Training Handbook for Artisanal and Small-Scale Miners in Zimbabwe

MARCH 2019

pact

Pact is the promise of a better tomorrow for communities challenged by poverty and marginalisation. We serve these communities because we envision a world where everyone owns their future. To do this, we build systemic solutions in partnership with local organisations, businesses, and governments that create sustainable and resilient communities where those we serve are heard, capable, and vibrant. On the ground in nearly 40 countries, Pact's integrated adaptive approach is shaping the future of international development. Visit us at www.pactworld.org.

In Zimbabwe, Pact is building the capacity of local organisations and institutions to better meet their public-service missions and to locally address the country's challenges. Pact is improving the lives of Zimbabwe's small-scale and artisanal gold miners by working to formalise the sector, bolster safety and environmental standards, and reduce the dangerous use of mercury in gold mining.

The development of this handbook was funded by the Transparency Responsiveness, Accountability, and Citizen Engagement (TRACE) program, led by DAI.

Recommended citation

Pact. (2017). Training Handbook for Artisanal and Small-Scale Miners in Zimbabwe. Washington, D.C.: Pact.

Contact

Thembile Phute
Country Director
Pact Zimbabwe
1 Downie Avenue
Belgravia
Harare
tphute@pactworld.org

Authorship

This handbook was compiled by Ruvimbo Kamba, Norman J. Mukwakwami, Motive Mungoni and Patson Chimuzinga. Special thanks are extended to the Pact team who provided guidance and support to the authors, including Thembile Phute, Tendai Mushonga, Trish Spencer and Innocent Mujajati. Also thanks are extended to the Pact headquarters team who formatted, reviewed and edited the document including, Dylan McFarlane, Daniel Stapper, Karen Hayes, Cristina Villegas, Stacy Langner, and Stefan Peterson.

Copyright info

Table of Contents

List of Figures

List of Tables

Foreword

The mining sector continues to play a pivotal role in the economic development of Zimbabwe, contributing more than 60% of export receipts, more than 13% to GDP and more than 50% foreign direct investment into the country.

The country is endowed with a huge and diversified mineral resource base which comprises of over 40 minerals that can be commercially mined. These minerals are exploited by both large scale and small scale miners.

The Government of Zimbabwe recognises the role being played by Artisanal and Small Scale Miners (ASM) in the country's socio-economic development, contributing immensely to mineral production and poverty alleviation in rural communities. The ASM sector is mainly concentrated in gold, chrome and semi-precious stones. In 2018, ASM sector produced more than 50% of the national gold output and over the years has been instrumental in the production of chrome ore, largely tributes to large scale mining companies, both to feed the local chrome smelters for export.

Despite its immense contribution to the economy, the ASM sector is associated with numerous challenges such as environmental degradation, lack of technical skills, funding, smuggling, lack of adequate equipment and machinery and lack of business acumen among others.

In recognition of the notable contribution and huge potential of the ASM, the Government of Zimbabwe, in line with the Transitional Stabilisation Programme, is working on capacitating the ASM sector so that it continues with the positive trajectory. The Government of Zimbabwe, therefore, welcomes support to this important sector from various stakeholders.

It is against this background that on behalf of Government, I applaud Pact for coming up with this Training Handbook towards enhancing the operations of ASM. More so, noting that Pact is an organisation that is working to build the capacity of local organisations and institutions to better meet their service missions through assisting ASM to bolster safety and environmental standards.

I, therefore, urge players in the ASM and other relevant stakeholders to utilise the Training Handbook in order to increase knowledge and skills necessary to facilitate efficiency and viability of mining operations. The Ministry of Mines and

Mining Development extends its gratitude to various institutions, donor partners and all organisations who contributed towards the publication of this ASM Training Handbook which will aid in the ASM sector in safer, sustainable and more productive mining practices.

Hon W. Chitando

Minister of Mines and Mining Development

Preface

In support of the Government of Zimbabwe's objectives, Pact Zimbabwe is implementing the Zimbabwe Accountability and Artisanal Mining Program (ZAAMP) which is working on a pilot project to support the formalization (legalisation and professionalization) of Artisanal and Small-Scale gold mining (ASGM) and trading in Zimbabwe.During ZAAMP Phase II (2015-2016), in collaboration with the Chamber of Mines of Zimbabwe (COMZ), Pact trained 300 miners at its four project sites on key mining topics. Since 2015, Pact Zimbabwe has piloted trainings to enhance artisanal and small-scale gold miners' skills in three districts: Gwanda, Kwekwe and Shurugwi. Trainings have covered topics which include; safety and environment management, mining legislation, efficient mining techniques, mercury abatement, child labour, gender equality & mining and financial literacy. These pilot interventions were in response to a growing concern that one of the several key challenges to the formalization of the sector is the low skill levels within the sector. An estimated 70 per cent of the miners in ASM are said to be unskilled.[1]

To ensure trainings are replicable and sustainable beyond the life of ZAAMP, and to build the capacity of local organizations to conduct similar trainings, Pact Zimbabwe consolidated training materials into a Training Handbook. Pact coordinated the development of training manual together with other stakeholders with a keen interest on artisanal and small scale gold mining (ASGM). We acknowledge the assistance of all stakeholders listed in the acknowledgements with special mention of the parent Ministry of Mines and Mining Development. The handbook doubles up as both a facilitator's guide and manual which the miners can easily refer to. The handbook is a vital tool towards equipping the estimated 500,000 artisanal and small-scale miners with fundamental knowledge on key mining topics. We sincerely hope the handbook will go a long way in professionalising the mining sector.

Thembile Phute
Country Director, Pact Zimbabwe

[1]Pact. (2015) A Golden Opportunity: A scoping study of ASGM in Zimbabwe. Washington, D.C.: Pact

Acknowledgements

The development of this handbook was supported with funding from TRACE under the Zimbabwe Accountability and Artisanal Mining Programme (ZAAMP), which has a prime focus on increasing the integration of formalised artisanal and small-scale gold mining into the mining sector. The Pact ZAAMP team acknowledges the input and support provided by stakeholders from academia, the private sector, civil society, and government. In particular, Pact wishes to extend its special gratitude to the following stakeholders who contributed to the development and peer review of various sections:

- **Antony Mamuse** contributed to the Mining Legislation section. He is an internationally published researcher and a geoscientist by profession with more than 20 years of experience in geoscience training and teaching, mineral exploration, and geological and geo-environmental research and consultancy. He is currently the Executive Dean in the Faculty of Mining and Mineral Processing Engineering at the Midlands State University.
- **Beauty Tsuro** contributed to the Financial Literacy section. She is an experienced human resources and business consultant.
- **Blessing Katiyo** contributed to the Efficient Mining techniques section and peer reviewed the Exploration and Evaluation of Mineral Deposits and Human Health sections.
- **Caleb Mutandwa** contributed to the Child Labour section. He is a practicing legal practitioner with more than thirteen years of experience in child rights, human rights, Constitutional law, and family law.
- **Dorothy Mushayavanhu** contributed to the Overview of Existing Mining Practices and the Mining Legislation sections. She is legal expert who specialises in international environmental law, human rights in the developing world, law and development, and gender.
- **Gabriel Chipara** contributed to the Financial Literacy section. He is a business consultant and coach, transformational speaker, and trainer.
- **Gift Dembetembe** peer reviewed the introduction and Overview of Existing Mining Practices. He is a mining engineer currently working at the University of Zimbabwe Faculty of Engineering.
- **Lyman Mlambo** peer reviewed the Overview of Existing Mining Practices, Gender, Mining Legislation and Compliance, Financial Literacy, and Markets sections. He is the current chairperson of the Institute of Mining Research at the University of Zimbabwe.
- **Maideyi Lydia Mabvira-Meki** contributed to the Exploration and Evaluation of Mineral Deposits section. She is currently the chairperson of the Geology Department at the University of Zimbabwe.

- **Motive Mungoni** contributed to the Environmental Management section. He is a trained mining engineer with vast experience in the academic sector.
- **Nyasha Chakanetsa** from Medent Pharmaceuticals, a local 3M agent, contributed to the development of the Occupational Health section.
- **Ruth Ncube**, a training consultant, contributed to the Gender section.
- **Standards Association of Zimbabwe** contributed information on approved standards of ASM operations.
- **Tamani Moyo** peer reviewed the Environmental Management section. He is a mining engineer currently working with the Zimbabwe School Mines.
- **Tanya Charles** contributed to the Gender section. She is an experienced gender consultant.
- **Tatenda Nyamagudza** peer reviewed the Mining Methods and Drilling and Blasting sections. He is a mining engineer and currently heads the Mining and Mineral Processing Engineering Department at the Manicaland State University of Applied Sciences.
- **Thomas Munyoro**, an expert in corporate finance, contributed to the Financial Literacy section.
- **Wonder Mutematsaka**, a mining engineer, contributed to the Drilling and Blasting section.

Acronyms and Abbreviations

AFSM	Austrian Foundation for Small Mines
AMD	Acid Mine Drainage
AN	Ammonium Nitrate
ANFO	Ammonium Nitrate/Fuel Oil
ASGN	Artisanal and Small-Scale Gold Mining
ASM	Artisanal and Small-Scale Mining
DTH	Down the Hole
EIA	Environmental Impact Assessment
EMA	Environmental Management Agency
EMP	Environmental Management Plan
FO	Fuel Oil
FOG	Fall of Ground
FPR	Fidelity Printers and Refiners
GBV	Gender-Based Violence
GMMDT	Gold Mining and Minerals Development Trust
ILO	International Labour Organisation
ISAL	Internal Savings and Loan Group
JORC	Australasian Joint Ore Reserves Committee
LBMA	London Bullion Market Association
LPD	Long Period Delay Detonator
MERP	Mine Emergency Response Plan
MFI	Microfinance Institution
MIL	Mining Investment Loan
MMA	Mines and Minerals Act
MMCZ	Minerals Marketing Corporation of Zimbabwe
NSSA	National Social Security Authority
PAYE	Pay As You Earn
PETN	Pentaerythritol Tetranitrate
PGM	Platinum Group Metal
PMD	Provincial Mining Director
PN	Prospecting Notice
PPE	Personal Protective Equipment

PPM	Parts per Million
RBZ	Reserve Bank of Zimbabwe
SACCO	Savings and Credit Cooperative Organisation
SAZ	Standards Association of Zimbabwe
SI	Statutory Instrument
SPD	Short Period Delay Detonator
TB	Tuberculosis
TNT	Tri-Nitro Toluene
TRACE	Transparency Responsiveness, Accountability, and Citizen Engagement programme
VAT	Value Added Tax
WHO	World Health Organisation
ZAAMP	Zimbabwe Accountability and Artisanal Mining Programme
ZIA	Zimbabwe Investment Authority
ZIMDEF	Zimbabwe Manpower Development Fund
ZIMRA	Zimbabwe Revenue Authority
ZRP	Zimbabwe Republic Police

About this Handbook

Background and rationale

Zimbabwe has an estimated 500,000 artisanal and small-scale miners, 70% of whom have not received any training. To provide them with much-needed skills, Pact conducted trainings for miners in Gwanda, Kwekwe, and Shurugwi districts in 2016 and 2017. Following up on and drawing on learning from these trainings, Pact compiled this handbook as a training tool, which can be used by government, miners' associations, and other interested stakeholders.

Providing training to miners in the artisanal and small-scale mining (ASM) sector can:

- Increase awareness of best mining practices that will reduce levels of accidents and incidents that have previously resulted in loss of lives, equipment and production time.
- Increase awareness of existing legislation that protects miners' and mine workers' rights.
- Improve ore extraction and metal recoveries through adoption of efficient mining and mineral processing methods.
- Create a clearer understanding of the minerals market and how miners can protect themselves against losses.
- Support the acquisition of mining skills that increase employability in the advanced formal mining sector.

Since ASM is regarded as informal, the contents of this handbook will acquaint miners in this sector with practices from the formal mining sector so that they can either adopt standard practices or hybridise what they have with proper mining codes of practice. It is the eventual formalisation of ASM that will bring safer and more productive mining practices and consequently improved livelihoods.

Intended audience

This handbook is for:

- ASM miners who want to improve their knowledge and skills in mining
- Government officials who want to engage the ASM sector
- Miners' associations that want to train their members
- Civil society organisations that want to develop the capacity of artisanal and small-scale miners

Structure and content

This handbook presents simple solutions to problems and challenges faced by artisanal and small-scale miners in Zimbabwe. It covers general knowledge and also provides detailed descriptions on specific topics. The handbook is designed so that each module can stand alone; readers can review the list below and select the topics most relevant to their needs. For reference, definitions of mining terms and units of measure are provided in the glossary at the end of this handbook.

Training methodology

The training content is designed for groups of up to 25 participants. A group of this size is small enough to allow for optimal interactive participation and robust exchange of ideas and experiences, yet large enough to be cost-effective and sustainable.

This handbook emphasises participatory processes and draws on the key principles of the Adult Motivation to Learn approach[2]:
Need to know: Adults need to know the reason for learning something.

- **Foundation:** Experience (including in some cases making mistakes) provides the basis for learning activities.
- **Self-concept:** Adults need to be responsible for their decisions on their own education and involved in the planning and evaluation of instruction.
- **Readiness:** Adults are most interested in learning subjects that have immediate relevance to their work and/or personal lives. For miners, this includes topics such as laws on mining, labour, health and safety, taxation and tributes.
- **Orientation:** Adult learning is generally oriented around problem-solving and addressing challenges faced by participants.
- **Motivation:** Adults respond better to internal versus external motivators.

Positive personal interrelations and an atmosphere of trust and open dialogue are important components of a successful learning activity. Trainers are also advised to take into account the cultural sensitivities of each mining site.

This handbook contains suggestions for:

- Ice breakers
- Brainstorming
- Plenary discussions
- Group exercises
- Role plays

[2] Wlodkowski, R. J. (2008). Enhancing adult motivation to learn: A comprehensive guide for teaching all adults (3rd ed.). San Francisco: Jossey-Bass, A Wiley Imprint.

Getting Started

Identifying trainers

A team of at least two trainers is recommended to co-facilitate this training. One trainer should serve as the lead trainer. The lead trainer's role is to:

- Outline the training objectives and frame issues
- Present training content and introduce new concepts
- Promote the exchange of information and experiences on mining
- Ensure that there is effective participation by all members

The role of the co-trainer is to:

- Record information on flip charts
- Be a time-keeper
- Help keep the discussion focused on the session's objectives
- Supervise group work

Trainers should be selected for their knowledge, expertise, and facilitation skills. In addition, it is preferable that the trainers have sound knowledge of the subject area, including the political economy of mining in Zimbabwe, economic opportunities arising from gold mining, and tools and strategies for engaging in the mineral industry. They should also have experience in training and facilitating workshops and in organising participatory activities, as well as excellent communication skills. Regardless of their background, trainers should familiarise themselves with the information and activities contained in this handbook prior to the workshop.

Opening the workshop

Introducing trainers and participants

At the start of the workshop, trainers should introduce themselves, giving their names and a brief description their mining experience.

Activity: Introductions  15 minutes

Let each participant introduce the person sitting next to him or her. Give participants two minutes to talk with their neighbour before the introductions begin. Each participant will then present his or her partner, giving their partner's name and a brief description of how the they and/or their community has interacted with the gold mining industry.

Examples:

- To my left is Joseph Siachola. He worked at a copper mine and diamond mine for 20 years and is now involved in small-scaling mining.
- To my right is Sebastain Magodo. He is a miner by profession and has been mining gold around Kadoma area for more than 10 years.
- This is Joe. He lives in the resettlement areas near Jumbo Mine. He is a 'mukorokoza' or gold panner working for a mine next to my field.

Activity: Icebreaker  15 minutes

Step 1: Ask all the participants to stand/sit in a circle.

Step 2: Throw a ball into the group of participants.

Step 3: Whoever (among the participants) catches the ball should shout the number of years of experience he/she has in mining.

Step 4: Write on a flip chart the number of years.

Step 5: Once everyone has gotten the ball, add the numbers of years and write the total on the flip chart.

Step 6: Wow, there are XXX number of years of experience! We are going to learn from each other because everyone is an expert!

Setting ground rules

Together with participants, trainers should set ground rules for the workshop. Examples include:

- Cellular phones should be off or in silent mode
- Every contribution is important
- Everyone should be respected while they are speaking

Outlining training objectives

At the end of a training workshop, participants will be conversant with key principles, concepts, or aspects covered in each of the 11 modules that make up this handbook, enabling a simple but practical application of knowledge gained in their day-to-day mining activities.

Module	Training participants will learn how to:
Module 1: Introduction to Mining	Understand the ASM sector
Module 2: Geology and Exploration	Explore for minerals Estimate mineral resources Control the grade
Module 3: Mining Methods and Maintenance	Consider which mining method to use Maintain mining equipment
Module 4: Efficient Mining Techniques	Drill and blast Sink a shaft Safely support underground mines
Module 5: Environmental Management	Protect the environment and prevent pollution Conserve and recycle water Prepare an environmental management plan
Module 6: Occupational Health and Safety	Improve productivity by safe, healthy miners Incorporate safety into their operation Use personal protective equipment
Module 7: Mineral Processing	Recover gold and other minerals efficiently Select the best mineral processing techniques
Module 8: Mining Laws and Regulations	Obtain a mining license Protect themselves from liabilities
Module 9: Business Skills and Markets	Make a financial plan Access loans, equipment, and finance
Module 10: Social Issues	Promote healthy working conditions Include women in operations Eliminate child labour
Module 11: Organisational Development	Form a mining syndicate or association Increase relevance of ASM to the supply chain

Setting expectations

As a facilitator, it is important to understand your participants' expectations. Before you begin covering the main training content:

- Ask each participant to share his or her main interests and expectations from the workshop.
- Capture them on flip charts or sticky notes and hang them on the wall for everyone to see.
- Go over them together as a group.

As you go through them, match each expectation with the objectives listed to make sure that when the objective is being covered, the expectation is not overlooked. For example, after listing an expectation on the chart, you can put the number of the corresponding objective in brackets. If an expectation does not match any objective, consider creating a new objective. Revisit these expectations at the end of the workshop by reading each expectation and asking the participants if it would have been met.

Introduction to Mining

This module includes the following topics:

- 🕮 Definition of mining
- 🕮 Definition of ASM
- 🕮 ASM and economic development

What is mining?

Mining is the removal of valuable minerals from the earth. The activities of a miner include searching (exploring or prospecting) for mineral ores, removing them from the ground, processing them into a valuable mineral product, and marketing or selling the mineral product.

Zimbabwe has more than 60 different minerals, though historically only 40 of these have been mined. Of the 40, about 20 are currently being mined. The most-mined minerals are gold, platinum group of metals[3], nickel, chrome, and coal. Zimbabwe's mining law categorises the minerals into six groups, namely:

- **Precious metals:** gold, platinum group metals, and silver
- **Precious and semi-precious stones:** gemstones such as diamonds, emeralds, tourmaline, and rubies. Some diamonds may not be of gem quality (industrial diamonds), but they still fall under this category.
- **Base metals:** copper, nickel, iron, cobalt, tantalite, tungsten, lithium, and tin
- **Industrial minerals:** limestone, phosphate, magnesite, feldspar, graphite, and asbestos
- **Quarry material:** sand, clay, basalt, and granite rocks
- **Energy minerals:** coal, coal bed methane, natural gas, uranium and petroleum

What is artisanal and small-scale mining?

There is no consensus in Zimbabwe on how to define ASM. It is, however, generally accepted that the sector has at least two categories:

- **Small-scale miners** own blocks of claims and may employ people. Small-scale mining is appropriate for mineral deposits where some degree of mechanisation is cost-efficient.

[3] Platinum group of metals (PGMs) include platinum, palladium, rhodium, iridium, and ruthenium. However, the production of PGMs results in by-products in the form of gold, copper, nickel and cobalt. The elements of most interest among PGM ore are the 4Es (that is, four elements) platinum, palladium, rhodium, and gold.

- **Artisanal miners** do not own blocks of claims and mine on other people's claims or on land that is not registered for mining. Artisanal mining is appropriate for small, shallow deposits that can be accessed manually. Artisanal miners can either be full-time or seasonal workers who engage in other income-generating activities. Their population fluctuates with mineral prices; sudden mineral finds (bonanzas), especially for precious metals and stones; and levels of productivity in other sectors of the economy.

10 interesting facts about ASM in Zimbabwe [4]

1. An estimated 500,000 Zimbabweans engage in ASM directly and at least 1.5 million people benefit from it directly and indirectly.
2. One in 10 of these miners are women.
3. ASM produced 53% of all the gold produced in Zimbabwe in 2017 [5]
4. Seven in 10 miners work on mines with a certificate of registration and a valid annual operating license.
5. 76% of miners completed secondary school education.
6. Seven in 10 miners have not received official training in mining. Nine out of 10 women miners have not been trained.
7. 4% of adult miners in ASM use child labour.
8. Most miners are married (78% of men, 62% of women), dispelling the notion that most miners are single.
9. Only one in four miners knows the dangers of using mercury.
10. Almost all miners have problems of accessing finance from the formal financial system because of lack of collateral security.

[4] All except for the third are from: Pact. (2015). A Golden opportunity: A scoping study of ASGM in Zimbabwe. Washington, D.C.: Pact.

[5] Reserve Bank of Zimbabwe January 2018 Monetary Policy Statement: Enhancing Financial Stability To Promote Business Confidence

ASM and economic development

The ASM sector has been a major contributor to the country's economy in recent years. As noted above, in 2017 alone, more than half of the national gold output came from the ASM sector. This record came from figures presented by Fidelity Printers and Refiners (FPR), meaning it only represents gold traded formally. If gold flowing illicitly within the sector was accounted for, a much higher figure could have been recorded.

Many miners who get into ASM do so to escape poverty. According to World Bank data, 72% of Zimbabweans are poor.[6] A study conducted by Pact in 2015 found that ASM can help get people out of poverty. Comparing miners and non-miners who are not gainfully employed in the same communities, the study showed that people who do not engage in ASM are 67% more likely to be poor than those who do. It also found that miners make 39% more money. Though most of the people in the ASM sector are informally employed, the sector has helped alleviate Zimbabwe's extremely high unemployment rate, which is estimated to be more than 85%. However, miners' incomes are still not enough to enable them to invest in better equipment. On average, a miner makes US $210 a month, has a family of five, and makes no monthly savings. [7] This income is below half of Zimbabwe's poverty datum line.

In addition, because of inadequate mining and processing methods and other poor practices, environmental damage from ASM can be serious and working conditions can be very dangerous for miners. Both issues contribute to poor health. When miners are sick or injured, they become less productive and their low incomes become even lower [8] This keeps miners in a vicious cycle of poverty in which their decreased income guarantees that they will not be able to afford the necessary equipment to improve their efficiency and productivity.

To launch a mining project in Zimbabwe, there are five simple steps that one can follow. These do not include steps taken by sponsors or other individuals who may want to merge with miners that are already in the business. The flow process below outlines the sequence of steps:

[6] World Bank. (2015). Zimbabwe poverty atlas.

[7] Pact (2017). Impact of ASM on poverty in Zimbabwe.

[8] Hinton, J. et al. (2013). Small-scale mining handbook. Kampala.

