwater levels within pit lakes will rise and are predicted to stabilize within 20 to 30 years. The pit lakes are predicted to be flow-through water bodies (i.e., with equal flow in and out of the pit lakes). Outflow will occur via groundwater, eventually discharging to surface water.

Impounded water will be tested and confirmed suitable for release into the receiving water course, after which storm water dams will be breached, the dams excavated and the area graded. Diversion channels and spillways not required for long term storm water management will be filled.

The remaining long term storm water management facilities will have the capacity for the 100 year, 24 hour event.

### 20.7.4 CLOSURE COSTS

The estimated gross decommissioning and reclamation costs is approximately $323 million. The decommissioning and reclamation cost estimates are representative of the total estimated cash costs to close the mine site under a scheduled situation and end-of year 2012 conceptual closure approaches, as updated within the Oxide Project ESIA, Title VI, Section 10 (August 2013).The estimate of long term closure costs have increased due to expanded definitions of closure items as part of the most recent ESIA. Closure costs are funded from annual payments into an environmental reserve account.

# 21 CAPITAL AND OPERATING COSTS

## 21.1 CAPITAL COST ESTIMATE

### 21.1.1 PHASE 2 EXPANSION CAPITAL COST

In September 2011, a feasibility study for the Phase 2 Expansion Project was completed by Hatch Ltd. (based in Toronto, Canada), which estimated a Phase 2 Expansion capital cost of $850 million. In 2012, TFM executed a value engineering exercise that reduced the project scope from the scope identified in the feasibility study by eliminating those scope items that did not directly contribute toward the Phase 2 Expansion copper production objective of 195,000 tpa. The result was the reduction to and approval of a $755 million capital budget allocation for the Phase 2 Expansion.

In 2013, TFM substantially completed the Phase 2 Expansion project on time and under budget at $670 million spent at year-end 2013. A high level breakdown of the capital cost spent is shown in the table below.

**Table 21-1 Phase 2 Expansion Capital Cost Spent (Year-end 2013)**

| **TFM Phase 2 Expansion** | **Capital Cost (US$ million)** |
|---|---:|
| Mine Equipment | 108 |
| Crushing | 3 |
| Grinding | 3 |
| Cobalt | 3 |
| Leaching | 2 |
| DCS | 1 |
| Electrowinning | 130 |
| CCD | 11 |
| Reagents & Chemicals | 25 |
| Site Infrastructure | 26 |
| Tailings | 1 |
| Solvent Extraction | 55 |
| Utilities | 10 |
| Bulk Orders & Supplier P&Gs | 67 |
| Contracted Indirect Services | 64 |
| Project Management | 161 |
| Contingency | - |
| **Total Phase 2 Expansion** | **670** |

With the completion of the Phase 2 Expansion and production of 210,000 tpa copper cathode in 2013, in excess of the nameplate capacity of 195,000 tpa, TFM continues to evaluate further debottlenecking and plant optimization actions to take advantage of the 270,000tpa tankhouse capacity as part of the operations' sustaining capital program.

### 21.1.2 SUSTAINING CAPITAL ESTIMATE

TFM plans for the installation of a new ball mill and new acid plant were deferred in 2013 under a program of capital restraint. The timing of these projects and their subsequent commissioning were reviewed, with the addition of a second acid plant expected to be completed in 2016 and the ball mill in 2017.

The following table shows an estimate of annual capital spending to 2023, which excludes future potential phases of expansion. This estimate, based on 2013 year end Reserves and LOM plan, includes both the new acid plant and ball mill as well as sustaining capital items such as support equipment, tailings dam raises and ongoing additions, replacements, and refurbishment of the mining equipment.

**Table 21-2 Sustaining Capital Cost Estimates**

| **Sustaining Capital Estimate** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|---|---|---|
| Annual Capital (US$ million) | 189 | 313 | 66 | 82 | 181 | 52 | 77 | 36 | 45 | 74 |

In general, the increase in sustaining capital estimated primarily reflects deferments in capital spending in 2013, the development of the mine plan which includes equipment purchases for optimizing loading and hauling, tailings storage facility expansions brought forward due to increased plant production, and the second new acid plant.

It should be noted that direct capital for future phases of potential expansion at Tenke have not been included in the TFM life of mine sustaining capital plans. Futures phases of potential expansion continue to be evaluated by TFM and FCX.

