Geological Society of Zimbabwe

PO Box 1719
Causeway, Harare
Zimbabwe

http://www.uz.ac.zw/science/geology/gsz/

Summer Symposium

8am to 5pm, Friday 5th December 2003
Geology Department UZ

ABSTRACTS

Mercury Use in Artisanal Gold Mining in the Kadoma-Chakari Region, Zimbabwe

Dennis Shoko

United Nations Industrial Development Organisation (Global Mercury Project)

It is estimated that there are between 300,000 and 400,000 artisanal and small-scale gold miners (ASM) sustaining the livelihood of at least 2 million people in Zimbabwe. About 20,000 to 30,000 people are directly involved in gold extraction in the Kadoma-Chakari region. There are three categories of people in the area: **miners** (about 3,000 to 5,000 people) who excavate the ore and take this to for processing at custom milling centers; **millers** (1,000 to 2,000 people within 70 milling sites) who process the ore to extract gold, and **panners** (15,000 to 25,000 people) who extract gold by panning gravels in creeks and rivers. The custom milling centers are a desirable solution which organizes the gold extraction activity and prevents the haphazard use of mercury (Hg). However, the millers allow miners (customers) to use their own mercury at any step of the process. It is common to see miners adding up to three teaspoons (150 g) of mercury in the centrifuges used for gravity concentration of gold. This “flours” part of the mercury which is then lost with the tailings. The use of copper-amalgam plates is very popular in the region and must be discouraged as it allows for the amalgamation of the whole ore. Mercury and gold sometimes accumulate on given points of the plate surface, and with subsequent attrition by passing ore, they are lost to the tailings. About 20 tonnes/annum of mercury are imported from Netherlands to Zimbabwe for industrial and dental use but a lot of this is often diverted to ASM. Based on field observations it is estimated that Hg losses in the region must be between 3 to 5 tonnes/annum.

Millers extract the gold left in the primary and amalgamation tailings by vat-cyanidation. Miners receive no compensation for this loss of gold. Most centers have 5 to 10 cyanidation tanks. When the Hg-contaminated tailings are leached with cyanide, part of the mercury goes into solution while the rest remains with the final tailings. The fate of Hg-cyanide in the tailings is unknown but the cyanidation process can also exacerbate the Hg methylation potential in tailings.

Panners in the Kadoma-Chakari area are nomadic individuals working in remote areas along the major rivers. They come to these rivers from parts of Zimbabwe but mainly are from neighboring countries. They are frequently harassed by the local police who consider them illegal. In the dry season, they divert the river courses and excavate gravels to concentrate gold in improvised sluice boxes. They process between 1.5 and 2 tonnes of ‘ore’ per day per individual and recover between 0.2 and 0.4 g Au and occasionally more. Equal quantities of mercury are irretrievably lost.

EVALUATION OF LEVELS OF SILICA DUST IN GOLD MINES AROUND HARARE MINING DISTRICT

BY
Benjamin MUTETWA and **Musekiwa CHIKONYORA**
National Social Security Authority
Occupational Health and Safety Division

Abstract

The purpose of this study was to determine levels of silica dust in selected gold mines around Harare Mining and assess possible impact of dust levels on the health of the workers through a measurement of total airborne and respirable dust in the mines. Personal samples were collected at various surface and underground mine locations to determine total airborne (inhalable) and respirable dust concentration using personal dust samplers. The study showed that almost all mines do have total inhalable and respirable dust levels exceeding maximum acceptable limit of 0.5mg/m^3 and 0.1mg/m^3 respectively. More importantly, average respirable dust for both underground and surface areas for almost all mines except one, exceeded the acceptable safe limit of 0.1mg/m^3. Hence such levels are liable to cause silicosis if adequate measures are not taken to protect the health of workers. It was also noted that dust levels are generally lower underground compared to those on the surface.

Application of Factor Analysis as a Tool in Groundwater Quality Management

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Although developed as a tool in the social sciences, R-mode factor analysis has proven highly effective in studies of groundwater quality. The technique examines the relationships between variables (such as chemical parameters in groundwater), which are shown by a number of cases (such as sampling points). In this study, two examples are presented. The first is of groundwater around a southern African iron ore mine and the second is of groundwater in the vicinity of a southern African municipal sewage disposal works. Groundwater samples were collected, their chemistry analysed and factor analysis was performed on each of the chemical datasets.