Figure 1: Process of launching a mining project

Geology and Exploration

This module includes the following topics:

- Basic geology
- Definition of exploration and exploration methods
- Simple economic evaluation of mineral deposits
- Grade control

Geology

Common rock types associated with gold in Zimbabwe

Gold deposits in Zimbabwe are found in a variety of geologic environments, but most are around granite-greenstone contacts as disseminations in the rock cut by the quartz veins. The deposits in Zimbabwe are mostly in the Archean terrain, but significant deposits are also present in the Proterozoic rocks. The ores are hosted by different rock types with different deposit morphology, gold content, and alteration. The belts occur between granite and gneiss bodies and can be recognised by a greenish hue imparted by metamorphic minerals. The rocks reported to contain gold are described below.

Figure 2: Granite

A coarse-grained, felsic granular igneous rock. Granite is rock with at least 20% quartz and up to 65% alkali feldspar by volume. It can be white, pink, or grey in colour, depending on the mineralogy.

Figure 3: Diorite

A coarse-grained igneous rock composed principally of the silicate minerals plagioclase feldspar (typically andesine), biotite, hornblende, and/or pyroxene. The chemical composition of diorite is intermediate, between a gabbro and granite.

Figure 4: Andesite

A light to dark grey fine-grained, igneous rock rich in plagioclase feldspar minerals. It may contain biotite, pyroxene, or amphibole of intermediate composition. Usually the grains are not easily distinguished by an unaided eye, but it often contains large grains in the fine matrix (porphyritic).

Figure 5: Tonalite

A coarse-grained igneous rock of felsic composition. Feldspar is present as plagioclase (typically oligoclase or andesine).

Figure 6: Basalt

A dark-coloured, fine-grained, igneous rock composed mainly of plagioclase and pyroxene minerals.

Figure 7: Monzonite

A felsic igneous rock composed of approximately equal amounts of plagioclase and alkali feldspar, with less than 5% quartz by weight.

Figure 8: Tuff

An igneous rock that forms from the products of an explosive volcanic eruption. It often contains fragments of bedrock, tephra and volcanic ash.

Figure 9: Felsite

A light coloured, very fine-grained igneous rock that may or may not contain large mineral grains. It is composed mainly of feldspar and quartz. Felsite is also called felstone.

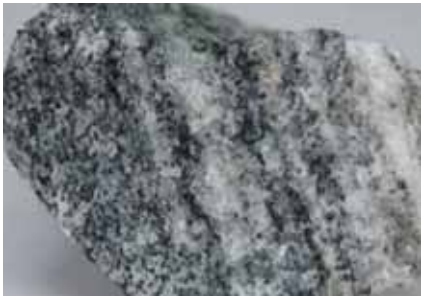


Figure 10: Gneiss

A metamorphosed igneous rock (granite) containing coarse linear banding defined by dark bans alternating with light bands.

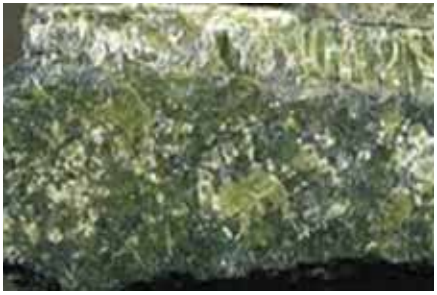


Figure 11: Serpentinite

A metamorphic rock formed by serpentinisation of mafic rock and composed of one or more serpentine group minerals. Serpentinite appears greyish, greenish, brownish, or spotted.

A dark-coloured, heavy and weakly foliated amphibolite with an igneous protolith. It contains amphiboles, especially hornblende and actinolite with plagioclase, and little or no quartz. The small flakes of black and white in the rock often give it a salt-and-pepper appearance.

Figure 12: Epidiorite

A fine-grained, foliated, homogeneous metamorphic rock composed mainly of clay minerals or micas.

Figure 13: Slate

A foliated metamorphic rock created from slate that is further metamorphosed so that very fine-grained micas achieve a preferred orientation.

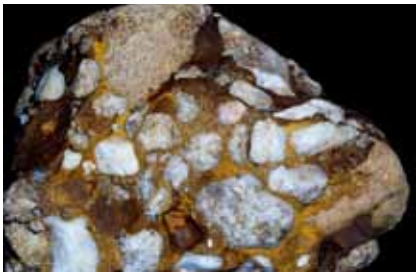
Figure 14: Phyllites

A medium-grained metamorphic rock with more than 50% flat, sheet-like grains in a preferred orientation. In Zimbabwe, schists reported to contain gold include serite schist, actinolite schist, tremolite schist, hornblende schist, chlorite schist, graphitic schist, talc schist, and carbonate schist.

Figure 15: Schist

A fine-grained, clastic sedimentary rock composed of mud that is a mix of flakes of clay minerals and tiny fragments (silt-sized particles) of other minerals, especially quartz and calcite. The ratio of clay to other minerals is variable.

Figure 16: Shale



A coarse-grained clastic sedimentary rock that is composed of rounded to sub angular gravel-size clasts that consists of granules, pebbles, cobbles, and boulders, larger than two millimetres in diameter.

Figure 17: Conglomerate

A medium-grained rock composed of sand-sized grains of minerals, rock or organic material. The grains usually consist of quartz. It is commonly red, but can be yellow, brown, grey or white.

Figure 18: Sandstone

A sedimentary rock consisting of repeated, thin layers of red and silver to black iron oxides alternating with shales, chert, chalcedony, jasper, or quartz.

Figure 19: Banded iron formation

Deposit Morphology

Deposit morphology ranges from veins to disseminated mineralisation. Greenstone gold-quartz vein deposits are the most common type. Usually, the gold is associated with quartz, which occurs as veins, stringers, shoots, and porphyries (coarse grains).In most cases, the quartz is white quartz. However, grey, blue, and black quartz have been reported to host gold in several localities in Zimbabwe. Blue quartz is rife in Gwanda, Chegutu, and Insiza. Gold is also associated with grits, carbonate veins, and quartz carbonate veins.

Figure 20: Quartz veins

Figure 21: White quartz

Figure 22: Grey quartz

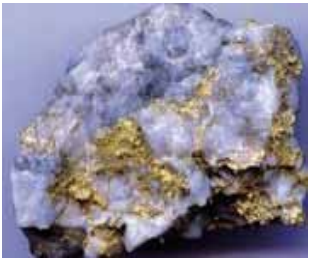


Figure 23: Blue quartz

Figure 24: Gossans

Figure 25: Box works

Figure 26: Sulphides

Indicators of gold ores

Pointers to gold mineralisation include:

Rock types: The rocks described above should be prospected for gold whenever encountered, particularly greenstone (rocks with a greenish hue).

Quartz veins: Quartz and carbonate veins running through rocks should be targeted. The quartz can be veins, stringers, shoots and porphyries.

Sulphides: Mineralisation in Zimbabwe is associated with sulphides; thus, occurrences of sulphides may contain gold.

Gossans: A gossan is an iron-bearing, weathered, rust-coloured rock product formed by oxidation of sulphides. It involves leaching out of sulphur and metals leaving hydrated iron oxides in form of a rock, mud or soil. In most cases it comprises of the iron oxides limonite, hematite and goethite. Though usually reddish brown, it can be stained various colours including yellow, brown and tan. It commonly forms from the oxidation of ore materials thus can be an indicator to a gold ore. In cases where gold hosting sulphides have rusted significantly, gold may be clearly visible.

Box works: When sulphides, especially cubic pyrite, oxidise and are removed, they often leave a relict texture of silica-rich ridges that look porous and are known as box works. Since sulphides are often associated with gold deposits, it is vital to investigate box works for gold. Whenever box works are found, it is prudent to visually look for gold at the ridges and to assay for gold in neighbouring material.

Streams, paleo streams, and depressions around greenstones: Gold is resistant to weathering but most rocks are not, so erosion tends to release the gold over time and transport the precious metal downslope to a nearby stream or depression; thus, low areas may be guides to placer gold.

Structures: Most auriferous quartz veins are controlled by structures such as faults, shear zones, foliations, joints, and fractures. These structures may indicate the presence of an orebody. Each time structures are encountered in the appropriate geological environment it is wise to sample and assay them for gold.

Geobotany: Some plants serve as indicators of gold mineralisation and are thus useful prospecting tools.

Mineral and element associations

Gold mineralisation in Zimbabwe is mostly associated with the sulphides: pyrite, pyrrhotite, chalcopyrite, arsenopyrite, sphalerite, and antimony. In many cases, gold has been reported to be associated with scheelite, molybdenite, bismuthinite, stibnite, tetrahedrite, gersdoffite, bornite, magnetite, tetradymite, cubanite, troillite, pentlandite, loellingite, niccolite, pyrolusite, malachite, jamesonite, crosoite, boulangerite, bertierite, gudmudite, and covellite, and with the elements including arsenic, antimony, silver, copper, palladium, and platinum tellurium. It also occurs as free grains in veins. Each of these mineral associations has special mineralogical characteristics that affect their processing. It can be difficult or impractical to remove some of the elements, like arsenic and antimony, from downstream processes.

Refractory gold

In Zimbabwe, significant gold occurs disseminated in sulphides or 'occluded' (locked up) in sulphides. Such gold is considered refractory gold and is not usually visible. Gold atoms can replace some atoms in the atomic structure of some minerals; for example, gold atoms are known to replace some of the iron atoms in the pyrite atomic structure. This gold is known as noseeum gold or invisible gold. It is not easy to extract refractory or noseeum gold using conventional methods of gravity concentration, amalgamation, or even cyanidation. The sulphides must be oxidised to expose or liberate the gold. Oxidation can occur through roasting, mixing with oxygenated water, or bleaching. Refractoriness in gold ores can also be caused by the presence of other metals or substances, such as copper or carbonaceous material.

Impacts of lithology in grade control

Processing of gold is dependent on the mineralogical characteristics of the rocks. Alteration and oxidation of host rocks also affects mining, milling, and recovery methods. Using mineralogical and occurrence characteristics, gold-bearing ores can be arranged in order of the ease with which they can be processed:

- Placers
- Oxidised ores
- Free milling ores
- Silver-rich ores
- Iron sulphide-rich ores

- Arsenic sulphide-rich ores
- Carbonaceous rich ores
- Copper sulphide-rich ores
- Antimony sulphide-rich ores
- Telluride-rich ores

Small Group Activity

In small groups, ask participants to considering their prospecting, exploration, and mining experience and answer the following questions:

- Which rock types described in this module have you overlooked in the past? Why?
- Which mineral/s and/or elements are associated with your gold?
- Which indicators of gold ores are realistic?

What is exploration?

Exploration can loosely be regarded as comprising of prospecting and exploration. Mineral prospection is the earliest stage of searching for a mineral. Exploration is concerned with establishing the size and characteristics of a mineral deposit. In essence, exploration depends on the results of prospection. The general purpose of mineral exploration is the discovery of new deposits that can be mined economically. Exploration is followed by mine design and planning, which then lead to the development of a mine, and finally to exploitation of the mineral resource. Further exploration can be carried out while exploitation is in progress to increase the mineral reserves. In Zimbabwe, various exploration methods and techniques such as geochemical analysis, geophysical analysis, and drilling are employed to determine the feasibility of mining and to prolong the life of mine among several reasons.

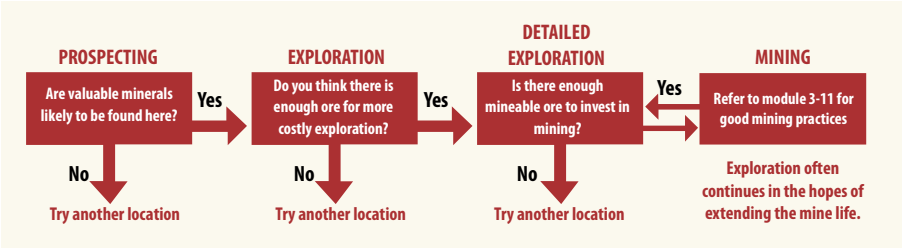


Figure 27: Steps from prospecting to mining

Exploration options for ASM are generally limited because of the high cost. However, exploration is an essential stage of mining because it deals with the establishment of the mineral deposit. Inadequate exploration can result in losses because miners sometimes invest in mineral occurrences without sufficient grade and tonnage to guarantee profitable returns. They may use very primitive methods and rudimentary techniques, such as the use of wires or grass straws, to identify mineral occurrences. Miners also rely on exploration that was done by former white miners, such as the Germans, before they left the country. It is generally believed that these miners planted certain types of trees along the path of gold reefs. Miners in ASM now use the trees as markers for gold reefs and roughly 80% of the time this technique yields positive results. The trees normally used are Cussonia arborea (mufenje), Syzygium cordatum (mukute), muvanga, and Ficus sycomorus L. (mukuyu). However, these techniques cannot be used to determine grade variations and tonnages of the orebody.

Exploration techniques

Geological exploration for gold mineralisation should follow systematically progressive stages, each employing at least one of the following methods.

- **Literature review:** Geological literature can provide guidance on where the sought mineral can be located. In Zimbabwe, the Geological Survey Department has readily accessible literature covering the whole country (to varying extents), including geological bulletins and geological maps.
- **Reconnaissance and prospecting:** This involves the initial actual physical search for the mineral.
- **Aerial reconnaissance:** Aerial surveys can utilise satellite imagery, remote sensing techniques, or aerial geophysical methods. These cover a wide area in a short period.
- **Geochemical survey:** The most common geochemical survey technique used in Zimbabwe is soil sampling. A grid is established, along which samples are collected for further chemical analysis at the nearest lab. This stage helps to demarcate the aerial extent of the orebody.

- **Geophysical survey:** Some mineralised areas possess unique geophysical properties and thus can be demarcated using various geophysical techniques carried out on a grid, such as geomagnetic surveys and induced polarisation. Geophysical techniques can help outline the aerial extent and in some instances the depth and position of the orebody.
- **Gold detectors**: These have been used by ASM miners and make use of frequencies that a particular mineral can give. In gold mining, gold detectors have proven to be useful where nuggets of gold or free gold can be found. The disadvantage is that they may detect other undesired metals at that frequency.
- **Pitting and trenching:** Once the mineralised area has been identified, pitting or trenching takes place. Trenching is systematically carried out across the strike of the near-surface ore body. Sampling is carried out in the pits and trenches.
- **Borehole drilling:** For very large and more deep-seated orebodies, a systematic drilling exercise is carried out to determine the extent, position, grade/quality, and any structural controls of the orebody. Common methods include reverse circulation and diamond core drilling. Borehole drilling provides information with a high degree of accuracy.

When carrying out exploration, it is important to identify the correct method to use at any stage, because each has a cost implication. It is therefore necessary to develop an exploration programme with the help of a geologist, which will help contain the exploration costs. For instance, after reconnaissance, a geomagnetic survey may follow, allowing areas without mineralisation to be eliminated and ensuring a focus on the mineralised areas for follow-up pitting and trenching. Locations for borehole drilling can then be easily identified as guided by the mineralised zones' geoparameters indicated during sampling of the pits and trenches.

The information resulting from exploration is useful evaluating the deposit and can be regarded as input for orebody modelling. This in turn is beneficial for mine design and subsequently for mine planning.

Sampling

One of the important parts of exploration and prospecting is sampling. This is critical for ensuring that mining is carried out based on facts. Samples need to be representative and care must be taken to make sure that samples are not contaminated, thereby giving a false impression of the deposit. It is therefore important to ensure that when minerals

The main methods of sampling include:

1. Grab sampling

2. Channel sampling

3. Chip sampling

4. Bulk sampling

The method you should use depends on the nature of the deposit and which properties you need more information about.

are collected they are properly secured. They then must be sent to a laboratory for analysis. From these samples, grades for the mineral deposit can be defined after finding assay values for the samples. The processing methods can also be defined at this stage.

Small-scale miners have another method of identifying rocks associated with gold. They grind the rocks using pestle and mortar and put the powder into a panning dish, followed by the complete process of mercury amalgamation. The presence of gold is deemed as the richness of that deposit. However, this rudimentary method does not give a true value of the mineral deposit.

Simple economic evaluation of mineral deposits

The purpose of evaluating the mineral resource is to determine the technical and economic viability of exploiting a given deposit. Technical viability depends on the results of exploration. Key questions include:

- Are the ground conditions favourable?
- How much water is there?
- Can it be pumped?
- What is the size of the deposit?
- Can the mineral be extracted from the ore?

Economic viability means that mineral extraction process can be done profitably and bring return to the investor.

Conducting resource and ore reserve estimates of mineral deposits is key for successful:

- Mine planning
- Investment and development decision-making
- Property and company valuations
- Acquisition and disposal of properties
- Debt and/or equity raising
- Financial accounting (e.g., calculating depreciation or impairment)

Keep in mind that resource estimates are approximations, not calculations. New information or a different geological interpretation can materially change estimates; there is no single correct resource or reserve estimate for a given deposit.

Resource estimation

A mineral resource is an estimate of size of the deposit in terms of tonnage and grade for a mineralised body. It is based on sampling and assaying. The estimate represents what is economically extractable based on reasonable assumptions about the technical and economic conditions. A mineral resource estimate involves determining the location, quantity, grade, geological characteristics and continuity are known, estimated or interpreted from specific geological evidence and knowledge. Mineral resources are classified as measured, indicated, or inferred based on confidence in geological and grade continuity and the quantity, quality, and distribution of sampling data.

Inferred Mineral Resources ▪ Mineral resource estimated with a **low** level of confidence due to inadequate geological knowledge, limited sampling data, data of uncertain or poor quality, or uncertain geological and/or grade continuity. ▪ Available data/information is not sufficient for detailed planning.	'It is inferred from geological evidence and assumed but not verified geological and/or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes which may be limited or of uncertain quality and reliability'[9]
Indicated Mineral Resources ▪ Mineral resource estimated with a **reasonable** level of confidence. ▪ Data/information is sufficient to allow the application of technical and economic parameters, and to enable an evaluation of economic viability.	'The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed'[10]
Measured Mineral Resources ▪ Mineral resource estimated with a **high** level of confidence. ▪ Data/information is sufficient to allow the application of technical and economic parameters, and to enable an evaluation of economic viability that has more certainty than an evaluation based on an indicated mineral resource.	'The locations are spaced closely enough to confirm geological and grade continuity'[11]

[9] Australasian Joint Ore Reserves Committee (JORC). (2004). JORC code.

[10] Ibid.

[11] Ibid.

Reserve estimation

An ore reserve is an estimate of the tonnage and grade that is expected to be delivered to the mill or treatment plant. It is the economically mineable part of a mineral resource (i.e., an economic asset). It is estimated based on mining, metallurgical, economic, marketing, legal, environmental, social, and governmental factors. Reserve evaluation statistically quantifies the grade continuity and mass of ore. Mining factors considered include the results of geotechnical assessments and engineering studies of the rocks within and surrounding the deposit, which determine potential instabilities. Metallurgical factors considered include milling and extractability characteristics of the ore, involving crushability, floatability, and other ore recovery parameters. Indicated and measured resources may be converted ore reserves. The factors assessed should demonstrate that extraction is reasonable and justified at the time of reporting. Ore reserves are sub-divided in order of increasing confidence into probable and proved ore reserves.

- **A probable ore reserve** is the economically mineable part of an indicated resource, and in some circumstances, a measured mineral resource. It includes diluting materials and allowances for losses that may occur when the material is mined.
- **A proved ore reserve** is the economically mineable part of a measured mineral resource. It includes diluting materials and allowances for losses which may occur when the material is mined.

Evaluation tools

Mining is all about managing operational costs to recover the initial investment and maintain production to secure revenue at fluctuating metal prices. Financial planning is therefore imperative. Some important tools and concepts in carrying out evaluations include:

- **Discounted cash flow** is a methodology often used for evaluations of mineral projects. It captures all cash inflows and outflows over the life of a project. The cash flow model must recognise the time-value of money by discounting at an appropriate rate to obtain the present value.
- **Net present value** is an indicator of how much value an investment or project brings to the investor.
- **Payback period** is the period required to pay back the initial investment from future cash flow. It provides an indication of how long it will take for a company to get a return on its investment.

Grade control

Gold grade is the proportion of the total mass of gold to the total mass of rock that contains it. It is the concentration in each mass, usually stated as grams per tonne. Grade is not equal to reserve, but when it is known, it is used to estimate ore reserves, thereby forming a basis for attaching a value to the property. The value of the rock can be stated in monetary terms by applying the price of gold; the profit is value obtained from rock minus costs. Since value depends on grade, the grade of your ore is one determinant of your profit margin. Thus, it is critical to control the grade of the ore to optimise its value and maximise profit. No matter how good the other processes are, the full potential of an operation will not be realised if the grade is not controlled. Additionally, by controlling grade, a miner can overcome uncertainty and minimise risks and conflicts with the miller.

Strategies for controlling grade

Understanding, quantifying, and controlling mining-related procedures assists in grade control. The main grade controlling mechanisms require an understanding of rock types, sampling, assaying, data management, and resource/reserve modelling. Some of the means utilised to control grade include:

1. Systematically obtaining rock samples and assaying the various gold bearing rock types occurring naturally in the mining concession.
2. Tracking laboratory performance of the gold bearing mineralisation using quality control samples.
3. Correctly delineating ore by including blast movements and rock alteration. Rocks and ore move when blasted and therefore grade control is not optimised unless this movement is taken into consideration. This is done by defining the post-blast ore polygons. This is not an onerous task; it typically takes less than half a man-day, but the potential benefits are orders of magnitude greater than the cost of not redefining. The orientation of the ore polygons relative to the direction of movement has a significant impact on ore loss and dilution.
4. Block modelling over appropriate levels depending on continuity of geology and grade.
5. Ensuring mining equipment implemented for ore extraction is optimal for the purpose especially where selective mining is taking place.
6. Checking whether material from the pits is being transported to the rightful stockpile destinations and carrying out a stockpile tally to confirm.

7. Managing your data well. A well-managed database is important for effective grade control and blending.
8. Blending ore to the required grade before processing. When rock is too low-grade to make money, it can be blended with high grade variations in geology and smoothed out when blending. The variability of the ore determines the amount of blending required. Process selected must then be able to cope with ore type variations that are inevitable, even after blending.
9. Selectively processing ore according to complexity. If you have a lot of noseeum gold, for example, which is costly to mine and recover, you may consider selling it to a mining company rather than taking on the cost yourself.

Sampling for grade control

Designing a good sampling program requires properly planned sampling methods and techniques. It also requires some understanding of the structure of the ore deposit, since adequate and representative sampling takes into considerations the deposit morphology.

Grade sampling techniques vary according to the mining method being used. Sampling can be either primary or secondary. The geology controls the correct orientation for grade control sampling. A mineral deposit should be resolved into distinct and separate types of mineralisation. Each type should be sampled as separate entity rather than one large sample to get a better grade estimate. In drilling, the angle and depth of the sample should go across the structure of the deposit.

Some things to think about include:

- **Rock types:** A correct extraction and collection of the material is delimited by type of rock and takes into consideration alteration, planes of weakness, and variations in hardness.
- **Mineralisation:** Always collect samples to represent all types of mineralisation.
- **Sampling methodology:** Use a methodology that is commensurate with rock type and mineralisation. Intervals, samples split, optimum sample length, number of samples and size of sample should be defined by geostatistics.
- **Sample homogenisation and splitting methodology:** Ensure the final sample represents the parent material.
- **Possible sources of losses and contamination:** Right and clean (free from foreign material) samples must be used.