## 21.2 OPERATING COST ESTIMATES

Due to global economic changes and the natural volatility in commodities prices, operating cost projections are regularly updated by TFM on a quarterly basis. Costs reported reflect the Phase 2 Expansion plant operation with annual production varying year-to-year according to ore processed, ore composition and acid requirements.

The operating cost drivers which are particularly sensitive to change are fuel, sulphur (for acid), lime and transportation. Predicted annual operating costs by major category per tonne milled are shown in Table 21-3 below. These unit costs do not include royalties, advisory fees, by-product credits or cash taxes.

**Table 21-3 Operating Costs per Tonne Milled (Life of Mine: 2014 to 2041)**

| **Operating Cost** | **US$/ t milled** |
|---|---:|
| Mine | 18.7 |
| Process | 47.5 |
| G&A (incl. export duties & non-cash taxes) | 16.4 |
| Delivery (transport) | 10.8 |
| **Total** | 93.4 |

In general, the increase in the estimated LOM operating costs reflects higher costs for mining materials, maintenance and contractual services, higher milling rates, and transport costs to and from site. Higher processing costs are estimated due to higher sulphur and third party acid price forecasts. These are expected to be partially offset by lower costs of producing additional sulphuric acid from the new second acid plant in 2016. It should be noted that the second acid plant will also provide additional on-site power as well as support further debottlenecking and optimizations as part of potential future expansions.

Estimated unit general and administrative (G&A) costs have decreased due to the increase in forecast production and reductions in the later years of operation.

# 22 ECONOMIC ANALYSIS

*Producing issuers may exclude the information required under item 22 for technical reports on properties currently in production unless the technical report includes a material expansion of current production.*

# 23 ADJACENT PROPERTIES

## 23.1 GENERAL

Mineral concessions held by other third parties surround the Tenke Fungurume concessions. Apart from artisanal mining of high grade copper and cobalt outcrops there is no significant history of exploration or mining activity immediately to the north, east or west of the Tenke Fungurume concessions. However, due south of the Fungurume concession lies the historic Kakanda Mine where high grade copper and cobalt mining continues.

Also in the same vicinity is ENRC’s Mukondo (Boss Mining) copper SXEW and cobalt hydroxide facilities which are significant producers of copper and cobalt.

The QP has been unable to verify the information from the adjacent properties and the information presented is not necessarily indicative of the mineralization from Tenke Fungurume.

# 24 OTHER RELEVANT DATA AND INFORMATION

The authors of this report are not aware of any additional information necessary to make the technical understandable and not misleading.

# 25 INTERPRETATION AND CONCLUSIONS

The main conclusions arising from review of the Mineral Resource and Reserve estimates and the current operations are as follows:

- The Mineral Resource and Reserve estimates have been prepared to NI 43-101 Standards.
- The Phase 2 Expansion has been substantially completed and the processing plant is now expected to operate with a throughput of 14,500 tpd or more.
- The current Mineral Reserves used for the mine plan are considered adequate to supply the process plant with 14,500 tpd over the remaining Life of Mine.
- All environmental and social permitting/plans are in place in support of continued operations.
- It is anticipated that ongoing exploration will continue to upgrade the confidence of known oxide Mineral Resources. In addition, mixed and sulphide Mineral Resources will continue to be added.
- Metallurgical test work and flow sheet development continue in support of developing additional Mineral Resources and Reserves for processing of low grade oxide, plus mixed and sulphide mineralization in the future. Associated mining, infrastructure, transportation, environmental and social studies are also underway with a view to further phases of expansion.
- Reconciliation between the long range mine plan (LRM) short range mine plan (SRM) and material sent to the process plant has been an ongoing issue since start-up. The SRM predicts more tonnes at lower copper grades but higher cobalt grades then the LRM. Improvements to the short range mine grade control model are planned in mid to late 2014 after more information is gathered. Forecast improvement work will focus on sampling, geological interpretation, grade control, and short-range model development.

## 26 RECOMMENDATIONS

This technical report has been prepared to provide an update resources and reserves and on the expansion of the Tenke Fungurume mine and processing facility. The Tenke Fungurume mine is a producing property. No recommendations are provided by the authors of this report.

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