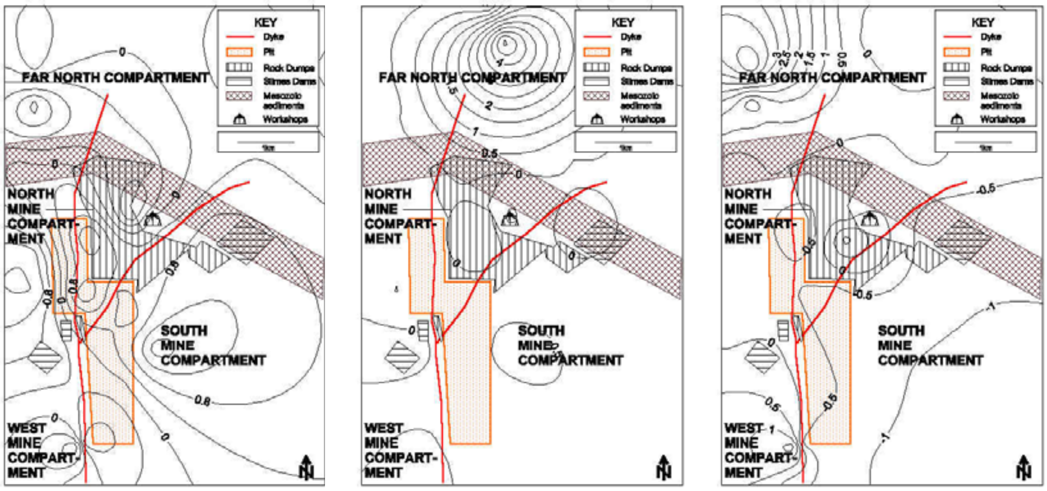
The mine studied is a large opencast operation in a Precambrian iron formation. The iron formation overlies dolomites, which form a major aquifer. The aquifer in the study area is divided into four compartments: the North, West and South Mine Compartments, separated from each other by diabase dykes, and a Far Northern Compartment, separated from the mine compartments by a valley of Mesozoic sediments (Fig 1). Potential contamination from oils and greases and from explosive residues (a diesel oil – ammonium nitrate mixture) has been suggested by site investigations. The northern area, away from the mine, is agricultural land.

Factor analysis of the groundwater quality data revealed the following factors:
Factor 1: Ca^{2+}, Mg^{2+} and HCO_3^- (dolomitic water signature)
Factor 2: K^+ and NH_4^+ (agricultural signature)
Factor 3: Na^+, Cl^- and SO_4^- (mine dumps)