- **Due diligence:** Ensure careful sample numbering, check on deliberate faults, and provide clear instructions to the laboratory.

The following sections describe the sampling techniques that are best suited for the major mining methods.

Surface/open-pit reef grade sampling

Depending on the depth to be drilled, the geology, costs that can be sustained, and target timelines, reef samples can be augured or drilled to produce rock chips or core samples. If a core is produced, a cone splitter should be used for secondary sampling. Material that hinders sub-sampling can be sub-sampled by means of a riffle splitter, choosing the sub-sample at random and not from the same side of the riffle for subsequent splitting.

The ideal primary grade sampling method is **reverse circulation drilling**. Some of the advantages of this method include accuracy, low contamination from other materials, and samples from greater depths. Reverse circulation drilling is also simple, fast, and safe, and it requires fewer man-hours and less water than other methods. The location and depth from which the sample was collected can be conveniently labelled. The disadvantages are that this method has less geological relevance and that the holes created are susceptible to movement if not properly stabilised.

Underground reef mining

For an underground operation, **chipping** is the ideal sampling method. The size and the sampling interval should be based on the channel width, variability of the grade, and the type of reef. Chip sampling can be done by hand or machine. No sub-sampling is usually necessary since chips are not big (in most cases less than 0.5 kilograms). However, a sample divider should be used to collect a specific mass fraction from the original sample after crushing if the original sample mass exceeds the capacity of the mill.

Placers

Sampling of placers is difficult, as placer deposits are naturally stratified. Placers can also have crevices, variable boulder size and number, clay content, water, false bedrock and other physical characteristics that affect sampling. **Stratified sampling** is thus ideal for placer deposits. The samples can be recombined statistically into one composite. Good placer sampling requires larger-sized bulk samples and accurate collection of materials from all layers. The nugget effect associated with most placer deposits makes sampling for grade even more difficult. Placers with less variation may be adequately assessed with a

reasonable number of samples, while a highly variable deposit may not be adequately sampled regardless of how many samples are taken. There is no one ideal method for sampling placers, but drilling placer deposits is recommended. Sampling a placer deposit should be done by or under the direction of a person with experienced in placer sampling.

Mine dumps

Often, old dumps contain economic mineralisation. This can be explained by oxidation of refractory ores, updated methods of recovery, past errors, and change in prices. Special techniques that consider the layered structure of mine dumps must be used, since mine dumps are created differently than natural hard rock deposits. **Stratified channel sampling** is thus ideal for dump sampling due to variations in either grain size or mineralogy. Channels cut across the surface of the dump need to be arranged perpendicular to the layers of the dump, a direction that is usually parallel to the haulage track on which the dump was built.

Mining Methods and Maintenance

This module includes the following topics:

- 🕮 Surface mining methods
- 🕮 Underground mining methods
- 🕮 Rock breaking (winning) equipment
- 🕮 Loading and hauling equipment
- 🕮 Hoisting or transportation equipment
- 🕮 Size reduction (comminution) equipment
- 🕮 Ancillary equipment

Established mining methods generally apply to large-scale mining operations and some already formal small- to medium-scale mining operations. Usually miners in the ASM sector just mine following the identified mineralisation, not paying attention to any pattern. This practice poses risks in terms of safety and productivity. Since no rock mechanics have been done to assess ground response and no appropriate corresponding measures have been put in place, there will likely be ground movement, which can result in fall of ground accidents. Many lives have been lost in this manner throughout ASM history. Because of the absence of a defined method, full recovery of the mineralisation is impossible. It is therefore necessary that ASM miners are educated on established mining methods so that they downscale or hybridise their current

mining techniques with the standard methods. Every mineral deposit, with its geology, grade, shape, and volume is unique. This means even though methods have been established, the rock is variable, and the world of mining will always display special features. This module lays out a basis upon which miners in the ASM sector can ensure safer working environments as well as more productive operations.

In Zimbabwe most gold is found either in placer deposits or in the hard rock/lode type deposits, commonly known as vein gold. In the placer deposits, gold has been washed away by flowing water or carried by blowing wind and deposited along with earth, sand and gravel onto the riverbeds. In the Zimbabwean ASM sector, 80% of miners engage in underground mining, 10% in surface mining, and the remainder have hybrid operations that incorporate both underground and surface mining

A mining method consists of a sequence of production unit operations, which are executed repetitively in and around the production blocks into which an ore-body is divided. The operations of ore mobilisation, extraction, and transport are common to all mining methods, while other operations may be specific to a particular method. Differences between mining methods involve different techniques of performing the unit operations. The different operating techniques employed in the various methods are the result of the different geometric, geomechanical, and geologic properties of the ore-body and the host rock medium.

Depending on the nature and geology of the ore deposit, various techniques can be used for mining the ore. Mining methods are generally categorised into two forms depending on the nature of existence of the gold: **surface mining methods** for placer deposits such as alluvial (along rivers) or eluvial (gravels) gold and **underground mining methods** to mine hard rock deposits. Beneath the broad classification are several methods resulting from the different geometric, geomechanical, geologic and economic properties of the orebodies.

Surface mining methods

When the ore deposit occurs close to the surface or where it is part of the surface soil or rock, it is usually more economical to mine it using surface mining methods. For large-scale miners, strip mining, open-pit mining, opencast mining, and quarrying are the most commonly used methods. For ASM, the most common methods are open-pit mining of sub-surface gold and gravels, alluvial mining (river panning), and dump reclamation.[12]

Open-pit mining

Open-pit mining involves the removal of topsoil and other layers of the ground to access the ore. Complete disruption of the surface always occurs with this

[12] At the time of publishing, river panning by individuals is illegal in Zimbabwe. Only the State can mine in rivers.

Figure 28: Abandoned open pit mine

type of mining, affecting the soil, animals, plants, and surface water bodies. This has an impact on other land uses such as farming and residential use. If the open pit reaches the water table, it can also affect groundwater. In some cases, the material is soft enough to be removed by mechanical means, ranging from digging using picks and shovels to using excavators and dump trucks. However, when the rock is solid and hard, it is shattered using explosives (rubble mining). The photo below shows an open pit abandoned in Zimbabwe which also became a death trap for livestock and other animals because it was left unfenced, making it possible for children and young adults to swim and drown in the deep pool of water that had collected in the pit over the years.

The sequence of operation for open-pit mining can either be drilling, blasting, and hauling or simply excavation by machinery in a systematic block-by-block manner.

Loading of mineralised and waste material is conducted using a combination of manual shovelling and mechanised loading. Mineralised material is broken using picks, pinch bars, and shovels, and the broken material is either hand-loaded or mucked into trailers using a multi-terrain loader. The broken material is then transported to a beneficiation plant through a tractor-trailer arrangement. Waste material is handled in a similar manner and transported to the waste dump.

ASM miners of the lowest rank often do not dig their pits in a sustainable manner. Instead, they typically dig random pits, usually up to two meters

deep and extending several meters laterally. Excavation then follows where the mineralisation leads, and this practice is usually performed on rubble ore deposits or mineral outcrops. Usually land is left degraded after mining.

Dump reclamation

In the past, processing methods to extract minerals such as gold were not as efficient as they are today, and mineral prices were often lower. This meant that grades of ore that were considered as waste rock in the past can be processed profitably today. Dump reclamation refers to the reprocessing of the tailing dumps or waste rock of old mining operations. Zimbabwe had hundreds of small-scale mining operations, many of which were abandoned. Some miners reprocess the waste rock and tailings dumps either to recover free gold but in most cases, they use cyanide to recover the contained gold. The key environmental impact of reworking dumps is the risk of contaminating surface water bodies with chemicals (such as cyanide) and dust pollution.

Alluvial and eluvial mining

A distinct feature of sand-mining operations is the application of the panel method. The panel technique of mining alluvia and eluvia can be carried out both at artisanal and mechanised operational levels. The difference between the two lies in the excavation methods employed. Artisanal miners use shovels, ground chisels, and pickaxes to remove the overburden, dig, and load the sand, while mechanised operations employ excavators for stripping, digging, and loading. The panel method requires that miners divide their areas into blocks prior to any mining operation. Once the area has been divided into blocks, the overburden is stripped from one block and deposited onto the next block. The mining of sand/alluvial is then carried out in the first block. After the first block is exhausted, the overburden is then returned to fill the hole left behind. The procedure is then repeated in the subsequent blocks. This minimises adverse environmental impact.

Strip Mining

Strip mining is ideally applied where the surface of the ground and the ore body itself are relatively horizontal and not too deep under the surface, and a wide area is available to be mined in a series of strips. Walking dragline excavators have been the most popular machines for this type of mining for many years due to their flexibility, utility, and availability, but more importantly, their low operating costs for waste mining.

Terrace mining

Terrace mining is a multi-benched, sideways-moving method in which the whole mine moves over the ore reserve from one end to the other, but not necessarily in a single bench. The number of benches used is usually a function of the excavation depth and type of machinery used.

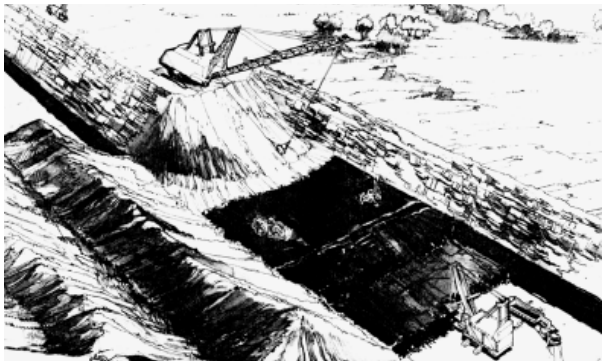


Figure 29: Strip mining with dragline on overburden and rope shovel loading coal below

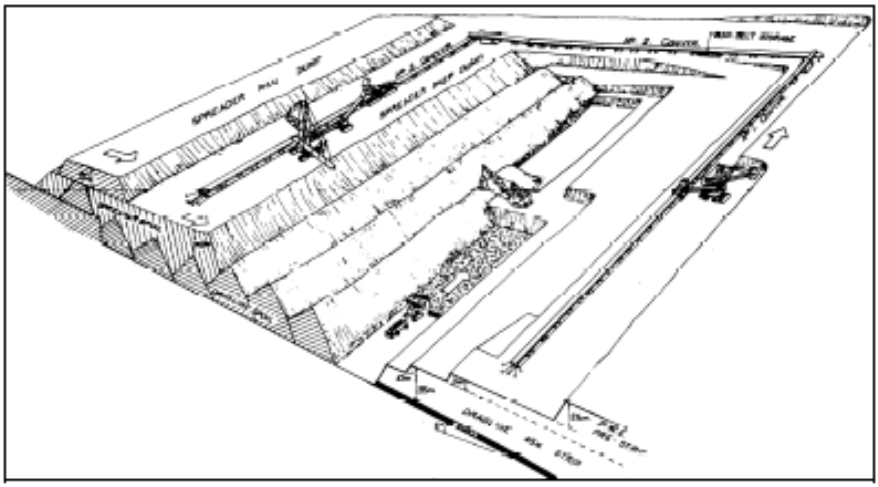


Figure 30: Combined terrace and strip mining methods and associated equipment

Underground mining methods

Figure 31: Vertical shaft

Underground mining is utilised when the ore lies deep in the ground and it is no longer economical to remove all the material above it to access it. The goal of underground mining is to access the ore while moving as little of the waste rock and material as possible. However, it often involves leaving behind some of the ore as pillars to ensure the underground tunnels do not collapse. There are some common mining techniques used in nearly all underground mines, such as developing access ways like declines or shafts, using pillars to support the hanging wall, using fans to ventilate workings, and using pumps to do dewatering. In the small-scale sector, underground mining can go as deep as 50 to 100 metres.

The most common types of shafts in Zimbabwe are vertical, as depicted in the photo above. In most cases, such shafts are sunk directly on top of the gold reef. With more rudimentary exploration techniques, the shaft may drive into an aquifer that may have been detected as a gold reef. When shafts intersect the reef, extraction of ore begins, usually following the leading reef with no mining pattern. The mining cycle employed involves compressor-powered jackhammer drilling, charging and blasting using explosive cartridges and ignitor codes, loading of broken ore into a wheelbarrow, coco pan, bucket, or skip then hoisting to surface with a mine hoist or windlass.

In general, the main direct environmental effects of underground mining methods are on groundwater, which is reduced by dewatering mine shafts and can be contaminated. Indirectly, underground mining contributes to environmental degradation due to the dumping of waste rock and tailings on the surface, surface subsidence because of dewatering, and the disposal of water pumped from underground during dewatering.

The figure below shows the basic infrastructure of an underground mine. Wherever access is made through a vertical shaft, there is a hoisting system comprising a head frame, shaft guides, a skip, and a cage. This shaft serves as an access way for men and materials as well as for ore hoisting. There must also be a ventilation shaft, which is usually an exhaust ventilation shaft through which foul air leaves the mine. Access to the orebody may continue to include extraction drives, cross cuts, ore passes, drifts, and draw points. The entire mine design criteria usually makes use of levels (systems of horizontal underground workings connected to the shaft). A level forms the basis for excavation of the ore above or below.

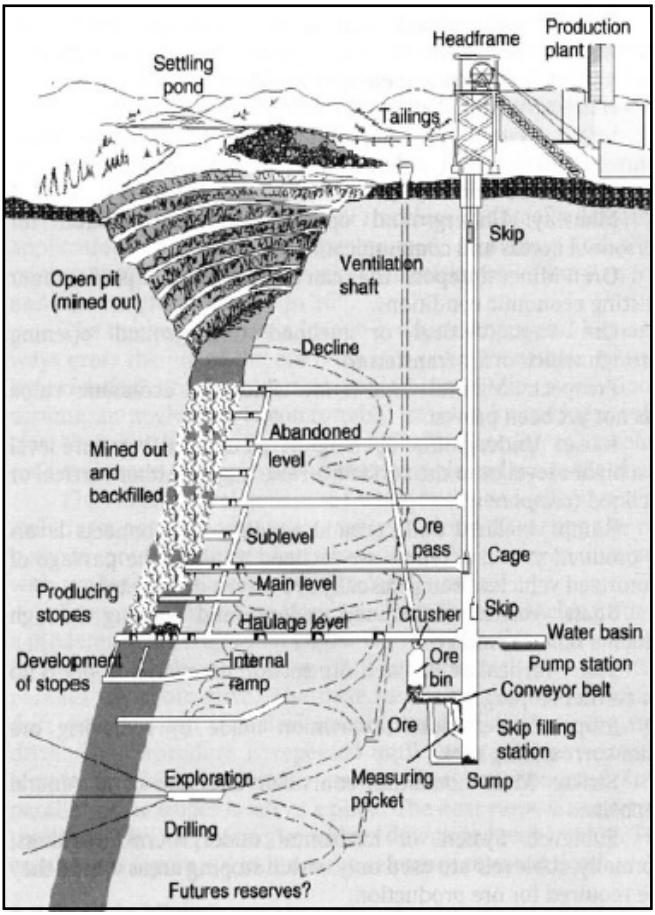


Figure 32: Basic infrastructure of an underground mine

The following sections outline the methods/techniques that can be employed economically in ASM when the reef or deposit is at great depth and the stripping ratio of the overburden to ore becomes unsuitable for surface exploitation. The choice of an underground mining method is often closely related to the geology of the deposit and the degree of ground support necessary to make the method productive and safe.

Mine Entries

Underground mine entry is mostly done using shafts, adits, or declines. Development workings (passageways for gaining access to the orebody from stations on individual mine levels) are called drifts if they follow the trend of

the mineralisation, and cross-cuts if they are driven across the mineralisation. Workings on successive mine levels are connected by raises, which are passageways that are driven upward. Winzes are passageways that are sunk downward, generally from the lowest mine level. Adit mining on hillsides or decline mining on flat ground can be done in rare cases, as shown below. In these cases, a horizontal or near-horizontal access is excavated into the mine. Hauling of ore from the mine is done either using a winch pulling the coco pans or by men pushing the coco pan. Similar mining practices are also employed by ASM miners on abandoned old mines.

Figure 33: Decline into a small-scale gold mine

Resue mining

Resuing, an underground ore extraction technique, is a method of stoping wherein the wall rock on one side of the vein is removed before the ore is broken. This method is employed when mining thin ore bodies including narrow gold veins (less than 30 inches/76 centimetres) and yields cleaner ore than when wall and ore are broken together. The resuing method consists of drilling and blasting the hanging wall waste to the full length of the stope face. The ore is broken down first and then the waste, or vice versa; usually the one that breaks more easily is blasted first. The broken waste is left in the stope, packed between the supporting props to completely fill the stope, and the ore is broken down on flooring laid on the fill to prevent admixture of ore and waste.

This method allows alternative cutting of waste to create working space and to expose the ore, which is then cut during the second phase. The loading and transportation of ore and waste material is done using a combination of manual shovelling and mechanised loading.

Underground 'ghetto' method

This method involves mining hard rock from underground workings, mostly in old and abandoned mines, that are accessed by shafts or adits. The fragmented gold-bearing rock is carried to the surface in bags by miners for processing. The underground method is employed by small-scale miners and is labour-intensive. It also involves high risks due to possibility of stope collapse in poorly supported stopes.

Diagrammatic presentation of mining methods

The figures below illustrate common underground mining methods. ASM usually sink a shaft perpendicular to the reef and once the reef is encountered, mining then takes any possible form depending on the behaviour of the reef. However, limited knowledge of the orebody structure is a major contribution to poor mine planning in ASM.

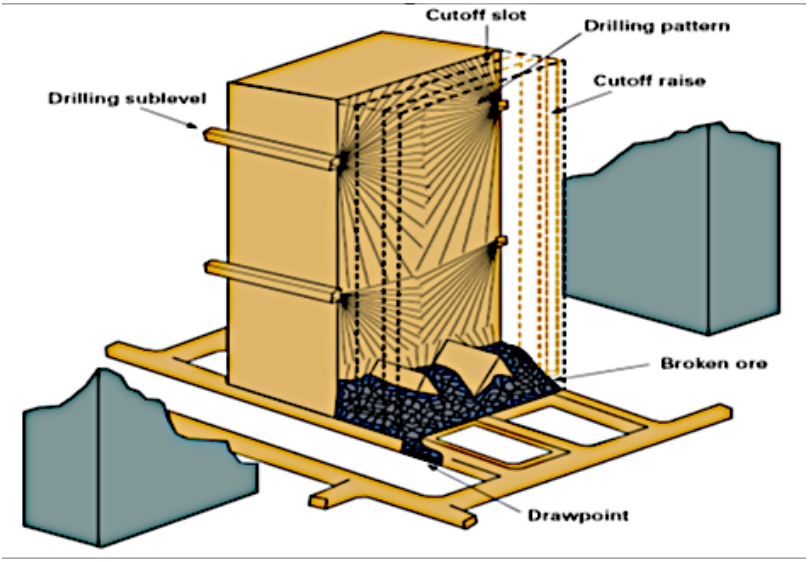


Figure 34: Typical generalised view of a sublevel stoping mining method, Mount Isa copper mine

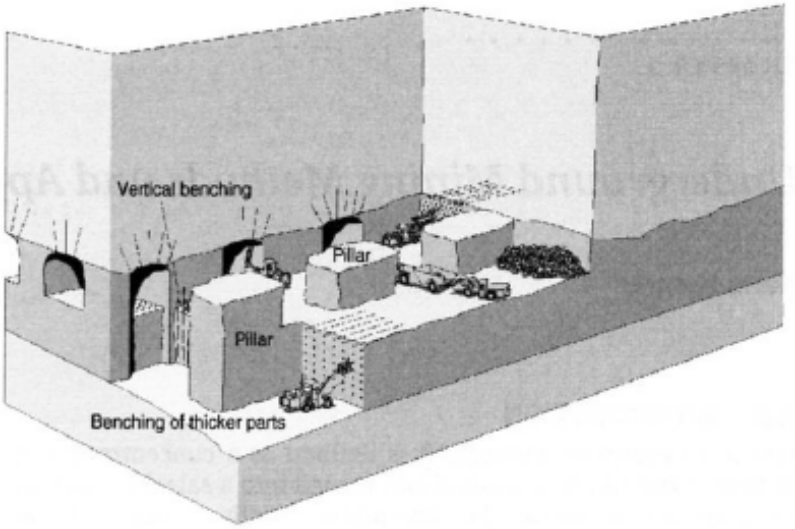


Figure 35: Room and pillar mine (classic variant)

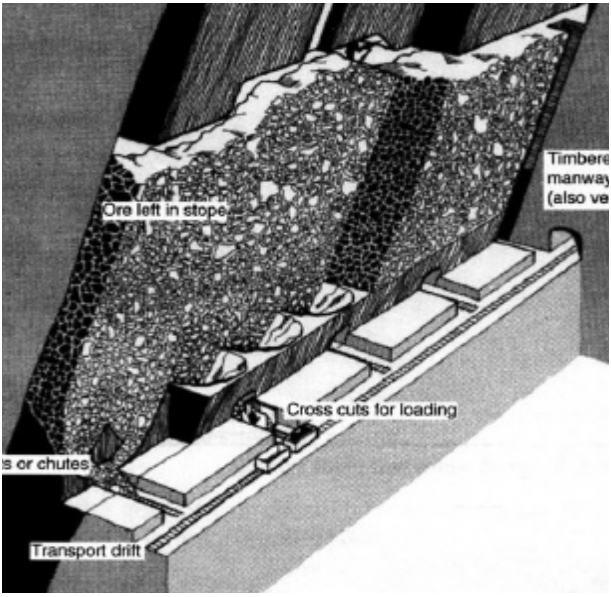


Figure 36: Shrinkage stoping

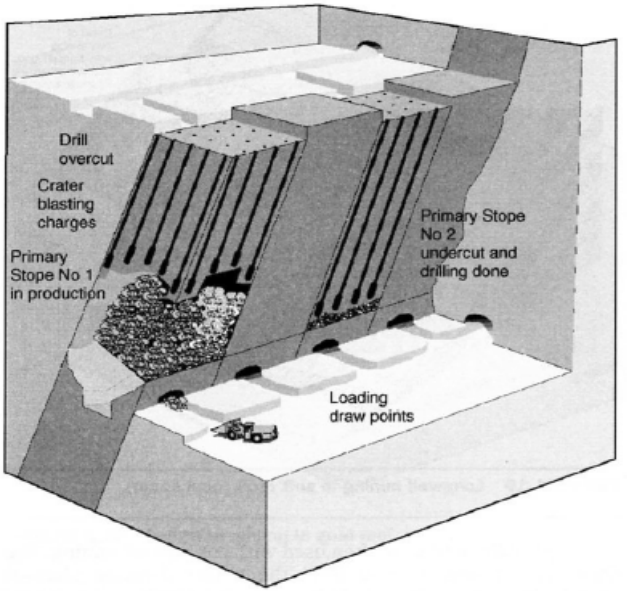


Figure 37: Vertical crater retreat method

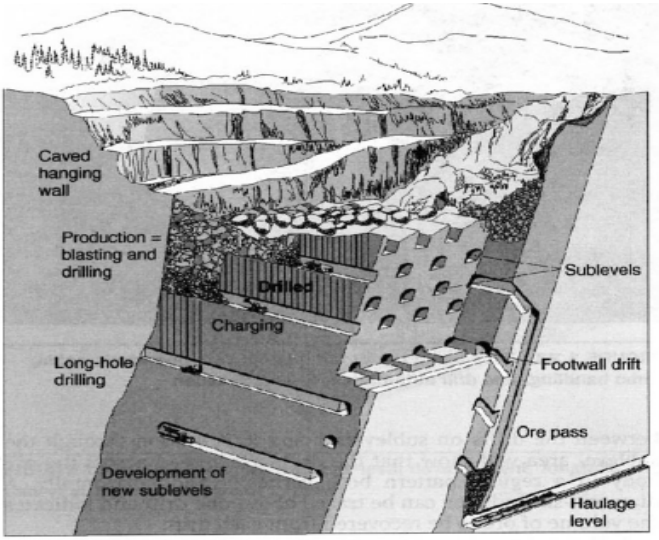


Figure 38: Sub-level caving

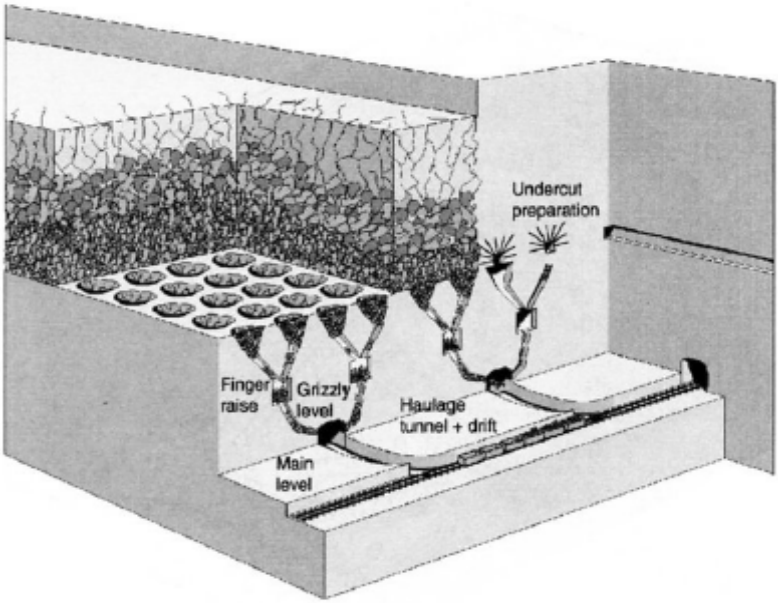


Figure 39: Block caving

Mining methods are not always uniform and therefore extraction procedures do not demand strict adherence to the theoretical or prescribed production cycle. The variations in ore deposits are so great and the state of mining technology so dynamic that being too specific could mislead learner miners. Every orebody is unique, and the successful application of a known mining method goes beyond classroom or textbook knowledge, requiring practical reasoning, creativity, and an openness to new ideas.

Maintenance of common types of equipment

Repairs and maintenance are expenses a business incurs to restore an asset to a previous operating condition or to keep an asset in its current operating condition. There are three basic types of maintenance: preventive/scheduled, corrective/reactive and predictive.

- **Preventive or scheduled maintenance:** Equipment or facilities are inspected, maintained, and protected before breakdown or other problems occur.
- **Corrective maintenance:** Equipment is repaired or replaced after wear, malfunction, or breakdown.
- **Predictive maintenance:** Sensor data is used to monitor a system

and continuously evaluate it against historical trends to predict failure before it occurs.

Organisations with best-in-class maintenance will spend 85% or more of their time performing planned maintenance. This can be further broken down into types: usage-based, condition-based, and unplanned. These organisations will spend about 30% of their time on usage-based maintenance and 50% on condition-based maintenance, leaving approximately 15% of their time for unplanned breakdown maintenance.

A successful maintenance program should have the following elements:

- **A work order system** that captures repairs needed, repairs completed, employee-hours consumed, and parts used.
- **A repair and cost history** kept on all major equipment units and components to track long-term repair problems requiring special attention.
- **Preventive maintenance** including strictly scheduled routine maintenance.
- **Oil analysis** done in conjunction with the preventive maintenance program.
- **Component failure analysis** that identifies the causes for component failures so remedies can be implemented.
- **Labour utilisation reporting** that tracks labour performance to spot inefficiencies in maintenance methods.
- **Mechanic training and safety incentives.**
- **Maintenance planning**, including daily and weekly plans to coordinate maintenance objectives and parts inventories.

A maintenance record can be made using a form like the one below.

Maintenance Record _____

Oil Changed (50 hr break, every 500 hrs thereafter) Changed by _____

Packing Change As Needed Changed by _____

Valve Change As Needed Changed by _____

Observations _____

Figure 40: Maintenance record format

Discussion Activity

1. Introduce the five categories of mining machinery: rock breaking equipment, loading and hauling equipment, hoisting or transportation equipment, size reduction equipment, and ancillary equipment.

2. Gauge existing knowledge by asking participants to give examples of pieces of machinery and equipment under category

3. Ask participants to share their ideas about why proper care and maintenance of mining equipment is important.

Rock breaking equipment

This category of equipment includes the machines that are used for the initial rock breakage from its in situ form. Rock can be broken by mechanical or chemical means. In mechanical rock breakage, only mechanical tools are used; in the ASM context, miners use a chisel and hammer, while in large-scale mining continuous miners, road headers, and tunnel boring machines can be used. In chemical rock breakage, the rock is first drilled with holes that act as repositories for chemicals (explosives), and then charging and blasting follows. Large-scale mines employ drilling jumbos, while ASM makes employs jackhammers.

Care, maintenance, and safe use of chisels and hammers

- Use a chisel that has been sharpened. Do not use a chisel that has a dull cutting edge.
- Do not use chisels that have mushroomed striking heads.
- Hold a chisel by using a tool holder, if possible.
- Do not use hammers with rounded, mushroomed, or damaged heads.
- Employ on-site sharpening and workshop machining of chisels and hammers every time the above anomalies surface.

Care, maintenance, and safe use of jackhammers

- Ensure all air and water hoses are flushed or blown clear before connecting them to the machine.
- Prevent dust or dirt entering the machine by plugging water and air inlets when disconnecting hoses from the machine.
- Fit the air-line with a lubricator, no more than three metres from the drill. If possible, fit it into the air inlet stem. Also, ensure that the

lubricator is working correctly and that it is regularly filled with the correct grade of rock drill oil.

- Ensure the end of the shank of the drill steel is flat and square to the axis of the drill steel. It must have a chamfer on the inside of the hole as well as outside the hexagon. Poorly maintained drill steels can cause damage to the drill.
- Do not use excessive thrust when collaring a hole.
- Increase the thrust gradually during a drilling operation. Under-thrusting of the drill will cause damage to the jackhammer and reduce its speed.
- Refrain from running the jackhammer at full throttle when it is not in use, this can cause the piston to seize in the cylinder.
- If a jackhammer is not working, do not try to force it to get running. This can cause subsequent damage. Remove the drill from the drill steel and ensure that it is not jammed in the hole. If the jackhammer is unable to run without the drill steel, send it for a service.

Loading and hauling equipment

This type of equipment is used to load broken rock and transport it for horizontal or near-horizontal distances within the mine or to a stock pile outside the mine. Large-scale mining operations use load haul dumpers, air loaders, locomotives, conveyor belts, underground dumpers, mine trucks, and loaders. ASM makes use of shovels and wheelbarrows, air loaders, mine cars, scrapers, and in some cases, small conveyor belts.

Care and maintenance of shovels and wheelbarrows

- For shovels, clean off mud, dry off water, and wipe with an oily rag.
- Clean wheelbarrow handles and pans and wipe them dry after use. Scrubbing
- with a wire brush should be done to remove stains.
- Grease the wheelbarrow axle before a squeaking sound starts. The frequency of greasing will depend on usage, so pre-task checks of all tools are necessary to
- ensure smooth operations.

Care and maintenance of air loaders/mucking loaders

- Check the hose assembly of the on-site loader.
- Always keep the mucking loader complete and clean. Pay special attention to the tunnel to prevent water leaking in by covering it with a rubber plate or canvas.
- Check and fasten bolts and nuts frequently checked. If the pin of the chain is
- missing, it should be added immediately.
- Frequently check each hydraulic component and the joints of pipes. Check if the high-pressure hose is not damaged, and immediately replace it if it is seriously damaged.

Care and maintenance of mine cars/locomotives

- Check and remedy any loose bolts and nuts, worn-out gears, thin bearing
- linings, and other minor defects before they become a source of serious trouble.
- Such inspections can be done before every shift and findings can be noted in a
- report of such format as below. This exercise can be applied to all equipment and reports submitted to mine supervisors.
- Ensure a stock of spare parts in the repair shop at the mine, especially those that experience has shown to frequently require repair or renewal.

XYZ MINING COMPANY

Report of condition of locomotive

Locomotive Number.....was carefully inspected by me on ...../...../...../...../.....and found to need the following repairs:.....
.....

Name:..... Signature:.....

Figure 41: Sample equipment inspection report

Hoisting or transportation equipment

This category of equipment is used to transport broken rock from the mine to the run of mine stockpile. It includes mine hoists, conveyor belts, locomotives, and windlasses. The figure below shows most common types of mine hoists. The single drum hoist is the most commonly used hoist system in ASM.

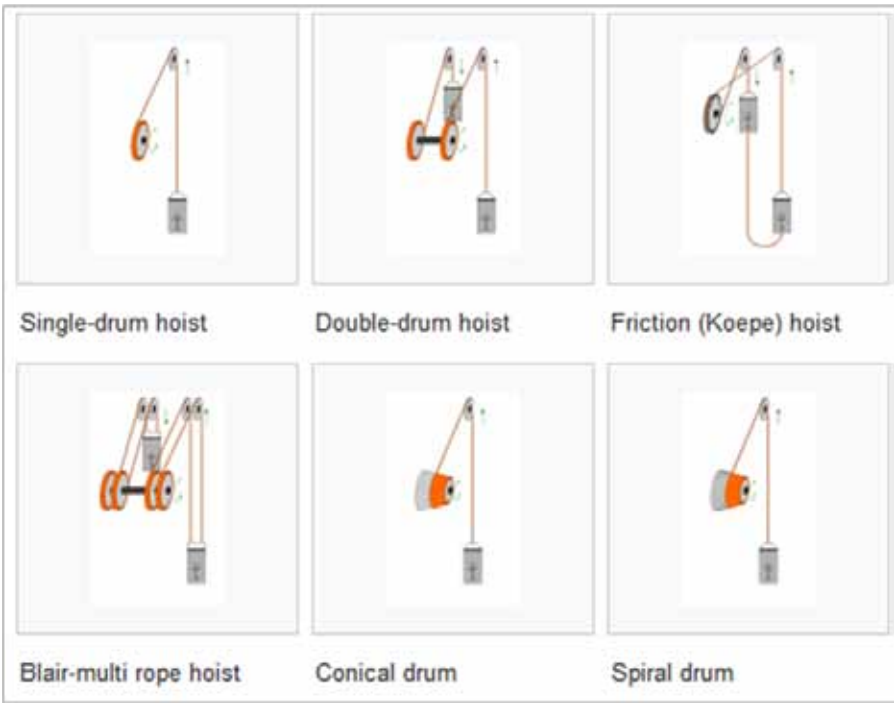


Figure 42: Mine hoists

Care and maintenance of mine hoists

- Maintain equipment so that hoist is operational when needed by inspecting and lubricating hoist and engine room equipment.
- Report defective machinery.
- Inspect safety catches on cages and conditions of cables.
- Make all required repairs.

Conveyor belts are not very common in ASM because of they require significant capital. However, in rare cases they are used, taking a simple construction shown below.

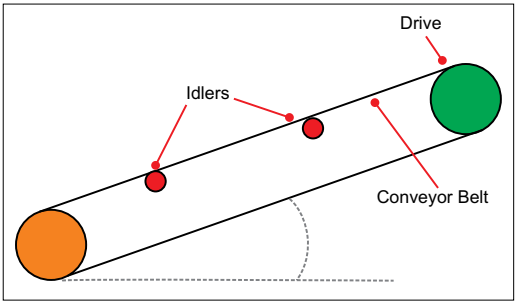


Figure 43: Simple conveyor belt system for ASM application

Care and maintenance of conveyer systems[13]

While the system is in operation, check the following issues and refer to all relevant safety warnings and information:

- Regularly walk around both sides of the system and note the condition, as well as any unusual behaviour of all the moving components.
- Note points of material build-up.
- Look for any signs of misalignment or improper belt tracking.
- Check drive amperage requirements and compare amperages to previous levels for similar loads and conditions. A rise in amperage levels may be an indication of increased drag within the system, perhaps due to failed or unlubricated bearings. This should be further investigated when the system is at rest and electrically locked out.

[13] Technology Transfer Services. (n.d.). Conveyor safety and preventive maintenance. Available at: https://www.myodesie.com/wiki/index/returnEntry/id/3050#Basic%20Conveyor%20Maintenance

While the system is at rest and electrically locked out:

- Confirm that components are in proper alignment and make necessary adjustments.
- Closely inspect suspect components and take corrective action as appropriate (i.e. if rolls are not revolving freely, re-lubricate or replace).
- Check all safety systems.
- Test control equipment.
- Check for belt wear (especially at edges and splices) and belt stringing.
- Check for damage or wear at loading and transfer points.
- Check clearances at chute and skirting areas.
- Remove any material build-up on components and clean up any spills along the system. Note that the causes of these should be investigated and corrected.
- Re-lubricate all pillow block bearings as per the manufacturer's schedule or the specific requirements of the installation.
- If it is capable of being relubricated, relubricate the troughing and return rolls as per the manufacturer's schedule or the specific requirements of the installation.
- Check the condition and functionality of belt scrapers and adjust or replace as needed.
- Confirm that all guards and covers are in place.
- Replace motor brushes as specified by the manufacturer.

Size reduction equipment

Size reduction equipment, as the name suggests, is used to further break rock into fine grains for either physical or chemical mineral recovery. Equipment in this category includes crushers and mills of different types, such as stamp mills, round mills, rod mills, and ball mills.

Care and maintenance of mills

- Keep pinions, gears, couplings, and gear reducers lubricated. Mill manufacturers is any of recommend Crater compound types.
- Reline ball mills.
- Conduct inspections at frequent, regular intervals paying attention to the condition of the wearing parts in the mill. Manufacturers recommend giving close attention to bolt tightness, foundation settlement, and condition of the grouting during the first 30 to 60 days of operation.

Ancillary equipment

Equipment that is used at a mining operation, but not used directly in the process of production, is called ancillary equipment. Examples include compressors, generators, diesel engines, pumps, and fans. There are many types of pumps, but the most common is the centrifugal pump. These pumps can either be pneumatically or electrically powered.

Care and maintenance of pumps

- **Routine inspections** for the whole range of pumps:
- Check the level and condition of the oil through the sight glass on the bearing frame.
- Check for unusual noise, vibration, and bearing temperatures.
- Check the pump and piping for leaks.
- Analyse the vibration.
- Inspect the discharge pressure and the temperature.
- Check the seal chamber and stuffing box for leaks.
- Ensure that there are no leaks from the mechanical seal.
- Adjust or replace the packing in the stuffing box if you notice excessive leaking.
- Perform the following tasks **every three months**:
- Check that the foundation and the hold-down bolts are tight.

- Check the mechanical seal if the pump has been left idle and replace as required.
- Change the oil every three months (2,000 operating hours) at minimum.
- Change the oil more often if there are adverse atmospheric or other conditions that might contaminate or break down the oil.
- Check the shaft alignment and realign as required.
- Perform the following inspections **once each year**:
- Check the pump capacity.
- Check the pump pressure.
- Check the pump power.
- If the pump performance is not satisfactory, and the process requirements have not °changed, then disassemble the pump, inspect it, and replace worn parts.

Efficient Mining Techniques

This module includes the following topics:

- 🕮 Drilling and blasting
- 🕮 Underground support and safety

Drilling and blasting in ASM

The objective of drilling and blasting is to prepare well-fragmented loose rock that is amenable to excavation and to enable greater productivity of the excavation machinery. The holes drilled for this purpose are defined as blast holes[14].

Drilling

In the context of mining, drilling refers to making holes in a rock mass. It is essentially a method of penetrating rock using a drill. In ASM, drilling is mainly required for production (i.e., for making holes for placement of explosives for blasting). There are two types of drilling: **exploration drilling**, which is done for geological survey purposes, and **production drilling**, which is done for placing explosives. Exploration drilling can include:

- **Diamond drilling:** Exploration diamond drilling is used in the mining industry to probe the volume and quality of known ore deposits and potential sites. By withdrawing a small diameter core of rock from the orebody, geologists can analyse the core by conducting chemical assays, and petrologic, structural, and mineralogy studies of the rock.
- **Auger Drilling:** Auger drilling is done with a helical screw which is driven into the ground by a rotation mechanism. The earth is cut and lifted up the borehole for further analysis by the blade of the screw. Auger drilling is an inexpensive and fast method used during the reconnaissance survey stage as part of mineral deposit exploration, but is also widely used in environmental drilling, geotechnical drilling, soil engineering, and geochemistry. This type of drilling is restricted to generally soft, unconsolidated material or weak weathered rock, unconsolidated alluvials, and old dumps.

Rock can be penetrated by overcoming its resistance to penetration by providing external energy. Depending on how this energy is imparted and how the broken

[14] Patil, J. & Damle, P.G. (2017). Up-gradation of rollers in track of open pit drill rig. International Journal of Scientific Research Engineering & Technology, 6(5), pp. 500-504.

mass produced by drilling is removed to get new surfaces to drill, the drilling methods and the drill can be classified into several categories. The table shows the classification of drilling and drills in a general mining environment from large to small-scale operation.

Table 1: Drilling classifications

Mode of energy application	Drill machine examples
Percussion	Jackhammer
Rotary	Auger or rotary drill, diamond drill
Rotary percussion	Drill jumbo, top hammer drill

Drills can also be handheld (e.g., jackhammers) or mounted on a skid, wagon, or crawler (e.g., skid-mounted drifters, pneumatic drifters). Crawler-mounted drills are used for drilling a hole in one pass (single pass drilling) from 7.6 to 15.2 metres, with a hole size from 120 to 229 millimetres. Wagon-mounted drills typically have a hole size of 63 to 150 millimetres.

Drills can use three different types of power:

- **Electric:** These have a higher cost but produce less noise.
- **Pneumatic:** These have a lower cost but produce more noise.
- **Hydraulic:** These may be diesel or electrically powered and they are hydraulically operated and controlled. They are a new development and produce less noise.

The rate of drilling a rock stratum varies with several factors, such as the type of drill and bit size, hardness of the rock, depth of the holes, drilling pattern, terrain, and time lost waiting for other operations. Once a drill type and bit are selected, then drilling production in terms of meterage can be estimated on hourly basis.

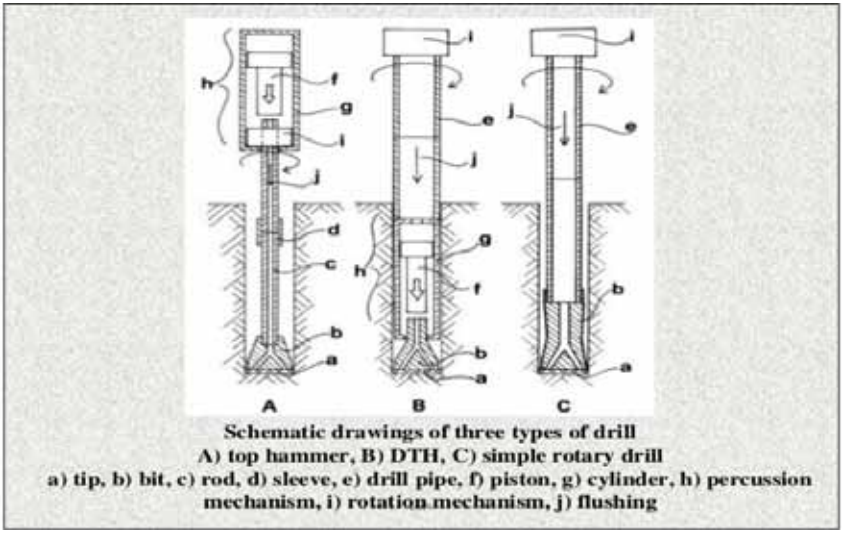
Rock drills, drilling accessories, and equipment

Drills: Jackhammers and jack drills are the most suitable and economical equipment for artisanal mining activities. The jackleg, which is a type of a jackhammer, is the most widely used drilling too in ASM. It operates on compressed air and provides fair productivity levels if properly maintained.

Figure 44: Jackhammer

Table 2: Types of drills

Type	Uses	Hole depth	Diameter
Jackhammer	General utility, shaft maintenance, shaft sinking (e.g., anchor holes, short vertical holes, pin holes)	0.3 to 3.7 metres	19 to 44 millimetres
Jack drill or jackleg	Small drifts or stopes, development	1.2 to 3.7 metres	32 to 44 millimetres
Stoper	Up hole drilling for stoping works	1.2 to 3.7 metres	32 to 44 millimetres
Drifters	Up hole drilling, horizontal and down hole drilling, long hole drilling, exploration drilling, grout hole drilling	1.2 to 30.5 metres	38 to 57 millimetres



Schematic drawings of three types of drill
A) top hammer, B) DTH, C) simple rotary drill
a) tip, b) bit, c) rod, d) sleeve, e) drill pipe, f) piston, g) cylinder, h) percussion mechanism, i) rotation mechanism, j) flushing

Figure 45: Drill types

When selecting the type of drill to use, consider:

- Type rock to be worked upon
- Method of mining
- Costs
- Availability of machinery
- Investment needed
- Age of mine

In addition, key environmental considerations include:

- **Noise control:** Jackhammers and jacklegs produce a lot of noise, so miners are encouraged to use earplugs when operating these machines.
- **Dust control**: Wet drilling should always be practised when drilling underground so that dust generation is eliminated at the source.

Drilling accessories: There are two basic accessory systems that are used in underground drilling: single pass and multiple pass phase systems. Single pass systems may be integral or tapered. An integral system has an integral drill steel consisting of a 25-millimetre hexagonal body that has some form of collar at one end and a brazed carbide tip at the other. They are popular for jackhammers, jack drills, and light mounted drifters, which are mostly suitable for ASM miners. Tapered systems are for drill jumbos in large-scale mining.

Drill bits are used to transmit the energy from the drill steel to the rock. They are the final interface between the rock and the drilling machine. Brazed bits are tungsten carbide inserts with a V-shaped cutting edge. They are found in the form of X-bits or cross bits and are commonly used with jackhammers. Button bits are cylindrical or spherical inserts (known as buttons) that are embedded in the cutting face. These are commonly associated with drifters.

Thrust and feed equipment: All drilling methods require a feeding system that pushes the drilling tool against the rock, maintains the advance of the bit as drilling progresses, and withdraws the tools once drilling is completed. A heavy weight or a pneumatic (pusher) leg is used with hand-held rock drills. For larger mechanised rock drills, whether hydraulic or pneumatic, the feed equipment is designed so that the drill sits on the carriage that travels a feeder called the guide shell.