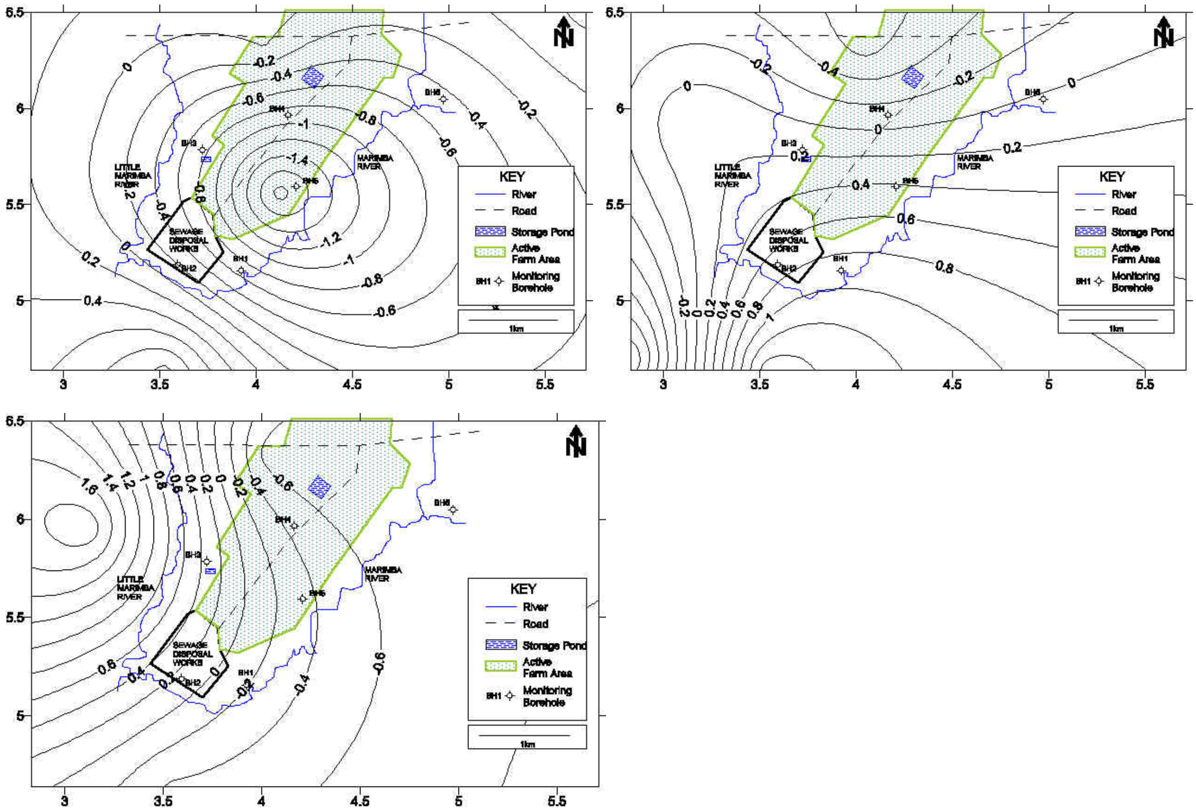
The sewage disposal works (Fig. 2) and its associated farm, in the City of Harare, have been in use since 1972. The active farm area, where sewage effluent mixture (SEM) is applied, consists of 25 paddocks (427.1 ha), draining into two rivers. The lower southern part of the farm area and the areas along the two rivers are wetlands, which do not dry out during the dry season and some parts are inaccessible during the wet season. The farm is provided with night storage ponds.

Factor analysis of the groundwater quality data revealed the following factors:
Factor 1: Minor chromium, negatively associated with phosphate, lead and nickel.
Factor 2: Nitrate and phosphate (SEM).
Factor 3: Iron and nickel (possibly due to iron content of granites).
Factor 2 is related to the impact of the sewage works, but since both nitrate and phosphate levels are within Zimbabwean regulations, this finding is of limited value for management purposes.

Thus although R-mode factor analysis can be a valuable tool studies of groundwater quality, this is not always the case. Multivariate statistical techniques like factor analysis should thus be used as supplementary to, but not in replacement of, conventional groundwater quality data treatment methods.



(Fig. 1. Distribution of factors, based on groundwater quality data from iron ore mine 1: a) Factor 1: Ca^{2+}, Mg^{2+} and HCO_3^- ; b) Factor 2: K^+ and NH_4^+ ; c) Factor 3: Na^+, Cl^- and SO_4^-)



(Fig. 2. Distribution of factors, based on groundwater quality data from sewage disposal works 1: a) Factor 1: ; b) Factor 2: ; c) Factor 3:)

The Reporting of Resources and Reserves

A Martin
SRK Consulting

The JORC Code developed by the Australasian Institute of Mining and Metallurgy has become with few modifications, the worldwide standard for reporting on Resources and Reserves (e.g. the SAMREC Code of South Africa and the CIM Standards of Canada).

A three-fold categorisation of Resources based on confidence levels in continuity of mineralisation is now accepted in most countries along with a two-fold subdivision of Reserves. A common error in the application of these codes is the belief that Reserves have higher confidence levels than Resources. Reserves are generated from the appropriate category of Resources by the application of modifying factors.

This presentation will discuss the application of levels of confidence, the definition of a competent person and the modifying factors required for conversion of Resources to Reserves.