Classification of drilling methods[15]

Drilling methods can be classified in several ways:

- By size of hole
- By method of mounting
- By type of power
- By form of rock attack or energy application

The following section outlines some of the key methods classified by form of rock attack as **mechanical**. Mechanical attacks encompass up to 98% of all rock penetration applications. Application of mechanical energy to the rock can be done through **percussion** or **rotary action**. A combination of percussive and rotary action yields hybrid methods, including **roller bit rotary** and **rotary percussion drilling**. In surface mining, roller bit rotaries and large percussion drills are in widest use.

[15] This section is adapted from: Satyanarayana, I. (2012). Basics of drilling. Retrieved from: https://www.slideshare.net/isnindian/basics-of-drilling-1

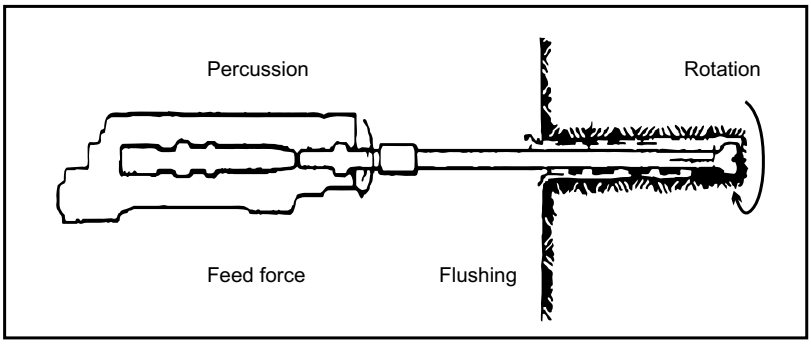


Figure 46: Illustration of rotary percussion drilling

A drill bit or the sharp end of the drilling tool is used to penetrate the rock, either through a dynamic force (percussion drilling) in which the bit rotates slightly in response to each stroke, or a static force (with a hammering effect). Small holes are most appropriately drilled in hard rock using percussion drilling with a top hammer. Conversely, down the hole (DTH) hammers are most appropriate for large holes in hard rock. Rotary drilling is most suited for large holes in soft-to-medium hard rock. As the bit advances through the rock, material is excavated and stripped out of the hole by shearing. The bit generally has a blade edge made of steel alloy ideal for soft rock drilling or an inserted carbide tip ideal for hard rock applications, or is composed of multiple round, conical, ballistic, or parabolic button tips made of hard alloy that are inserted into the leading face. Compressed air is blown through the drill rod, forcing out cuttings and providing a cooling effect on the rotation bearings and the bit. Compressed air also serves to minimise vibration and reduce friction between drill rods and the walls of the hole. Further, it maintains hydrostatic pressure, which sustains the walls and counters formation pressure.

In rotary drilling, the drill bit attacks the rock with energy supplied to it by a rotating drill stem. The drill stem is rotated while a thrust is applied to it by a pull-down mechanism using up to 65% of the weight of the machine, forcing the bit into the rock. The drill bit breaks and removes the rock by either a ploughing-scraping action in soft rock, or a crushing-chipping action in hard rock, or by a combination of the two. Compressed air is supplied to the bit via the drill stem. The air both cools the bit and provides a medium for flushing the cuttings from the hole. Water may be used in addition to the compressed air to suppress the effects of dust, however, this is normally found to have a detrimental effect on bit wear.

Blast hole sizes produced by rotary machines range from 100 to 445 millimetres in diameter, with the most common sizes being 200, 250, 311 and 381 millimetres. These drills usually operate in the vertical position, although many types can drill up to 25 or 30 degrees off the vertical.

There are two drilling methods by rotary drills: pure rotary drilling and DTH drilling. Pure rotary drills drive tricone or fixed-type bits. The fixed-type bits, such as claw or drag bits, have no moving parts and cut through the rock by shearing it and are limited to soft material. In DTH drilling, high pressure compressors are used to provide compressed air through the drill string to drive the DTH hammer.

The primary difference between rotary drilling and other methods is the absence of percussion. In most rotary applications the preferred bit is the tricone bit. Tricone bits rely on crushing and spalling the rock. This is accomplished by transferring downforce, known as pulldown, to the bit while rotating to drive the carbides into the rock as the three cones rotate around their respective axis. Rotation is provided by a hydraulic or electric motor-driven gear box (called a rotary head, which moves up and down the mast via a feed system).

Flushing

Cuttings are usually removed by compressed air in surface mining. Compressed air is efficient and versatile in long downward-sloping holes. Care must be taken to ensure that the annular gap between the rod and the hole is kept neither too narrow nor too wide. If the gap is too narrow, it will become clogged with coarse cuttings. If it is too wide, the air velocity will be too low to carry the cuttings. In this case the cuttings will be reground at the bottom of the hole, wasting drilling energy.

Blasting

Blasting operations in ASM are normally executed using safety fuses and cartridged explosives.

What is an explosive?

An explosive is a substance or mixture of substances which, with the application of a suitable stimulus (e.g., shock, impact, heat, friction, ignition, spark) to a small portion of the mass, is converted in a very short interval of time into other more stable substances, mostly gaseous, which occupy a much larger volume than the explosive in its original configuration.

Types of explosives

Explosives either react slowly (deflagrate) or rapidly (detonate). If the decomposition reaction moves through the explosive faster than the speed of sound in the explosive, it is termed detonation. If it is comparatively

slower, then it is deflagration, which is a rapid form of combustion. When an explosive detonates, it is transformed into a glowing high-pressure mass with temperatures up to 4,500°C and pressures of up to 400,000 bars. Since the energy is released within a split second, the power will be extremely high.

There are seven classes of explosives. You can remember these by taking the first letter of the words to make a sentence: '**G**o **B**ack **N**ow **C**oz **F**oreman **D**oesn't **B**last.'

Table 3: Classes of explosives

	Class	Example
Go	Gunpowder	Blasting powder, core of the safety fuse
Back	Blasting Agents	Water gels, slurries water emulsions
Now	Nitro-Compounds	Chemical compound consisting of nitro-glycerine
Coz	Chlorite Mixtures	Any explosive that contains a chlorite
Foreman	Fulminates	Chemical compound used for initiating detonation, e.g., Nonel
Doesn't	Detonators	Long period detonators (LPDs), short period detonators (SPDs), IEDs
Blast	Blasting Initiators	Ignitor cords, shur starts

There are four main types of modern commercial explosives:

- **Initiating explosives** are used only as a charge in detonators and detonating cord.
- **High explosives** are explosive materials that detonate, meaning that the explosive shock front passes through the material at a supersonic speed, producing a shattering effect. High explosives detonate with explosive velocity ranging from 3 to 9 kilometres per second. Examples of this type of explosive include tri-nitro toluene (TNT), nitroglycerin, dynamites, ammonium nitrate/fuel oil (ANFO), Explogel, Tovex, Megamite, and Power-Gel.
- **Low explosives** have a reaction velocity which does not exceed the sound velocity in the explosive. The explosion deflagrates instead of detonating. In action, they are characterised by a push or a lift rather than a shatter. Examples of this type of explosive include blasting powder, gun powder, ignitor cords, and safety fuses.

- **Blasting agents** are mixtures consisting of a fuel and oxidiser system, where none of the ingredients are classified as an explosive and cannot be detonated by means of a No. 8 test blasting cap when unconfined. A blasting agent consists primarily of inorganic nitrates and carbonaceous fuels and may contain additional non-explosive substances such as powdered aluminium. Examples of blasting agents are ANFO, some water gels, and emulsion explosives.

Explosives can also be classified according to their consistency or form. This decisively affects the cost-benefit ratio of blasting work by influencing the capacity and density of charging. It is quite usual to distinguish between the plastic and semi-plastic, the solid and the liquid explosives. Explosives are also classified in broad families as dynamites, water gels, and emulsion explosives, and as cap sensitive and non-cap sensitive. Cap sensitive explosives are those that are reliably initiated by a 6D detonator (e.g., dynamite, other nitroglycerin-based explosives, ANFEX, ANFO) while non-cap sensitive explosives are not. For these, more powerful priming is required using an 8D detonator.

The following are examples of high explosives:

- **Nitroglycerin:** A highly adaptable type of explosive that can give excellent results in small blast holes. However, with a new generation of explosives now available, the general trend has been to move away from nitroglycerin-based explosives, due to cost and potential to become unsafe because of severe environmental conditions and lengthy storage. Examples are Amon Gelignite, Dynagel Amon, and Dynamite Shaft trim.
- **ANFO:** A low cost, high power, high safety explosive made from porous prilled ammonium nitrate (AN) and fuel oil (FO) at a ratio of 7.5 litres FO to 100 kilograms AN. Once mixed, it is usually charged pneumatically into blast hole. It has a density of 0.85 and is not water-resistant. Nitrogen from AN combines with oxygen to form nitrous fumes. Fuel shortage will create excess oxygen condition, while excess fuel increases the amount of carbon monoxide formed.

  The optimum mixture of ANFO is given by the formula below:

  Fuel oil (in litres) = [6/94 * mass of AN] / 0.85

  ANFO is the least expensive explosive available, giving an explosive cost one-third to one-quarter that of nitroglycerin-based high explosives. When correctly used, ANFO performs as well or better than the dynamites and is safer to handle. However, it is soluble in water, so it cannot be employed in wet conditions.

Larger-diameter ANFO is supplied either in bulk or in waterproof polyethylene bags. The separate components, delivered for bulk mixing on site, are not classified as explosives and so can be shipped without incurring the extra costs of transportation and storage precautions. For relatively dry holes, bulk free-running ANFO is best because superior coupling is obtained.

- **Water gels:** Essentially ANFO made water-resistant by adding water and forming a gel. Due to some of the additives, like aluminium, they have a high velocity of detonation and produce less nitrous fumes. Examples are Explogel, Tovex, and Energex.
- **Emulsions:** Essentially ANFO made water-resistant by adding oil water to create a stable oil water emulsion of varying densities. These products are the safest and do not become more dangerous during prolonged charging periods.

Figure 47: Pre-packed water gel explosive

Figure 48: Bulk loading of ANFO

Shaft sinking

In mining, shafts form a system of vertically or inclined passageways, which are for transportation of ore, refill, personnel, equipment, air, and/or electricity and for ventilation. The blasting operation is carried out against gravity, and the scatter of the broken rock is confined in the shaft. It is common to use generous distribution of explosives throughout the rock, using a large number of small diameter (35 to 42 millimetres) shotholes.

The number of holes (N) required for sinking a shaft of cross-sectional area (A) in square metres is given by the formula:

$N = 2.5A + 22$

The drilling patterns for shaft sinking are basically the same as those used in tunneling, but generally the cone cut is favoured because it heaps blasted muck onto the shaft center for easier mucking and it also avoids overbreak.

Blast initiation systems

Firing methods can be divided into three main groups: non-electric (e.g., capped fuses, detonating cords, nonel), electric detonators, and electronic detonators. However, blasting in small excavation and small works is non-electric. Capped fuses and ignitor codes are the most economical way of initiating a blast.

- **Fuse blasting:** Safety fuses are supplied with a detonator of a 6D or 8D detonator on one end and an ignitor cord connector on the other, forming a capped fuse. 6D detonators are for use with nitroglycerin-based explosives. They are loaded with 0.35 grams of pentaerythritol tetranitrate (PETN). 8D detonators are used in combination with less sensitive explosives such as ANFEX. 8D detonators are loaded with 0.78 grams of PETN and are twice as powerful as 6D detonators.
- **Nonel:** Nonel is a small-diameter, hollow plastic tubing coated with a thin film of reactive material. When initiated by a detonator or detonating fuse, it transmits a shock wave of 2000 metres/second inside the tube to a detonator crimped onto one end. Nonel is resistant to accidental initiation by static electricity, stray currents, radio transmission, flame, friction impact, and lightning and it is immune to fires caused by current leakage in conductive ore bodies. It is simple to use and eliminates the need for electrical circuits and short firing equipment.
- **Long period delay detonators (LPDs):** LPDs provide inter-number delay varying between one quarter of a second to two seconds and are more suitable for tunnelling.

- **Short period delay detonator (SPDs):** The SPD range has inter-number delays of between 14 and 100 milliseconds and provides excellent fragmentations in all rock-breaking applications.
- **PETN**: Pentolite boosters are designed to initiate non-cap sensitive explosives in bulk or packaged form. They contain a mixture of TNT and PETN, have a high velocity of detonation (6,000 metres/second) and are exceptionally powerful, yet much less sensitive to shock, friction, and impact than nitroglycerin.

Selecting the right explosives

When selecting explosives for a job, there are many factors to consider. Selection should be based on an understanding of the basic properties of explosives.

Important characteristics of explosives include:

- Detonation velocity
- Strength
- Safety in handling
- Detonation stability
- Storage qualities
- Flash-over tendency
- Density
- Water resistance
- Resistance to freezing
- Medical aspects

Detonation velocity is a measure of the speed at which the detonation travels through the explosive. Generally, an explosive with a high detonation velocity has a great shattering effect, while explosives with a low detonation velocity have a more shearing effect. The velocity of detonation of an explosive is higher when the explosive is confined than unconfined. Detonation velocity has been found to be equal to the velocity of the seismic shock wave through the rock. High detonation velocity is thus favourable in the case of hard rock. Explosives like Dynamex M and Emulite are suitable for hard rocks like granite, gneiss, and basalt, while ANFO is appropriate for softer rocks like limestone and sandstone. High velocity of detonation is of greatest importance for boulder blasting with concussion charges and underwater blasting with shaped charges. The high velocity is necessary to give the powerful impact at detonation required to cause the tensile stresses that break the rock.

Strength and blasting effect of an explosive refer to energy content. The blasting effect cannot be indicated in terms of a single quantity. Important properties in determining the blasting effect include:

- Heat of explosion
- Volume of gas liberated
- Pressure and temperature of the gases

The strength of an explosive is in most cases expressed as a percentage of the strength of blasting gelatine. The weight strength denotes the strength of any weight of an explosive compared with the same weight of blasting gelatine. The bulk or volume strength denotes the comparison of any volume of an explosive with the same volume of blasting gelatine. Since gelatine has been phased out, manufacturers have lately started to compare the weight and volume strengths with those of ANFO, which has become the most widely used and well-known explosive.

Safety in handling is one of the obvious requirements of an explosive when it is being transported and used under normal forms, so that risks to those carrying out the blasting are minimised. Explosives are subjected to extensive tests before they are approved by appropriate authorities. Some of the basic stress tests include:

- Drop hammer test
- Friction test
- Projectile impact test
- Heat test

Detonation stability and sensitivity to initiation are also key characteristics. For obvious reasons, it must be possible to initiate an explosive and the detonation must be stable. Normally, the explosive is initiated using a detonator. However, certain explosives, such as ANFO and slurry explosives, are so sluggish that they require more powerful initiation. ANFO and slurry explosives are normally initiated by using Dynamex primers or special primers consisting of an explosive with a high detonation velocity. Detonation stability means that the detonation of an explosive column does not stop for any reason until the entire column has detonated. This is a rather difficult demand to meet because of the rapid procedure during detonation and the high pressure involved. All types of explosives have a smallest possible diameter (critical diameter) for which the detonation is stable.

Water resistance is the ability of an explosive to withstand water penetration and is normally expressed as the time an explosive can be underwater and still detonate reliably. The water resistance of an explosive depends on the packing as well as its inherent ability to repel water. An explosive can be affected by water in two different ways:

- Salts can be dissolved in water and leak out of the explosive
- The water pressure can reduce the size and amount of air bubbles, which act as 'hot spots' and result in explosives becoming desensitised.

Plastic explosives normally have high resistance to water. Emulsion explosives like Emulite have excellent water resistance properties, as the salts are

protected by an oil/wax film and the 'hot spots' are produced from air filled micro-balloons. Explosives with inherent water resistance properties can be used in water-filled blast holes, if proper packaging materials, such as plastics, are used.

Initiation of blasts

A powerful localised shock is required to initiate detonation in commercial explosives. This is generated either by a detonating cord or by a self-contained detonator or blasting cap inserted in a cartridge of the high explosive to form a primer or booster.

A safety fuse is a cord-like incendiary device which burns and does not explode and does not contain its own means of ignition. Safety fuses provide a delay interval between lighting of the fuse and initiation of the detonator by the fuse flame. They consist of a central core of black powder around a strand of cotton, enclosed in a textile wrapping. The fuse is cut to a length chosen to provide ample time for the shot-firer to withdraw to a place of safety. When lit with a hot flame, the powder burns slowly until burning reaches the end that has been crimped to the detonator. The diameter of a safety fuse is between 4.7 and 5.0 millimetres with burning rate statutory limits of 99 to 121 seconds per metre. As shown in the table below, you can remember the colours and burning speeds of different fuse types using the sentence: '**D**o **Y**ou **R**emember **B**aby **G**irl **L**oves **B**iscuits?'

Table 4: Burning speeds of different safety fuses

	Colour	Speed (s/m)
Do	Dark blue	99 to 102
You	Yellow	102 to 105
Remember	Red	105 to 108
Baby	Black	108 to 111
Girl	Green	111 to 114
Loves	Light blue	114 to 117
Biscuits	Brown	117 to 121

An igniter cord is a cord-like fuse that burns with an intense flame. It is similar in construction to the safety fuse but has either a larger or smaller diameter and consists of a copper wire at its core. Igniter cords are used to ignite the safety fuse, leading to individual blast holes to which they are connected at intervals along their length. They are colour-coded according to slow, medium, and fast burning rates of between 18.36 and 71 seconds per metre. The burning speeds of slow igniter cords are 30 to 45 seconds per metre, medium igniter cords are 25 to 35 seconds per metre, and fast igniter cords are 15 to 25 seconds per metre.

As the flame reaches each connector, it automatically lights each safety fuse in turn. All fuses in the round must be alight and burning before the first hole detonates. Therefore, the length of the igniter cord between the first and last fuses is chosen to give a time interval shorter than that for the complete burning of the first safety fuse.

The detonating cord, known also by trade names such as Primacord and Detaline, consists of a core of high explosive in a plastic sheath and protective wrapping. Unlike the safety fuse and the igniter cord, it has a high velocity of detonation (6.5 kilometres per second). When initiated by a single plain or electric detonator to which it is taped, it generates the pressure of a detonator almost simultaneously firing of widely spaced charges, and for the mass initiation of very large charges.

Detonating cords, which are extremely water-resistant, are much safer to handle than a detonator because they reduce the hazards of lightning. It is particularly useful for underwater blasting applications. In quarry blasting, a trunk line of detonating cord usually extends along each line of holes, connected to branch or downlines in each hole.

A detonator consists of a metal tube of copper or aluminium with a base charge of a secondary explosive and a priming charge of a primary explosive. Plain detonators (blasting caps) are ignited using a safety fuse by crimping the mouth of the detonator to the fuse. Plain No. 6 detonators are in general use, while plain No. 8 detonators are used when a more powerful detonating effect is needed.

Primers can be made on site by burying a detonator in a cartridge of cap sensitive explosive, usually a water gel explosive. An opening about 50 millimetres deep is formed in the end of the cartridge, using a wooden, brass, or copper skewer. The detonator end of a capped safety fuse is inserted into this hole.

Boosters are factory-made primers with a high density and velocity of detonation. They are initiated by a blasting cap or detonating cord and are used when making up primers.

Underground blast design

Typical underground blast rounds can be divided into two basic categories:

- **Heading, drifting, or tunnel rounds** in which the only free face is the surface from which the holes are drilled.
- **Bench or stope rounds** in which there is more than one free face (short hole and long hole drilling).

They can also be classified as development rounds or production rounds.

Development rounds are working faces that are excavated to open up new peoduction areas in an undergrond mining operation. The initial and most critical part of development rounds is the **opening cut**. The essential function of this cut is to provide additional free faces against which the rock can be broken. Opening cuts fall into one of four classifications:

- Angled cuts
- Parallel hole cuts
- Drag cuts (particularly suitable in small sectional drifts where a pull up to one metre is very useful)
- Fan cuts (one-half of a wedge cut, applicable mainly where only one machine is employed in narrow drives. Generally the depth of pull is limited to 1.5 metres)

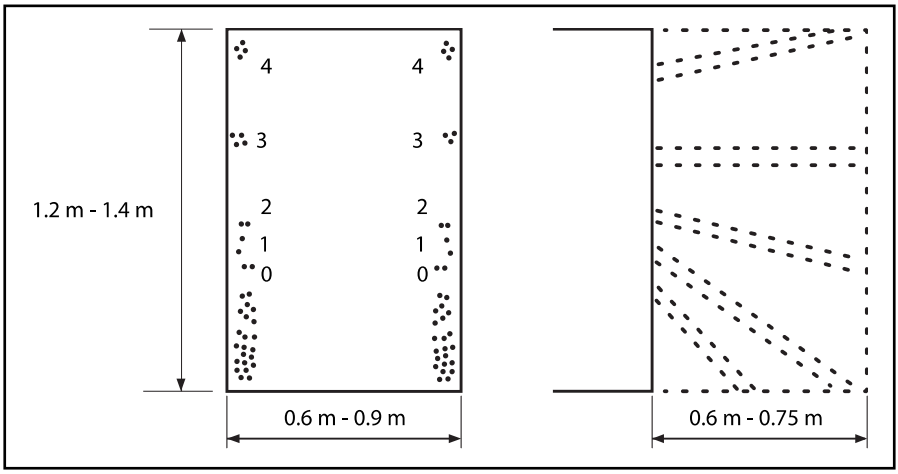


Figure 49: Angled cut for a development round

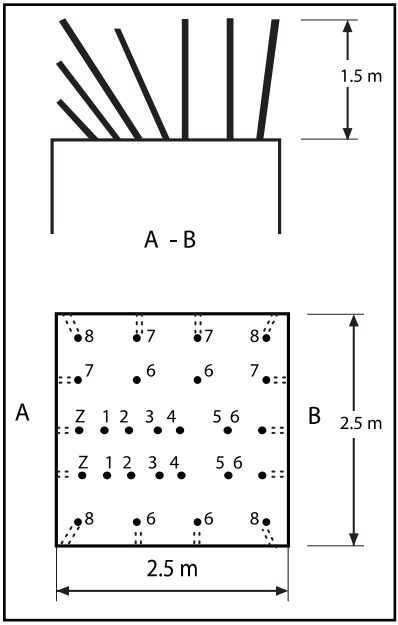


Figure 50: Parallel cut for a development round

Production rounds are working faces primarily excavated for production drilling, charging and blasting. In shorthole blasting, the diameter and length of shortholes are usually limited to a maximum of 43 millimetres and four metres, respectively. Shorthole blasting is usually used in breast stoping for narrow, tabular orebodies. It is suited for underground reef mining, which is synonymous with ASM.

Blasting in surface excavation

Blast holes can be drilled in either square or staggered patterns. A staggered pattern produces a more uniform distribution of explosive effect.