Application of GPS in Exploration

CF Ngorima (IMR-UZ)

Abstract

The global positioning system has now become integrated in he day to day activities of humans. The GPS is a world wide radio-navigation system navigation system that uses satellites as reference points to calculate positions. Surveyors use GPS for an increasing portion of their work. GPS offers cost savings by drastically reducing setup time at the survey site and providing incredible accuracy. Basic survey units, costing thousands of dollars, can offer accuracies down to one meter. More expensive systems are available that can provide accuracies to within a centimeter.

GPS uses a system of three components to locate positions. These are the space segment, the control segment and the user segment. The space segment consists of 24 satellites in six orbital planes, the control segment consists of five land based control stations and the user segment is a person and a GPS.

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map.

A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

The application of GPS in most geological survey work was limited because of the errors associated with the system. However, a new system called Wide Area Augmentation System (WAAS) is currently available mostly in North America. Basically, it's a system of satellites and ground stations that provide GPS signal corrections, giving even better position accuracy. The accuracy is an average of up to five times better. A WAAS-capable receiver can give you a position accuracy of better than three meters 95 percent of the time. Also the intentional degradation of signal (SA) by the US military was discontinued in the year 2000. This coupled with modern technology such as the field Palm note books should increase the applications of the GPS in exploration programmes. This also ultimately means that geological data can now be directly logged onto the final GIS map sheets such as geochemical data as the exploration survey is taking place.

TITLE: PGM mineralisation and grade modelling in the Sebakwe Subchamber: Implications for exploration.

Coniace Madamombe

Abstract: Economic platinum group metal (PGM) enrichments in the Sebakwe Subchamber of the Great Dyke are largely confined to the Platinum Group Elements (PGE) Subzone stratigraphically positioned below the Base metal Subzone of the Main Sulphide Zone (MSZ), in the bronzitite unit of Proxenite Number1 (P1) layer. The most common PGM suite comprises sperrylite ($PtAs_2$), cooperate (PtS), braggite [$(Pt,Pd,Ni)Te_2$], hollingworthite [(Rh>Ir>Pt)AsS], laurite[$(Ru>Ir>Os)(S>As)_2$], palladium melonite [$(Ni,Pd)Te_2$], moncheite [$(Pt,Pd)(Te>Bi)_2$], irasite [(Ir≥Pt>Rh)AsS], zvyagintesvite (Pd_3Pd) and platinum-iron alloys (Pt_3Fe) (Oberthur et al. 1998, 2002: Wilson, 1999). Pd and Rh may occur as traces in principle sulphide phases of the MSZ such as pentlandite, chacolpyrite and pyrrhotite.

Average PGE grades on the four principal precious elements (4E) (Pt, Pd, Rh and Au) do not have a wide spatial variation over a 2.5-3m optimized thickness within the PGE Subzone. Slightly elevated precious metal accumulations that have been influenced by gravity separation and their location away from the feeder, are largely confined to the north and west in conformity with the geometry of the Sebakwe Subchamber that is characterized by deeper parts towards the west and north than east and south. Because of their higher density relative to silicates the metals occupied the deepest parts of the subchamber (Wilson, 1996). Vertical 4E grade distribution profiles display repetitive well pronounced precious metal peaks in a way that resembles a systematic depletion from the magma. The Pt peak coincides with the visual base of massive sulphide enrichment that is marked by a decrease in grain size and abundance of principal sulphide phases. The Pd peak occurs in the interval 1-1.25m below the Pt peak. Pt/Pd ratios range from 1.19 to 2.24 in the 3m intervals below the Pt peak position.

The Wedza Model can be applied to explain the origin of the metal enrichments. The model envisages repeated influxes of magma into the magma chamber through fountaining resulting in a thick pile of magma that was maintained at elevated temperatures of about 1320 ^{o}C, prolonged bronzite fractionation while suppressing sulphide exsolution, and consequent enrichment in sulphur and chalcophile elements within the residual magma (Prendergast and Keays, 1989). Turbulent mixing of old and new magma in the layers below the MSZ inhibited sulphide liquation and allowed equilibration to be reached between sulphide droplets and large volumes of silicate liquid. This coupled with double diffusive convection promoted further cooling, pyroxene fractionation and the ‘scavenging’ of chalcophile metals from the resident magma according the magnitudes of mineral-melt partition coefficient (Kd) values [$Kd_{Rh}>Kd_{Pd}>Kd_{Pt}>Kd_{Ni}$ ($>Kd_{Cu\sim Au}$)] (Madamombe, 2002; Naldrett, 1990; Prendergast and Keays, 1989).