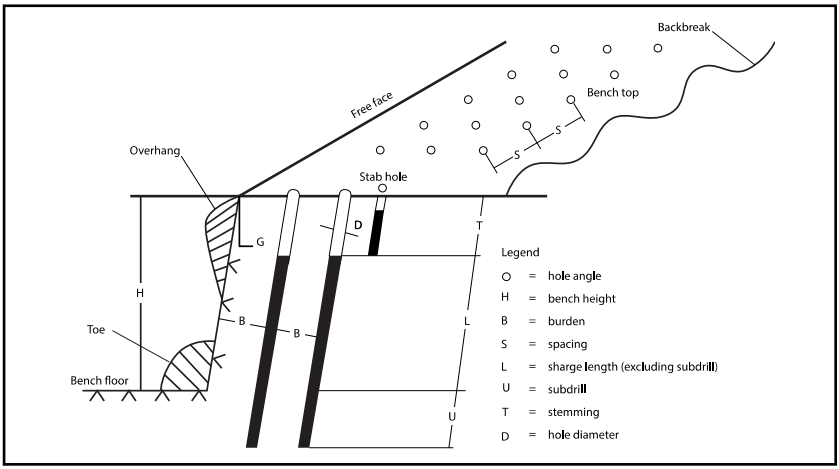


Figure 51: Geometric configuration of a bench in surface mining and drilling patterns

Drilled and charged holes (whether square or staggered) can be fired using either a closed or open chevron pattern. A **closed chevron pattern** produces a high-profile pile with a possible secondary fragmentation due to impacts between rocks projected from opposite directions. An **open chevron pattern** gives evenly spread rock piles, particularly suitable for front-end loaders and may produce less toe problems.

In normal blasting, all blast holes do not blast at the same time. Bench blasting is normally carried out as short-delay blasting. The firing pattern must be designed so that each blast hole has free breakage.

Procedures for safe charging and blasting

Preparations:

- Thoroughly bar down the area after drilling.
- Pump out any accumulation of water from the face with de-watering equipment.
- Clean all drilled and reamed holes to be charged if possible, using a two-way blow pipe with the aid of compressed air, and ensure that the holes are completely clean and dry.
- Ensure that the drilled holes are to the correct depth and in the right direction.

- Test the presence of flammable gases before charging and continuously test for the presence of the gases using a gas detecting instrument.
- Move all unnecessary tools and equipment to a safe area.
- Clear all personnel who are not needed from the charging site.
- Barricade off the area to be charged with 'NO ENTRY – CHARGING IN PROGRESS' signs.
- Order and transport explosives to the site in accordance with the Explosives Regulations (see Annex A for more details about these regulations).
- Place explosives in a dry place, with fracture explosives and accessories stored separately.

Charging:

- All charging assistants should be under the direct supervision and within site of an appointed blasting licence holder.
- Prepare primers equal to the number of holes to be charged and carefully press home into the drilled holes. Ensure that the primer is pushed to the back of the hole. Use a charging 50 centimetres longer than the drilled hole.
- Ensure cut holes are charged fully with high energy explosive.
- Ensure the grid holes and lifter holes are charged to approximately two-thirds of the hole length with high energy explosive and effectively tamped using the tamping material provided.
- Ensure all perimeter holes are charged with low energy explosive to minimise damage to the hanging wall and side walls.
- Timing must be the sole responsibility of an appointed competent charger, who must be a blasting license holder.
- When connecting the easy stopers, ensure that the cord is not pulled so tight that the cord enters the charged hole at 90 degrees, because that will cause unnecessary single misfires.
- The team leader/miner in charge should connect the safe-start detonator to the trunk-line delay.
- The team leader/miner in charge should physically visit all areas of their responsibility to clear personnel and equipment.
- The blasting license holder can then proceed to initiate the blast using the applicable method on site.

- It is important never to:
- Allow people in areas containing explosives other than those directly involved with charging.
- Allow open flames/sparks in areas containing explosives.
- Ram explosives into a hole.
- Leave explosives unattended.
- Hide unused explosives; always return such explosives to the underground magazine.

Procedures for transportation and handling of explosives

Before ordering explosives from the manufacturer, ensure that you have the following:

- Permit to store explosives
- Permit to transport explosives
- Storage magazine of an approved type
- Magazine Master's appointment
- Magazine Master's blasting licence
- Vehicle to be of an approved type to ferry explosives
- Vehicle registration book
- Vehicle's valid fitness certificate from the Vehicle Inspection Department
- Vehicle to be insured and licenced
- Driving licence
- Four red flags
- Chain for earthing the vehicle
- Tarpaulin tent (to cover explosives)

Before collecting explosives:

- Ensure that the Magazine Master has the order signed by the Mine Manager and that the order form is stamped.
- Phone the manufacturer/distributor telling him/her of your order and the date and time you will be at the site.
- Inform and get clearance from the Inspector of Mines and the police on the date, time, and route to be used.
- Ensure the vehicle is well-serviced and in good working order.
- Ensure that you have a phone that is well-charged and has enough airtime.

When transporting explosives from the manufacturer to magazine or mine site:

- Blasting cartridges and detonating fuses may be carried together but must not be carried with any other explosives.
- Detonators, safety fuses, capped fuses, igniter cords, and electric initiators may be carried together but must not be carried with any other explosives.
- When explosives have been loaded in the truck, cover them with tarpaulin and secure them tightly to prevent them from falling off or being seen by the general public.
- Check that the earthing chain reaches the ground.
- Put your red flags at the four corners of the vehicles.
- Put on the hazards lights.
- Follow the designated route and never stop enroute.
- The driver should never carry passengers other than the Magazine Master.
- Do not carry any other items together with explosives.
- Switch off your phone and radio.
- Travel at no more than 60 kilometres per hour and never overtake other vehicles unless it is absolutely necessary.
- Where possible, leave a distance of at least six times your vehicle size in front and at the rear to avoid possible sabotage.
- When it is absolutely necessary to stop (e.g., to relieve yourself), pull off the road and park at a safe distance away from the building, walkways, and rail and power lines. Always leave the truck guarded. Place no smoking signs and danger warning signs around the truck.
- In case of inclement weather, park the vehicle at a safe distance away from built-up areas or any other structures and switch off the engine. Put up no

smoking signs and danger warning signs. Wait until the inclement weather passes and then proceed.

Storage of explosives should be done in accordance with the provisions of the Explosives Regulations (See Annex A). Most miners in the ASM sector do not have any approved storage facilities for explosives. Explosives should be stored in either immovable or portable magazines. Immovable magazines apply mostly to large-scale mines with operations that will run for decades. ASM can make use of the portable magazines. The regulations for construction of a portable magazine include the following.

- The sides, top, bottom, and door should consist of mild steel plates, not less than 5 millimetres in thickness.
- All joints should be welded.
- The door should:
    - Be constructed of steel plate not less than five millimetres in thickness and lined with wood or similar non-ferrous material so that no iron or steel is exposed to the interior of the magazine.
    - Be hung in a substantial frame which is securely set in the concrete of the building.
    - Open outwards, and the hinged edge shall be secured when closed by not less than five internal fixed dog bolts or lugs engaging with the frame.
    - Be locked by means of two or more concealed and protected security dead locks each fitted with at least five levers or a bolt mechanism with a concealed and protected dead lock fitted with at least five levers and such door and lock or bolt mechanism shall be of a design approved by the Chief Inspector.
- The magazine shall be lined throughout with tongued and grooved matchboard or other similar material not less than 15 millimetres in thickness secured by brass or copper screws or nails so that there is an airspace of at least 35 millimetres between the lining and the top, bottom and sides of the magazine;
- Ventilation shall be provided such that on opposite sides of the magazine there are not less than 4 openings. These openings must be:
    - 25 square centimetres in size.
    - Covered with fine wire gauze.
    - Protected on the outside by a weather-proof louver and the inside by a steel plate not less than five millimetres thick, set back 10 millimetres, and overlapping the opening by 25 millimetres all around.

- Placed 150 millimetres above the bottom and 150 millimetres below the top on opposite sides of such magazine.

- The wooden or other lining shall be drilled opposite each opening with eight holes, 10 millimetres in diameter.
- If the magazine contains a separate chamber for detonators or capped fuses:
    - There shall be an airspace of not less than 220 millimetres between the chambers.
    - If the door of the chamber for detonators or capped fuses does not exceed 500 millimetres in either dimension it may (notwithstanding the above requirements) be secured by one lock and three dog bolts.

Other general rules:

- Explosives boxes should be under direct supervision or be guarded at all times while containing explosives.
- No person should be permitted to take any flame or contraband within one meter of explosives storage area underground.
- No explosives such as ignitor cord, safety fuse, capped fuse or electric detonators should be kept with fracture explosives.
- Only sufficient primers for work in hand should be made up at any time and they should be transported to the working faces in approved containers.
- Explosives boxes must be kept clean. Stocks should always be used in the sequence in which they are received (first in, first out). Any explosives that are unfit for use should be destroyed using an approved method.
- Empty cartons, bags, ignitor cord reels, etc. should be brought to surface for disposal daily.

Underground support and safety

Three key pillars of mining are **production, safety,** and **costs**. Together, they form the basis around which a mining business revolves.

Fig 52:The three key pillars of mining

Discussion Activity

As a group, share ideas about why these three pillars are important and identify how they affect each other.

Production: The aim of mining is to get as much of the mineral as possible. Mineral production is the amount of ore that has been produced from the mining activities. The higher the production, the higher the amount of mineral produced, and the greater the revenue obtained. One may be tempted to concentrate on getting the highest production possible at the lowest cost possible, without adequate attention to safety measures.

Costs: Production requires spending money (mining costs). The mining costs indicate the amount of money that has been spent to produce the tonnage of ore. The most effective measure is the cost per tonne ($/tonne produced) and comparisons of different methods can be done using the cost per tonne measure. A higher production ordinarily would lead to lower production costs per tonne of ore produced. However, an unsafe working environment leads to loss of production time and eventually to higher production costs.

Safety: While production can be increased, and low costs can be maintained, it is important to ensure that no lives are lost, there are no injuries to persons, and that no equipment is damaged. Measures therefore need to be put in place to ensure that mining activities are carried out safely. Safety can be defined in several ways:

1. The state of being safe; freedom from the occurrence or risk of injury, danger, or loss.
2. The quality of averting or not causing injury, danger, or loss.
3. A contrivance or device to prevent injury or avert danger.
4. The action of keeping safe.

Unsafe mining can result in:

- Loss in production time as operations are suspended (due to investigation time and rehabilitation time)

Discussion Activity

As a group, brainstorm how unsafe mining results in higher costs for the mine.

- Medical bills for the injured
- Funeral expenses
- Loss of equipment, requiring new equipment to be bought

Safe production model

A safe production model includes standards, procedures, and programs; communication; and compliance, as shown below.

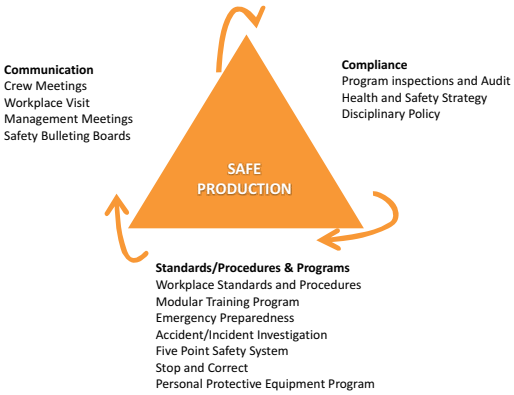


Figure 53: Safe production model

Standards, procedures, and programs[16]

Every workplace must have properly laid out safe working steps for each task conducted. Each employee must be familiar with his or her roles and responsibilities in relation to standards, procedures, and safety programs in the workplace. This typically requires:

- **Workplace standards and procedures:** Every site should develop, communicate, implement, maintain, and constantly update suitable arrangements for managing occupational health and safety. The arrangements can be put into documented procedures on how to safely carry out every task at work. Generic standards can be adopted at an organisational level and should therefore adhere to the minimum standards predefined by the nation's legal and statutory instruments on safe mining practices. Job-specific standards should be adhered to at operational level (i.e., when the actual job is carried out).
- **An ongoing, comprehensive training program:** All workers must be trained to ensure a competent work force. Modular programs can be effective to avoid overloading trainees by covering everything at once.

[16] This section is adapted from: Technica Group, Inc. (2015). Health and safety program: Volume VII.

- **Emergency preparedness measures**: All sites should establish and maintain emergency response capabilities, which will minimise loss from unexpected events.
- **An internal responsibility system:** This is a system to advise the entire workforce that **safety is everybody's responsibility** and that **'safety starts with me'.** It defines responsibilities such as:
    - Stop and correct (if a worker finds a substandard or unsafe condition, he or she should stop whatever he or she is doing and correct it immediately).
    - Safely perform assigned duties.
    - Use safety equipment as directed.
    - Correct or report unsafe conditions.
    - Report incidents regardless of severity; they could potentially result in an injury and/or equipment damage.
    - Work in a manner that will not endanger yourself or others.
    - Advise others of known unsafe conditions or work practices.
    - Be aware of and follow all applicable legislation and safe work procedures.
- **Accident/incident investigation:** This is carried out to determine why an accident or incident occurred, so that appropriate preventative action(s) can be implemented to reduce the likelihood of recurrence.
- **Five-point safety system:** This is a system (described below) that assists workers to perform work safely, without exposing themselves to unnecessary risks.
- **Personal protective equipment (PPE):** PPE requirements should be identified and communicated, and the best products available to reduce exposure to hazards that cannot be engineered out of the workplace should be provided.

You can protect an employee against danger by:

1. Removing the danger (e.g., cleaning up oil spills, barring down any bad hangings)
2. Separating the danger and the person (e.g., barricading disused open pits, placing of barricades)

3. Shielding the danger from the person (e.g., using safety equipment)
4. Shielding the person from the danger (e.g., wearing safety clothing)
5. Influencing the behaviour of the worker (e.g., using warning signs)

Communication

Thorough and effective communication is critical to safe production. It includes use of safety talks (given by any team member during briefings at the beginning of every shift, prior to embarking on any work) or safety slogans, as well as posters. Display of safety signage at strategic positions. During safety talks, all workers who have reported for duty should, discuss safety topics, which may include a review of any previous accidents/incidents, specific hazards, work practices or legislative requirements. The topic for discussion ideally is selected by a designated Safety, Health, and Environment Representative; however, anyone present from the team can choose the topic for discussion for the day. This provides an opportunity to encourage safe work habits and raise safety awareness. Workers may come up with a safety slogan as a way of promoting safety consciousness among themselves.

Communication does not have to be verbal. It can also include:

- Lights
- Signage
- Barricades
- Whistles
- Bells
- Guards
- Flags (red flag/white flag)

Mining accidents

What is an accident?

It is any unplanned event that results in any of the following:

- Injury or ill health of people
- Damage to or loss of property, plant, materials, or the environment
- Loss of a business opportunity

Incidents, on the other hand, are the 'near misses' that could have resulted in these things. Common accidents include:

- Rockfalls
- Gassing
- Shaft accidents
- Accidental detonation of explosives
- Flooding
- Falling

These and other accidents are avoidable.

Discussion Activity

Ask participants what they think are the most common types of accidents and the most effective ways to prevent them.

Five-point safety system

The five-point safety system is a step-by-step approach to eliminating hazards and fostering a commitment to safety. It assists workers to perform work safely, without exposing themselves to unnecessary risks. This is a standard system used throughout the world and is applicable to both large-scale and small-scale mines. It was introduced by Neil George in 1942 and is also known as the **Quebec System**.

What are the five points?

1. Check the entrance to the place of work.
2. Are working place and equipment in good order?
3. Are people working properly?
4. Do an act of safety.
5. Can, and will, people continue to work properly?

If a worker finds a substandard or unsafe condition, he or she must correct it immediately (stop and correct).

A five-point safety system board/poster should be posted at the entrance of every shaft and at every waiting place to ensure that workers are reminded all the time. All danger warning signs must be posted in appropriate places and must be visible to all.

Re-entry procedures

Before entering a work place after a blast, a proper re-entry procedure should be followed. Mine re-entry procedures during the production cycle include:

1. Enter the workplace after a previous blast:
    - Check that ventilation has removed blasting fumes.
    - Provide for dust suppression by watering down.
    - Inspect back and ribs for loose material.
2. Install initial ground support:
    - Scale, bar down, or otherwise remove loose material.
    - Install temporary or initial ground support.
3. Pile up and load fragmented material.
4. Haul material in gathering systems (e.g., coco pans, wheelbarrows).
5. Install permanent ground support if needed.
6. Extend utilities if needed, including ventilation, power (electricity or compressed air), and transportation.
7. Drill blast holes.
8. Blast:
    - Load explosives into boreholes.
    - Connect detonators to provide desired firing order and times.
    - Blast when safe.
    - Return to step 1.

If drilling is not done properly, then step 3 cannot be carried out.

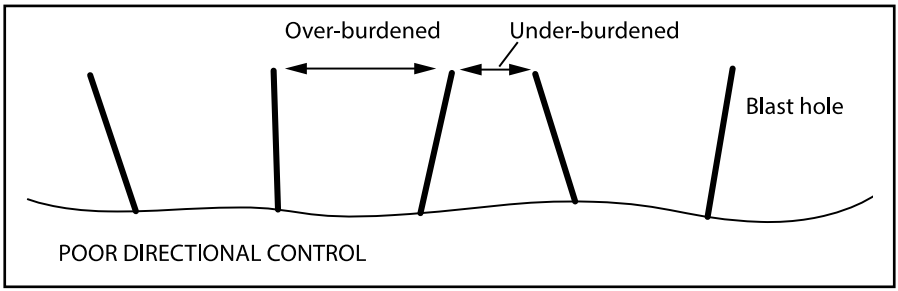


Figure 54: Control in drilling

Fall of ground (FOG)

Major accidents in Zimbabwean small-scale mines are due to FOG. These accidents occur in:

- Shafts
- Stopes
- Drifts, drives, travelling ways, manways

The primary reasons for FOG include:

- Poorly planned excavations
- Poorly supported excavations

Preventive measures include:

- Making safe procedures
- Use of proper artificial support
- Use of natural support (pillars)

To prevent FOG, look at the stope width or the size of an excavation. If the width is too big, the ground is likely not to be able to support the weight. Secondly, consider the time of support. Large areas of ground should not be left unsupported for a long time. During cleaning, temporary support should be in place, with permanent support installed soon after cleaning. Third, ensure that the right type of support is used based on the ground conditions, materials available, and the training given to personnel.

Making safe (barring down)

The steps of safe barring procedures (Kugwara) apply in all types of excavations and include:

1. Examine the pinch bar (Mugwara):
   - The flat end should be sharp and bent at a degree to give enough leverage.
   - The opposite end should be sharp. It should be used to open cracks so that the flat end of pinch bar can be inserted.
   - To determine the correct length pinch bar:

- Stand up straight and place the sharp end of the pinch bar in the one hand.
- Put that hand straight down the same side's leg.
- Take the shank of the pinch bar in the other hand and straighten that arm so that the arm is level with the foot wall.
- The bent part of the pinch bar indicates the maximum height that pinch bar can be used to bar with.

Figure 55: Pinch bar (source: www.teamequipment.com)

2. Water down the blasted area before barring down to expose bad hangings.
3. Search for a safe place to bar from:
   - Test the hanging and or sidewall with the flat bent end of the pinch bar turned toward the rock face to be tested.
   - A safe place to bar from in a stope is next to a pack or stick in a development end next to a prop.
   - In all cases, be on the up-dip side of the rock to be barred down.
4. Begin barring down bad hanging walls
   - Only start barring down when all necessary safety precautionary measures have been taken.
   - Bar until rock is solid.
   - Test by turning the flat end upside down.
   - Sound the hanging rock. Listen whether a solid sound/hollow sound is produced. A hollow sound means further barring is needed.
5. Plan an escape way:
   - In case of an unexpected fall, the barring down operator must be able

to escape uninjured.

- Remove obstruction from the planned escape way before barring.
- Do not bar down bad hangings in confined areas (areas where the barrer cannot stand at a normal posture).

6. Warn all persons in the vicinity to stand clear; the fall might be bigger than expected or a person might walk through underneath.
7. Barricade off the area with a reflective tape if the bad ground cannot be barred down.

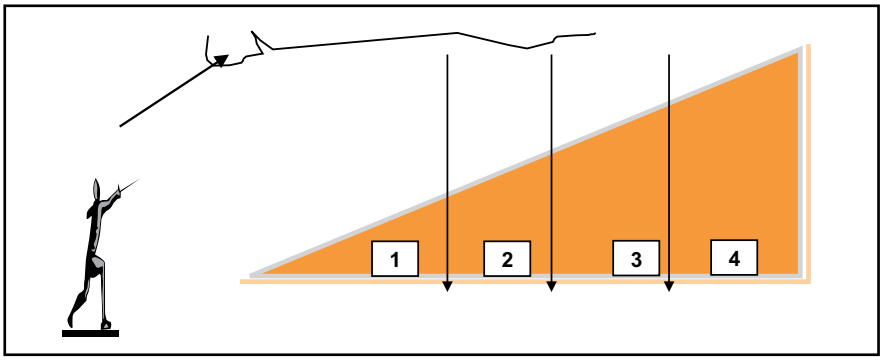


Figure 56: Barring down sequence

The illustration above shows the barring down sequence at re-entry into a blasted area. The shaded region represents the muck pile after the primary blast. First bar down roof before and directly above slot 1. Then, when the end is exposed progressively during loading and hauling, repeat the barring down process for slots 2, 3, and 4 respectively toward the face.

Artificial support

There are two main types of artificial support:

- **Active:** Acts immediately after installation
- **Inactive/passive:** Acts at a later stage when there is movement of rock

Forms of support include:

- Timber sets
- Timber props
- Mat packs
- Roof bolts
- Backfill

Ground conditions

At one point or another, every miner has seen one or more of the ground conditions described below.

- **Joints**: A joint is a fracture or crack that breaks rock continuity by subdividing a rock into at least two sections with little or very insignificant displacement.
- **Faults**: This a planar feature which in instances can also be gently curved along which a rock is fractured resulting in displacement because of tensional or compressive forces.
- **Shear zones**: A shear zone is a deformation that develops because of shearing stress in localized regions of high strain. The nature of the material does not allow for a fracture to develop but allows for deformation.
- **Dykes**: A dyke is an intrusive tabular or sheet-like igneous body that is often oriented vertically across or steeply inclined to the bedding of pre-existing intruded rocks
- **Alteration zones**: An alteration zone is a zone of mineral replacement, enhancement or depletion commonly occurring within and surrounding the structural features mentioned above. In alteration zones, the pre-existing rock property or mineral values are either enhanced or depleted, or replaced, where part or all of the original minerals within the rock are replaced with newer minerals.

These conditions may result in the failure of excavations.

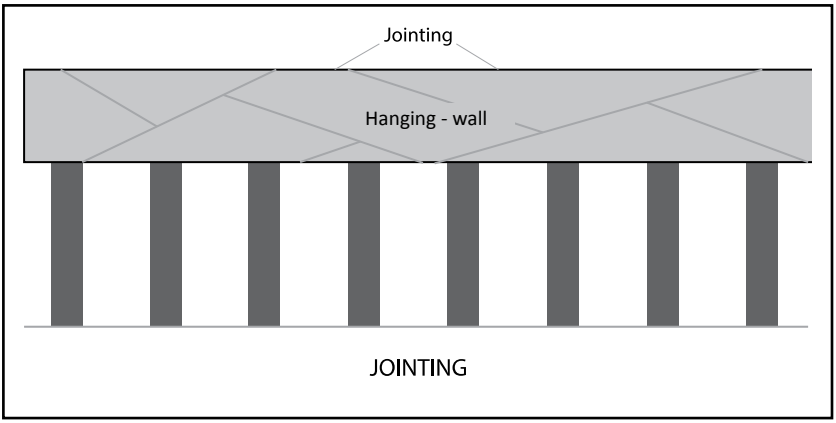


Figure 57: Joints

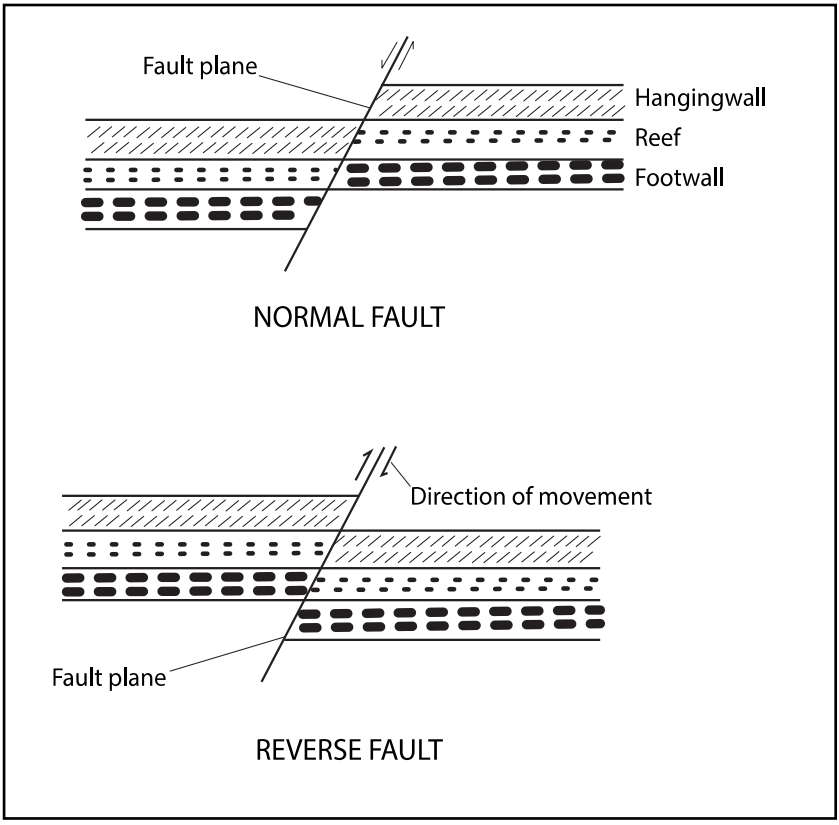


Figure 58: Faults

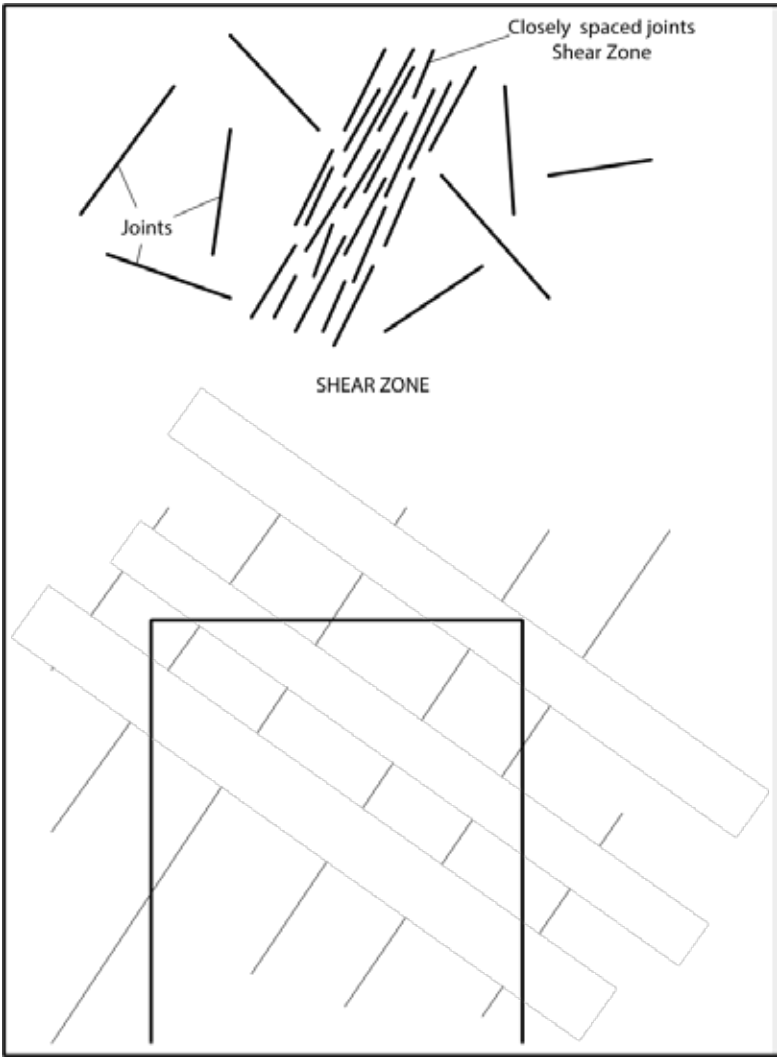


Figure 59: Shear zones

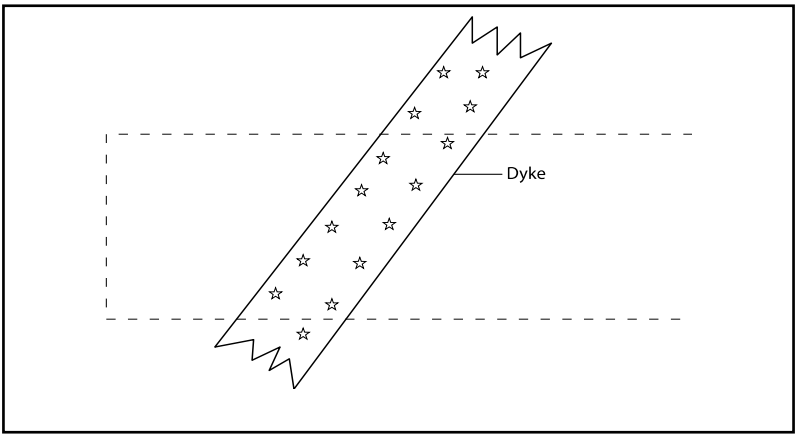


Figure 60: Dyke

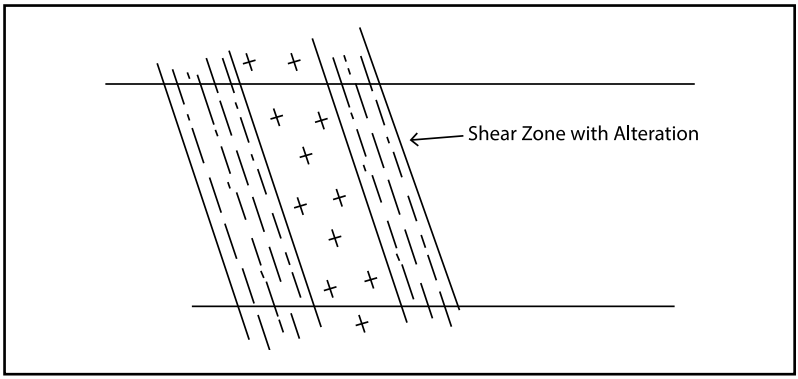


Figure 61: Alteration Zones

Table 5: Guidelines for support in different ground conditions

Structure	Additional support
Dykes, faults, shear zones	In-stope pillars, double up stick support on both sides, timber sets, mat packs
Alteration zones	Increase bolt density, timber sets
Flat joint planes	Roof bolts, timber sets, mat packs

Natural support (pillars)

Natural support is made up of pillars that are left unmined. The pillars may be left in a stope, between shafts, or between any two excavations. The fact that they are natural makes them a good support for mining excavations. The disadvantage, however, is that some mineralised areas are left unmined. The temptation for most miners is to mine the pillars to recover the mineral left in them. When the pillars are removed, the roof of the mine is left unsupported and collapses. If the pillars are over-mined and a small pillar is left, it may not be able to bear the weight of the overburdening material.

Shafts

This is a vertical or near vertical excavation. A shaft should be drilled to service the mine for a long time and should therefore be properly planned. The cost of developing a shaft is high, and therefore one cannot afford to lose it and start another one. The dangers that are experienced in the shaft include the collapse of the shaft or fall of ground in the shaft. To avoid these dangers, the following standards need to be followed.

- The shaft must be placed under a shade to prevent rain water from entering directly into the shaft.
- The shaft must be properly positioned on competent high ground. Before developing the shaft, look for the best position in the claim. This must be closest to the reef or orebody, and the ground must be competent enough.
- The shaft needs to be of a good size (about 1.2 metres on the sides). Square or rectangular shafts are recommended. Circular shafts are more competent, but there may be challenges requiring additional support that is costly for small-scale miners. The challenges arise from the need for massive reinforced concrete structures for circular shafts which might go beyond the affordability of most small-scale miners. With rectangular shafts, additional support is simply by means of timber as shown below.
- The shaft may be collared using concrete if the ground at the top is loose.
- Each shaft must be equipped with at least a windlass where there is no hoist installed.
- About 15 metres should be allowed between vertical excavations. This leaves a good pillar between the vertical excavations.
- A shaft pillar of about five metres should be left between the shaft and stopes.
- The shaft must be supported using timber.

Figure 62: Timbered shaft

Mine support is achieved using timber from indigenous trees, usually obtained from the surrounding forests. Trees with long fibre are usually recommended (Musasa, Munondo). The eucalyptus tree (gum tree) can also be recommended for exotic trees. Straight poles are cut and arranged as shown in the picture above. Areas where the ground is competent (i.e., when the shaft is now in solid rock) may not necessarily need to be timbered.

Falls in shafts can be prevented by:

- Installation of abutment rings (pins) for safety belts.
- Good illumination.
- Barriers at the opening of working platforms.
- Installation of drilling/working platforms.
- Use of safety belts/safety chains.
- Installation of ladder way in shafts with platforms at 6 metre maximum intervals depending on the size of the ladder. The ladder should protrude about 1 metre. All platforms in the shaft must be secured by pins.

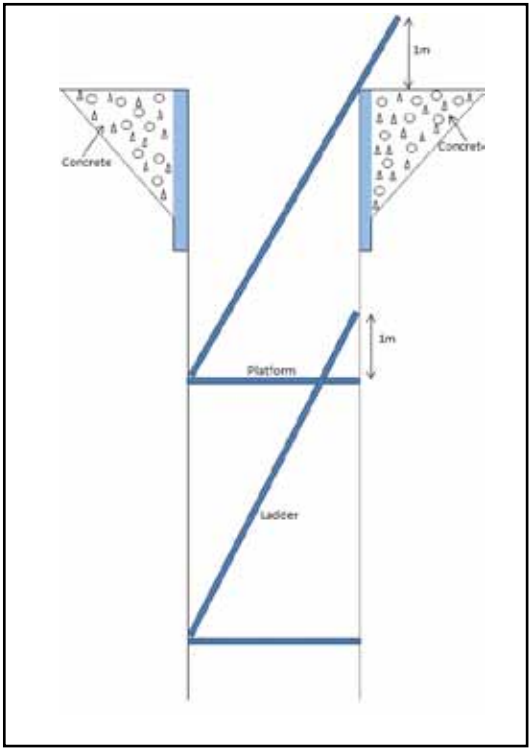


Figure 63: Concrete Collared Shaft Section

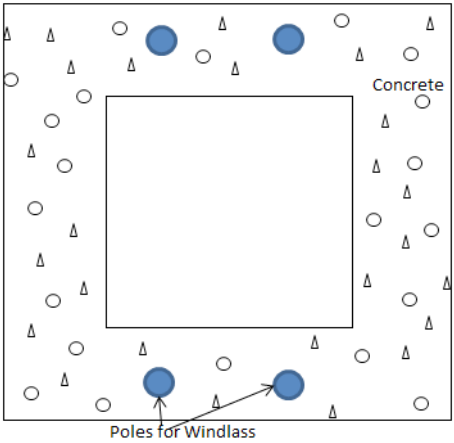


Figure 64: Concrete collared shaft viewed from above

Figure 65: Windlass

The windlass is manually operated and should not be used for more than 30 metres.

Stopes

This is the excavation where the actual production happens. In the stopes, larger openings are made compared to those made in the manways/drifts. When the excavations are too large, the roof can easily fail. It is therefore important to control the size of the excavations. It is recommended to make excavations not greater than 5 metres in competent rock. Pillar sizes of about 1.5 metres by 1.5 metres may also be left. Additional support of mat packs and timber props may need to be put in place.

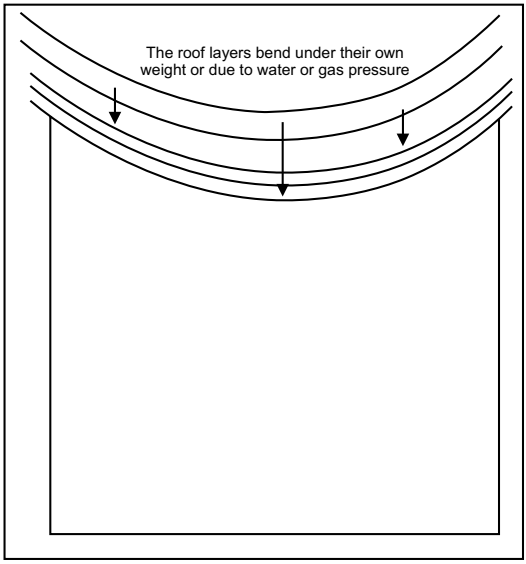


Figure 66: Effect of weight on large rooms[17]

Timber props

Timber props may be used for the ground conditions shown in the cross section in the figure above. Once a timber prop is installed, it cannot be removed. If it is to be removed, additional props must be put in place to support the area around. It is important to ensure that the floor is cleaned to solid ground before installing the timber prop. Timber props must be perpendicular to the floor and roof to give maximum thrust. Wedges may also be used on top of the timber props.

Figure 67: Timber props

[17] TVorster, B. & Franklin, D. (2008). Southern African Institute of Mining and Metallurgy Narrow Vein and Reef.

Figure 68: Timber props in a stope (source: www.mcrocks.com)

Mat packs

Mat packs are also made from timber from the forest. One-metre long pieces of timber may be used. They must be installed after barring down. A layer of wedges must be put in between, which must then be hit with a 12-pound hammer to ensure that the mat pack is firm with the roof.

Figure 69: Construction of mat packs

Backfilling as a form of support can be used in areas that are being permanently closed. Waste rock is used as a form of filling material. Timber may be used construct a barricade and the area behind the barricade is then filled with waste material. This support is not very common in gold mining, but in chrome mining where the waste rock is easily separated from the ore.

Drifts, drives, travelling ways, and manways

Where there is bad ground along drift and drives, timber sets can be used. Timber sets can also be used on adits (horizontal entrances to a mine). Adits are usually developed in bad ground, where the ground is not consolidated. These entrances may also be protected using concrete.

Figure 70: Timber sets in a drift (Source: www.goldrushexpeditions.com)

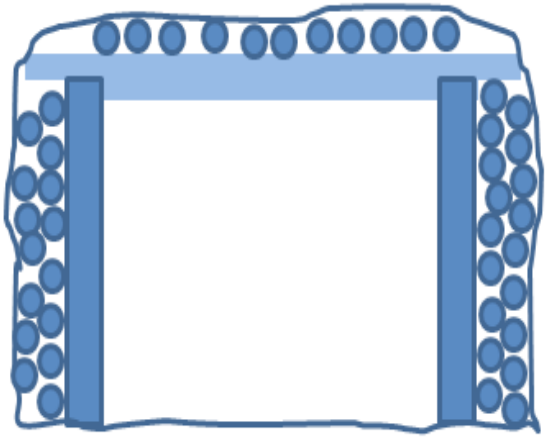


Figure 71: Section across a drift/drive/tunnel (tonera) showing support using timber sets

Roof bolts are long bolts that are inserted, secured, and anchored in rock to ensure the stability of an excavation. There are several types of roof bolts. The simplest types of roof bolts that can be used in small to medium scale mines are called 'shepherd crooks'. These are a simple roof bolts made from twisted bars as shown in the diagram below.

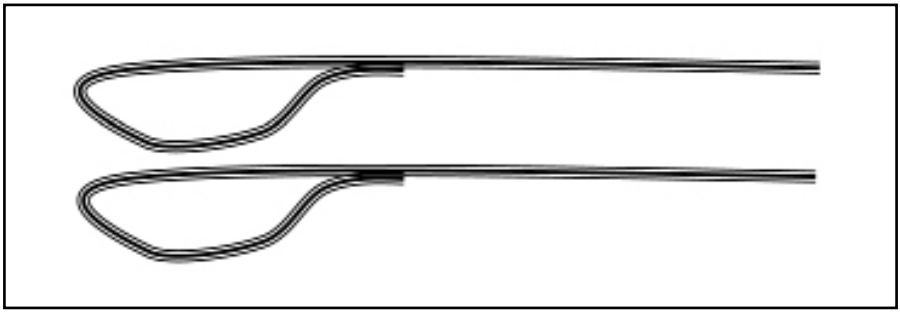


Figure 72: Shepherd crooks

Shepherd crooks require cement grouting, which is necessary to ensure bonding with the supported rock. The 'grouting cement', in the form of capsules, needs to be forced into the drilled hole using a 'grouting gun'. The grouting gun is operated using compressed air. Immediately after filling the hole with grouting cement, the shepherd crook must be hammered into the hole while the grouting cement is still wet.

Correct installation is important to ensure maximum benefit from the use of the roof bolts. If the roof bolt is not installed properly, the rock stratum can fall together with the roof bolt.

Three things need to be considered during installation:

1. **Length of the roof bolt:** Roof bolts can be of various lengths from one to two metres. Enough length of the roof bolt must be provided to ensure that the rock is supported.
2. **Distance between roof bolts:** They can be placed depending on the need. However, if the number of joints are close to each other, the roof bolts must also be close to each other.
3. **Correct angle:** Usually the roof bolts need to be as steep as possible or perpendicular to the joint to ensure support. The illustrations below give some tips on how to correctly install the roof bolts.

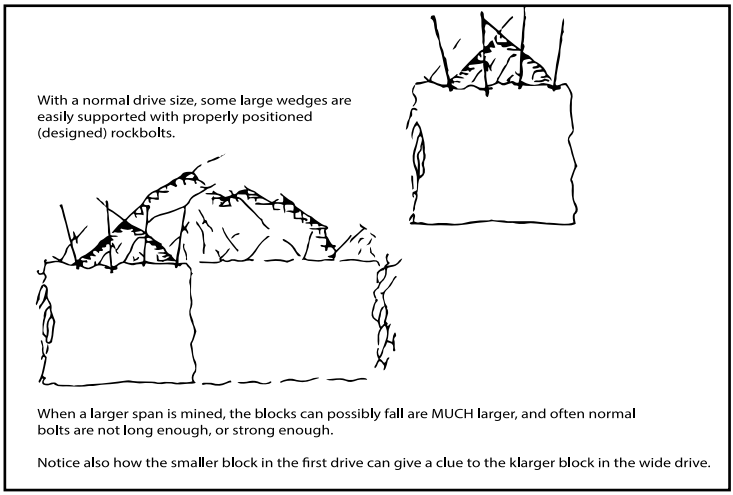


Figure 73: Rocks and spans

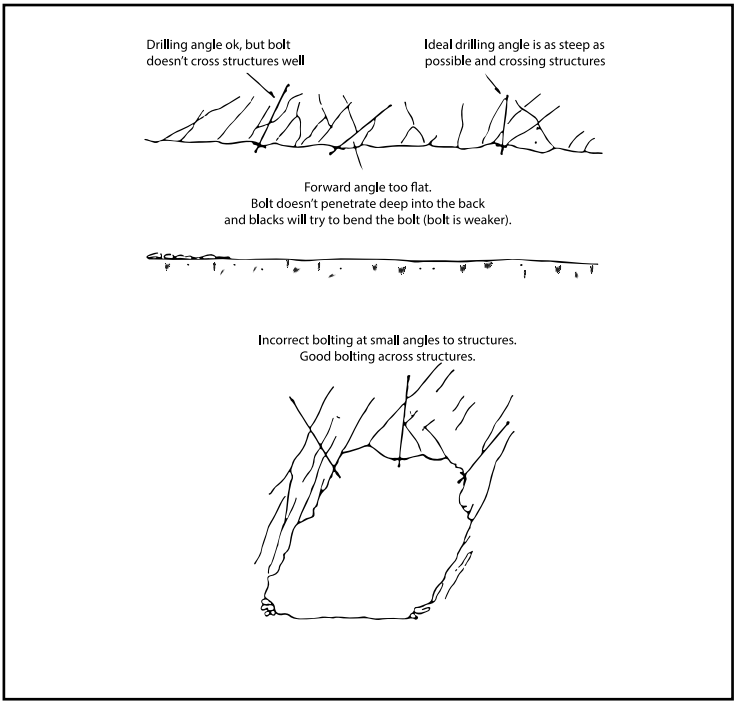


Figure 74: 'Forward drilling'

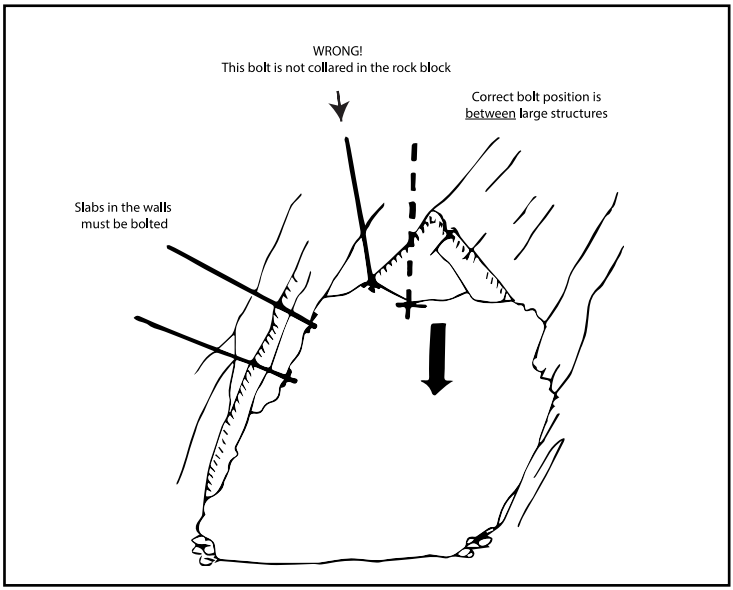


Figure 75: Bolt drilling to support hanging wall

Ventilation hazards

A mine must be supplied with fresh air for:

- Supplying oxygen for humans and machinery
- Expelling foul/contaminated air from underground
- Creating conditions necessary for humans (temperature and humidity)

If there is poor ventilation, hazards created include:

- Accumulation of poisonous/noxious gasses
- Poor working environment (temperature, humidity, dust particles)
- Oxygen deficiency

Ventilation hazards can be broken into their associated risks.