The PGE vertical distribution profiles, spatial variation and the geometry of the subchamber have an important bearing on the PGE exploration and exploitation, especially when determining limits for evaluation drilling, open pit and underground mining. Exploration for the most economically attractive zones should be directed northwards and westwards. The repetitive nature of the vertical grade distribution profiles and metal ratios enhance for easier grade control.

Quality Controls in Exploration

A Martin
SRK Consulting

Quality controls and quality assurance are fundamental to any exploration programme in order to avoid failure of a mining project and prevent fraudulent practices.

Amongst the basic errors that have been identified as leading to project failure are poor data management and unreliable assays. These two issues are directly under the control of the exploration geologist.

An exploration geologist must create a bulletproof exploration database, working on the assumption that this will be subject to independent audit and due diligence.

The database should include all relevant and material information on every aspect of the work, from initial sampling to accepted assays, in addition to other issues such as tenure and locality. All of these require a paper trail that links results to validation procedures. The database will contain both factual data, and information – defined as a reliable interpretation of the data. A competent person must do the interpretations.

Databases tend to be large, and routine in-house checks on inputs should be supplemented by regular independent audits. All of these should be on-going and not left to the final stages of an exploration programme. Database back-ups area essential.

Quality assays can be achieved through proper planning and setting up of control protocols; good communication with the laboratory is essential. The planning process should provide for routine submission to the laboratory of standards, blanks and repeats with every batch of samples. Reference material assay receipts should be assessed immediately using the Half Absolute Relative Difference or HARD value and scatter plots. Assays outside acceptable limits should be reported to the laboratory and re-assayed prior to acceptance by the geologists and issue of an assay certificate.

Maintaining quality of Resource data is a fundamental project management issue readily addressed using a range of simple techniques.

What's in a sample?

Chris Tobayiwa, Rio Tinto Assay, Eiffel Flats

There is traditional rivalry between chemistry and a geology as illustrated by a number of mutually well known examples and anecdotes. Sometimes the rivalry arises from the fact that there are competing contraints in resources like time and money and control. At other times career paths are speeding towards the same door. This often destroys the energy that should make these proffessions complementary.

The objective of this presentation is to establish dialogue between the chemist and the geologist by illustrating the chemist's road to numbers. The intention is show that the chemist's estimate is there to complement the original estimate by the geologist.

The relationship is best when quality control is in both camps. The circus show appears classic when one is trying to fix the other.

The parts per trillion mine will come in the same way that Plutonium was discovered by those who wanted to pay the price.

GEOPHYSICAL SERVICES AVAILABLE IN ZIMBABWE

By P. Mpofu (Geophysics GPR Zimbabwe)

Abstract

A wide range of geophysical services is available in Zimbabwe and these range from academic and research, government services, private consultant services and in house geophysical services for mining houses.

The University of Zimbabwe offers an MSc in Exploration Geophysics degree and is the main provider of geophysicists to the industry and government institutions. Doctorate degree by research can also be obtained at the UZ.

The National University of Science and Technology (NUST) based in the second city Bulawayo mainly offers geophysics as one of the subjects in their applied physics degree programme. Some NUST students take up geophysics projects as their degree project and get attached to geophysical institutions such as the geological survey.

The Geological survey provides the main database of geophysical data available in Zimbabwe. This includes data itself and information on where other geophysical services can be obtained in the country.

Private consultant companies offer geophysical services to the industry at commercial level. These services cover the mining, groundwater, civil engineering and environmental studies. In this talk the specific type of services available locally are explained and this includes the equipment available and specifications.

Small Mining Supplies (Pvt) Ltd
in Association with
Peacocke, Simpson & Associates
Providing

Innovative Services and Equipment for the Small Mining Sector

PEACOCKE SIMPSON & ASSOCIATES
Mineral Process Engineers

What are we about?

Clean, appropriate solutions
Specifically targeting small miners
Alluvial and hard rock
Gold and other minerals
Particular attention to gravity recovery and avoidance of cost & skill levels required by chemical means
Emphasis upon small, translocatable plant
SMS and PS&A are Zimbabwean companies making African solutions for Africa

A typical solution….

High efficiency Knelson operating upon stamp mill product
A blend of technologies that work!
The ore dictates its terms
Starts with innovative testwork
Maximising gravity recovery at lowest price
Why build process cities when most of the job can be done in 0.25 seconds?
Why cyanide if you don't need to, or it doesn't make economic sense?
Why crush & grind if the gold is in the soil?
Involves gravity testing at various grinds (or after scrubbing with no grinding) to optimise grind effort and cost against recovery gain.
Involves gravity testing at increasing mass yield, to optimise gravity effort against recovery gain.
Introduces innovation such as intense leaching of gravity concentrates in small batch vessels, rather than bulk leaching of ore in big tanks.
Culminates in appropriate equipment for optimum recovery at minimum cost:
For example the Katanka single-stamp mill, which comprises flanged pipe frame and cylindrical mortar box, is small enough for one-man or co-operative mines, and is easily erected.
It can be supplied with pre-cast concrete foundations.
May not include grinding. Many rubble and eluvial deposits carry the gold in the soil or clay, with relatively barren rocks.In this case, scrubbing is required to liberate the gold from the clays and soil.The SMS rubble scrubber has been developed specifically for sticky African clays.
May even involve relatively high-tech equipment such as a Knelson Concentrator (seen here fitted with an overhead hammer mill).This offers the highest gravity recovery, but is not always affordable.
As a result PS&A & SMS are developing a cheaper, unfluidised centrifuge for local conditions.
Might not even involve gold. This Hi-Y jig was developed specifically for chromite.
May also involve some "chemistry", such as this Acacia Reactor for intense cyanidation of gravity concentrates.
This very machine, which has a capacity of 0.5 tpd concentrates, increased overall plant recovery at How Mine, which processes about 1000 tpd of ore, by >3%.
That's appropriate!

A case study – Dericose Mine

A small scale high grade mine
Has progressed from artisanal through to more formal stage
Currently being upgraded to high technology at small scale – no mercury!

Located in the Mazowe Valley, 40km north of Harare

Infrastructure

Even at small scale, 1tph, a properly run mine is able to support reasonable infrastructure:
Housing, office, workshop, store, etc

Formal underground mining

Neat, tidy, safe mining
Aesthetics and concern for the environment

Milling and gravity recovery

Currently via stamp mill to a copper plate followed by bowl concentrator and mercury amalgamation – not efficient and environmentally poor.

Tailings treatment

Tailings are treated in a vat leach plant, up to eight day cycle due to high grades left in the tailings by inefficient gravity recovery

Carbon in solution and elution

Gold is won from solution onto carbon and then eluted off using Zadra elution. Carbon regeneration via vertical Kiln – miniature of large scale system

The next stage – a world first!

Crushing & ball milling
Knelson concentrator in closed circuit with ball mill, at high mass pull to maximise gravity and minimise tails.
This will result in both free gold and sulphides in the gravity concentrate.
Free gold and sulphide concentrates will go to an Acacia Reactor, which is designed to treat exactly this type of material.
Acacia solution will go to direct electrowinning from solution using EMEW cells.
Highly efficient and contained processing
Sophistication in miniature, applied appropriately!

The solution will result in….

Maximised gravity recovery via Knelson, with quick cashflow and minimal chemical use in the Acacia reactor (leaching 100kg/day of high grade concentrate carrying most of the ore feed gold).
>98% recovery.
Higher security in the gravity plant.
Minimal tails grades, which will either enable reduction of leach times or total elimination of tailings leaching.
Reduced leach times means reduced cyanide use and cost, and quicker cashflow.

Sponsors

The Geological Society wishes to thank the following sponsors:-

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