Table 6: Ventilation risks and control measures

Hazard	Danger	Control
Gases and fumes	Ignition, explosion, asphyxiation	Use proper ventilation such as openings and exhaust fans to blow gases out of the mine. Water down. Monitor using portable gas detectors. Do not enter or remain in fume clouds. Comply with mine re-entry procedures post-blasting.
Dust	Airborne dust – respirable / inhalable and dangerous float dust	Control airborne and respirable dust via dust extraction units. It is easier to keep dust from becoming suspended than it is to eliminate or control it once in suspension. Water down dust using sprays (machine-mounted or fixed systems). Prevent dust formation by wet drilling. Ensure there is not too much air velocity. Limit employee exposure to dust.
Diesel emission and particulate	Diesel particulate – Respirable and unknown health issues	Ensure air quantities are sufficient to dilute emissions. Ensure a well-maintained diesel fleet with regular testing of exhaust systems. Ventilate 'dead ends' and 'blind stubs' if personnel are working in these places with diesel-powered machines. Consider decreasing the diesel fleet and increasing battery powered fleet.

Heat	Dehydration, exhaustion, injury	Maintain reasonable air velocities for cooling effect. Ensure that operators are educated in hydration principles. Conduct regular humidity checks and monitoring. Ensure that management understands the physiological issued that are created when heat is an issue.
Poor / inadequate ventilation	Frictional ignition, spontaneous combustion, heat, dust and particulate contamination, gas issues	Install additional fans Assess airways for air resistance.

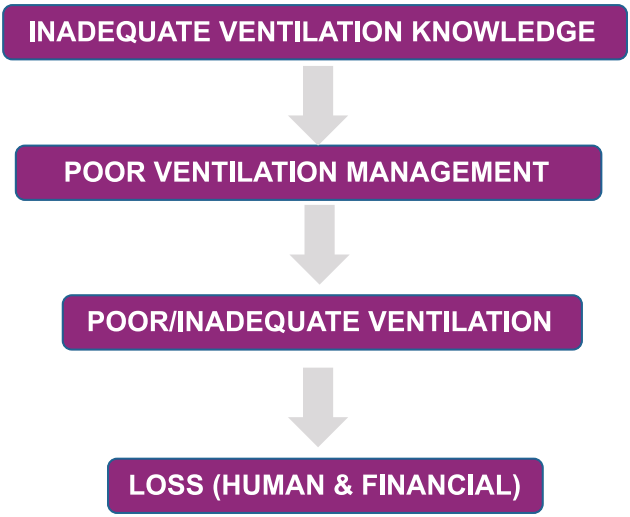


Figure 76: Hierarchy of error

According to the regulations, a mine must have at least two shafts or openings. The second shaft should act as an escape route and can also act as a ventilation shaft. The second shaft provides a good alternative for natural ventilation.

Ventilation risk controls include, but are not limited to, natural and mechanical ventilation. **Natural mine ventilation** is a natural air current which happens without human assistance. This is possible when one opening of the mine is located higher than the other. Differences in temperature and air density between the inside and outside air results in natural ventilation. The airflow direction, however, changes with the seasons as shown below. **Mechanical ventilation** should be used when natural ventilation fails. This refers to the application of fans where electricity is available, and may be used together with natural ventilation.

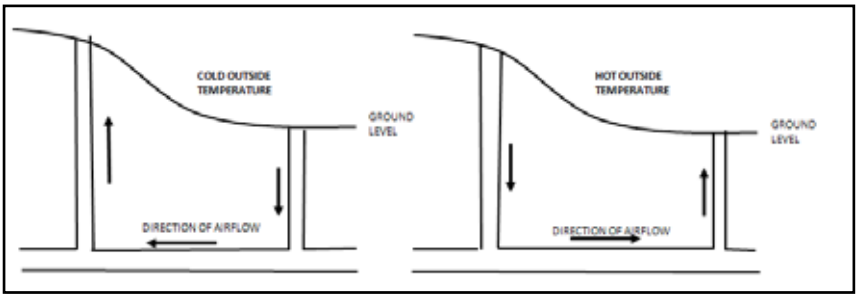


Figure 77: Natural ventilation

For most of small-scale mines in Zimbabwe, a simple **axial flow fan** or a **centrifugal fan** may be used to aid the flow of air. The fan may be placed in a main drive or haulage or it can be placed in a second shaft.

A centrifugal fan is placed at the mouth of the second shaft to suck up air from the mine. If the contaminated air in the mine is sucked up, fresh air is forced into the mine through the main shaft from the outside. The possible fan positions are shown in the diagram below.

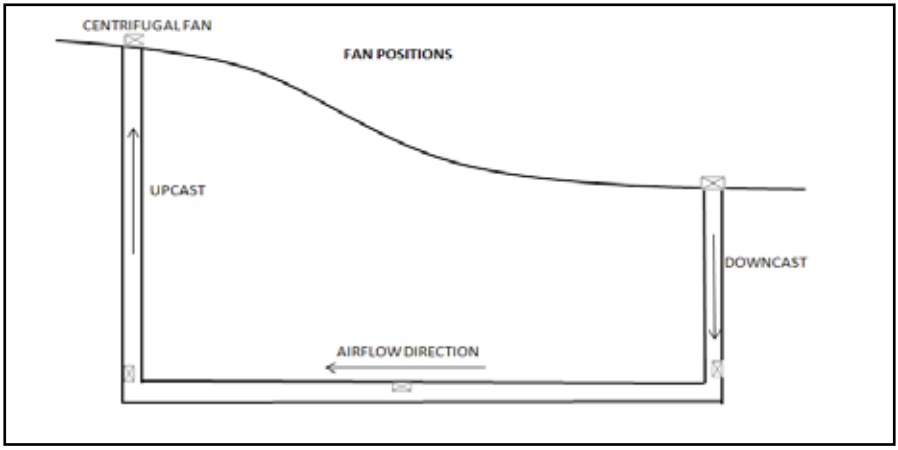


Figure 78: Location of fans

Air can be directed into the working areas with any of the following controls:

- Auxiliary fans
- Doors
- Regulators
- Brattice

Good mining practices can ensure safety from ventilation hazards. For example:

- Re-entry must be carried out by a holder of at a least a mine blasting licence holder. This is a person who has been trained to identify mine gases.
- Ensure that re-entry times are observed. This is the time between blasting and the time that it is safe to re-enter the mine. In Zimbabwean mines, re-entry time is usually four hours, except in cases where the

Inspector of Mines has advised otherwise. Within this period, the mine gases are expected to clear from the mine due to ventilation.

- By Zimbabwean law, stationary diesel/petrol machines cannot be operated underground to avoid the accumulation of gases.

The important gases (also shown in the table below) are:

- **Carbon monoxide**: Most dangerous gas with no smell and no taste. Kills within minutes and does not support combustion.
- **Carbon dioxide**: Kills by asphyxiation. It is generated from blasting, decomposing timber and diesel machines.
- **Nitrous fumes**: Kills by causing blisters in the lungs and one drowns in their own fluid. It has a pungent smell of ammonia.
- **Hydrogen sulphide:** Has a smell of rotten eggs and is usually found in stagnant pools.

Table 7: Mine Gases

Gas	Symbol	Common Name	Spec. Gravity	Source or Cause Where Found	Effect On Life	How Detected	Explosive	Combustible	Characteristics	Remarks
Carbon Dioxide	CO_2	Black Damp	1.52	Respiration of men and nimals, fire	May displace oxygen	Multi-Gas Detector	NO	NO	Colourless, ordourless, tasteless in low conc.	TLV 0.05% for 8 hours
Carbon Monoxide	CO	White Damp	0.967	From Incomplete Combustion, blasting, & diesel exhaust	Poisonous	CO Detector	YES	YES	Colourless, ordourless, tasteless, poisonous	TLV 0.005%; 50 ppm – 8 hours
Nitrogen	N_2	Nitrogen	0.967	Normal constituent of air	Will not support life	Chemical Analysis	NO	NO	Colourless, ordourless, tasteless	78% of air
Hydrogen	H_2	Hydrogen	0.069	Battery charging stations, Incomplete combustion in mine fires	No harmful effects with O_2 present	Methano meter or special lab testing	YES	YES	Colourless, ordourless, tasteless, poisonous	Explosive range: 4.1 – 74%
Oxides Of Nitrogen	N_2O N_2O_2 NOx Etc.	Oxides of Nitrogen	1.59	Blasting fumes, diesel; exhaust	Toxic, causes edema of the lungs	Multi-Gas Detector	NO	NO	Red-brown in high conc, tasteless, poisonous	TLV 0.005% anytime
Methane	CH_4	Fire Damp	0.555	Sewage, decaying plants or animals; coal seams	No harmful effects with O_2 present	Methano meter or Flame Safety Lamp	YES	YES	Colourless, ordourless, tasteless	Explosive range: 5 – 15%
Hydrogen Sulfide	H_2S	Stink Damp	1.19	Decomposition of some sulfur ores, stagnant water ponds	Sense of smell deadened; paralyzed resp. system	Rotten egg odour or multi-gas detector	YES	YES	Poisonous, colourless, smell of rotten eggs, irritating	Expl. Range 4.3 – 45%, TLV 0.001%, 10ppm
Oxygen	O_2	Oxygen	1.105	Atmosphere	Essential to Life	O_2 Detector or Flame Safety Lamp	NO	NO	Colourless, ordourless, tasteless	Supports combustion

Accidental detonation of explosives

To avoid accidental detonation:

- Only blasting licence holders should use/handle explosives.
- Proper storage and transportation of explosives is important.
- Accessories (detonators, ignitor code, power code) and cartridges (majaratini) must be stored separately in approved magazines.
- Approved magazines have been examined by inspector of mines and must be lockable, well ventilated and no metals protruding inside (permanent or portable magazines).
- Accessories must be transported separately in Cholla bags.
- Primers must be prepared in cool dry places.
- No iron objects should be used. If priming either wooden or aluminium objects may be used.
- During charging no iron objects should be used. Wooden or aluminium charging stick may be used.
- No contraband (matches, lighters) is allowed near explosives.
- Correct timing of blasting each round is important.
- Counting of the number of explosions is important.

Flooding

Flooding in mines is both a threat to miners working underground and a hindrance to their operations. Excess water in mines can interfere with operations and create safety hazards.

Submersible pumping systems have traditionally been the mainstay when it comes to draining underground mines. Pneumatic pumps (Chidhakwa) are also in use.

A proper water reticulation system can be designed to avoid danger and reduce cost. This will involve the use of pumps and pipes, construction of underground dams.

Noise

Health hazards from noise, such as noise-induced hearing loss, arise primarily from sources associated with manufacturing, recreation, entertainment, and transport and not from natural sounds.

Loud noise can:

- Mask warning shouts or signals, creating a danger of accidents.
- Disturb worker attention, creating danger at the workplace.
- Result in elevated blood pressure through activation of the autonomic nervous system
- Damage the sensory cells in the inner ear and result in hardness of hearing and deafness.

In small-scale underground mining, damaging sound can come from:

- Jackhammers
- Compressors
- Hitting other metals
- Defective machines

This can be avoided by wearing earmuffs/ear plugs and by repairing machines.

Environmental Management

This module includes the following topics related to the natural and human environment:

- 🕮 Water
- 🕮 Land
- 🕮 Biodiversity
- 🕮 Mercury
- 🕮 Cyanide
- 🕮 Air
- 🕮 Social impacts

Usually, artisanal miners do not make a deliberate effort to protect the environment. Their goal is just to extract the mineral. Visits to ASM mining sites reveal serious land degradation to an extent that lives are lost when people fall into open pits and shafts left after mining. In places where mining of alluvial gold or rubble is done, bare and rocky ground is usually left, which does not support revegetation. Mercury release into the environment is still a concern, though financially able miners now use other gravity separation methods like the germini table. More miners, especially at milling sites, have adopted the use of retorts during mercury amalgamation.

Figure 79: Degraded land left after rubble gold mining

However, at milling sites, the mill owners pay considerable attention to environmental issues. This happens because environmental government agents (e.g., from the Environmental Management Agency [EMA]) frequently visit milling sites to check compliance with environmental regulations.

Virtually all stages of mining pose significant risks to the environment and disturb the aesthetic appeal of Zimbabwe's landscape, flora, and fauna ecosystems. Mining can be sustainably carried out if deliberate practices and systems are put in place to ensure proper environmental management during mining. Such practices include rehabilitating disused mines, reducing the release of mercury into the environment, and using alternatives to mercury for gold processing. Such practices are encompassed in Environmental Management Plans (EMPs) during the operational phase and predetermined by means of an Environmental Impact Assessment (EIA). In this chapter, we will outline the effects of ASM on the various facets of the environment.

Mercury

Mercury, also known as quicksilver, is a heavy, silvery-white metal that is liquid at room temperature and evaporates easily. In nature it is usually found in the form of cinnabar, used in the past as a red pigment. Mercury can be released into the air, water, and soil through industrial processes including mining, metal and cement production, and through fuel extraction and the combustion of fossil fuels. The gold mining industry, which encompasses large-scale miners and ASM miners, uses mercury to extract free gold. In Zimbabwe, mercury amalgamation is widespread due to it being a simple, cheap, and effective method to increase the recovery rate of fine gold. However, ASM are the largest source of anthropogenic mercury emissions and releases to the environment (approximately 1,600 tonnes per year worldwide[18]). Unfortunately, ASM miners do not follow international best practices regarding correct mercury handling and storage and they seldom know the dangers posed by mercury. For this reason, they are more prone to mercury poisoning than their counterparts.

Mercury use in artisanal and small-scale gold mining (ASGM)

Mercury in the ASGM community is often improperly handled due to inadequate provision of PPE and clothing. To store mercury, miners use low density polyethylene plastics 25 microns in thickness. These plastics are normally used by pharmacies when dispensing medicine and they have a zipper top to easy sealing. This is the most common method of transporting mercury before eventual storage in a high-density polyethylene container or a glass container.

[18] Gonçalves, A. (2011). Analysis of gold extraction processes of artisanal and small-scale gold mining in Portovelo-Zaruma, Ecuador. Retrieved from: https://open.library.ubc.ca/media/download/pdf/24/1.0308783/4

A cloth is used separate the gold/mercury mixture by wringing it, allowing the mercury to escape through the fine pores in the woven material. There may be no visible trace of mercury, as most of it will be of sizes between 0.5 and five microns. Particulate matter of this size can enter the body through the respiratory tract by passing nasal hairs for filtration.

In ASGM, mercury use is usually in two forms:

- Whole ore amalgamation
- Concentrate amalgamation

The gold ore is mined and crushed to pebble- or stone-size, mostly by pounding manually. The crushed material is transferred to a metal drum. Introduction of mercury at this stage is referred to as whole ore amalgamation. However, if the ore is further refined by means of a crusher or until it is sand-like, mercury is added for concentrate amalgamation. The amount of mercury added to the ore milling process ranges from a few grams to several kilograms depending on the ore type, the expected amount of gold to be won, and the volume of the drum. Milling time depends on hardness of gold ore. During milling, mercury attracts gold particles, resulting in the formation of a gold amalgam. The amalgam is heated, resulting in the evaporation of mercury and the gold remaining behind. The recovered gold, however, contains 5 to 10% mercury, and this will be burned off further by gold dealers and miners.

Figure 80: Initial steps of separating gold from ore using mercury (amalgamation)

Improving amalgamation

The main factors that limit efficient amalgamation are:

1. Poor liberation (the gold surface is not exposed).
2. The gold surface is dirty.
3. The mercury is not 'activated' and it is not catching the gold.

Even if a particle of gold is not completely liberated from the gangue minerals, it is possible to concentrate it. If some gold is 'occluded' (i.e., hidden) in a particle of another mineral, this can make the particle heavy enough to be concentrated in a gravity process, such as sluicing. In this case, the concentrate needs to be further ground prior to amalgamation to expose the gold and to enable trapping by the mercury. The way to identify occluded gold is through chemical analysis (by a chemical lab) of gold in the amalgamation tailings. To collect a sample of tailing:

1. When the sluice or other concentration process is running, collect a cup (about 0.25 litre) of the pulp of the tailing every 15 minutes (or less) and toss it into a 20-litre bucket.
2. After collecting about five to 10 litres of pulp, wait for the solids to settle at the base of the bucket and siphon or pour the water out.
3. Spread the wet tailings (which will look like a paste) on a plastic tarp and let them dry in the sun.
4. When dry, break up the chunks of tailings in a mortar with a pestle; bring this material back to the tarp.
5. Mix the powder vigorously on the tarp to homogenise it, and make a pile.
6. Collect about 1 kilogram of the powder from each side of the pile a spoonful at a time and put it in a plastic bag. Close the plastic bag and write a label with the name of the sample and date.
7. Send it to a lab. If a chemical lab is impossible to find, grind the tailings sample in the mortar and pan it to see if there is any visible gold.

If the tailing analysis indicates gold grades above 20 milligrams per kilogram or 20 parts per million (ppm), or if there is visible gold in the pan, this is an indication that either the amalgamation has not been properly performed or that the gold particles were not exposed (i.e., liberated) to the mercury for amalgamation.
If in the panning process some droplets of mercury are visible, this is an indication that the amalgamation process has been too long, or that the mercury introduced into the drum was 'sick'. The solution is to reduce the amalgamation time (keep the time around 30 to 40 minutes), and to use 'activated' sodium-amalgam instead of pure mercury in the amalgamation process.

Sometimes the surface of gold is covered with organic matter, oil, or iron oxides (red earthy minerals). A good way to get rid of this is by using a bit of caustic soda (one gram per kilogram of concentrate) or non-foaming detergent. A vigorous agitation of the concentrate with a little water (30% water) before the amalgamation can also remove any earthy minerals adhered to the gold surface. Then adjust the water content up to 50%, add mercury into the drum, and perform the amalgamation as described above.

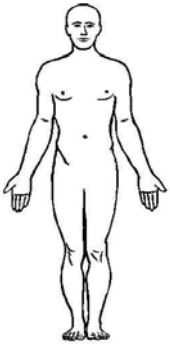
When the mercury is 'sick', it does not amalgamate gold efficiently because the mercury is 'oxidised'. To find out if the mercury is 'sick', introduce a shiny copper wire into the mercury and check if the wire comes out amalgamated. If not, the mercury is 'sick'. Sodium or zinc amalgams have better properties to amalgamate gold than pure mercury.

Effects of mercury exposure

Mercury is a known carcinogen, meaning that it can cause cancer in living tissue. Factors that determine whether health effects occur and their severity include the:

- Type of mercury concerned
- Dose
- Age or developmental stage of the person exposed (the foetus is most susceptible)
- Duration of exposure
- Mode of exposure (inhalation, ingestion, or dermal contact)

The health hazards associated with improper mercury use include:



- Impaired neurological development (cognitive thinking, memory, attention, language, and fine motor and visual spatial skills may be affected)
- Tremors, insomnia, memory loss, neuromuscular effects, headaches, and cognitive and motor dysfunction
- Increased protein in the urine, kidney failure
- Negative effects on digestive and immune system
- Skin rashes and dermatitis

The picture below illustrates that mercury affects the air, water, soil, and the food chain. Research has highlighted that fish in Insukamini Dam in Lower Gweru are dying because of mercury poisoning from the use of mercury in amalgamation of gold upstream.[19]

Figure 81. Mercury flow through the food chain

The effects of mercury can be reduced by complying with the law. For example, the laws on explosives prohibit the storage of hazardous substances in homesteads, while health and safety laws promote the wearing of protective clothing.

According to Hon Muchinguri, 'Mercury is a naturally occurring element that is found in the air, water, and soil. However, human activity is the main cause of mercury releases, particularly coal-fired power stations, residential coal burning for heating and cooking, industrial processes, waste incinerations and mining for mercury, gold, and other metals[20]'

Mercury can affect miners, their families, communities, and the environment. Mercury contamination can have an impact up to two kilometres away from the amalgamation processes, while the vapour can travel greater distances. Mercury only comes down when it rains. It is therefore important for the miners to look for alternative ways of processing their gold.

[19] ZHRC. (2015). Baseline study on perceptions, attitudes, and understanding of human rights in Zimbabwe. (Unpublished).

[20] Samukange, T. (2016, January 13). Small-scale miners' mercury use scars environment. Newsday Zimbabwe.

Safe mercury handling techniques

To demystify the use of PPE amongst ASGM miners, increased awareness of the dangers of not using or improperly using PPE in mercury-prone environments is critical. Awareness is a necessary predisposing factor for behaviour change, and that knowledge can also dramatically improve attitude, dispel misconceptions, and consequently enhance small-scale mining practices.

Miners should endeavour to acquire and wear impervious clothing such as gloves, face shields (8-inch minimum), and other clothing which prevents continued exposure or skin contact with liquid mercury. If miners' clothing is contaminated with mercury, they should change into uncontaminated clothing before leaving the work premises and ensure all contaminated clothing is quarantined in a closed storage container until it can be disposed of or the mercury is removed through an approved methodology.

Miners who have skin contact with liquid mercury should immediately and thoroughly wash exposed body surfaces with soap or a mild detergent and water.

Eating and smoking should not be permitted in areas where mercury is handled, processed, or stored. Miners who handle mercury should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

Methods of reducing open-air amalgamation

Zimbabwe is a signatory to the Minamata Convention on Mercury, a global treaty that seeks to reduce and eventually eradicate the use of mercury. The treaty came into effect on 16 August 2017, and the Government of Zimbabwe has so far restricted the movement of mercury across the country's borders and initiated a multi-stakeholder engagement to plan its implementation. This calls for drafting and implementing solutions to the mercury crisis with the aim of promoting miners' livelihoods while reducing and subsequently eliminating the use of mercury.

Two cycles are believed to be involved in the environmental transport and distribution of mercury. One involves the atmospheric circulation of elemental mercury vapour. The second cycle is local in scope and depends upon inorganic mercury from sources like the gold mining process. Alternatives currently proposed to be used include the following techniques and methods.

Retorts

To avoid open burning, the mercury in the amalgam can be captured and recycled using a retort or fume hood.

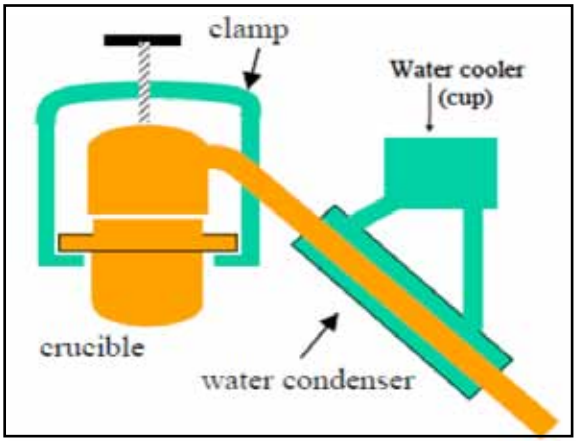


Figure 82. Components of the classic retort

Retorts heat amalgam in one part and cool and condense the mercury vapour back into a liquid in another part of the device. The process of burning amalgam involves placing amalgam in a stainless steel retort, clamping the retort tight, and placing it on a gas burner. Mercury vapour leaves the amalgam, condenses in the steel tube, and drips into the vessel containing cool water. Once the retort has fully cooled after use, it is opened to recover the gold. The mercury can then be re-used.

Capturing and recycling mercury can be an effective first step in moving towards mercury-free processing. Simple and affordable models can reduce mercury emissions by 75 to 95%. Recycling mercury prevents the need for fresh mercury imports. This can lower costs for miners and gold shops by reducing mercury consumption. The cost of a typical mercury retort ranges from $90 to $160, depending on the load capacity and mercury input requirement.

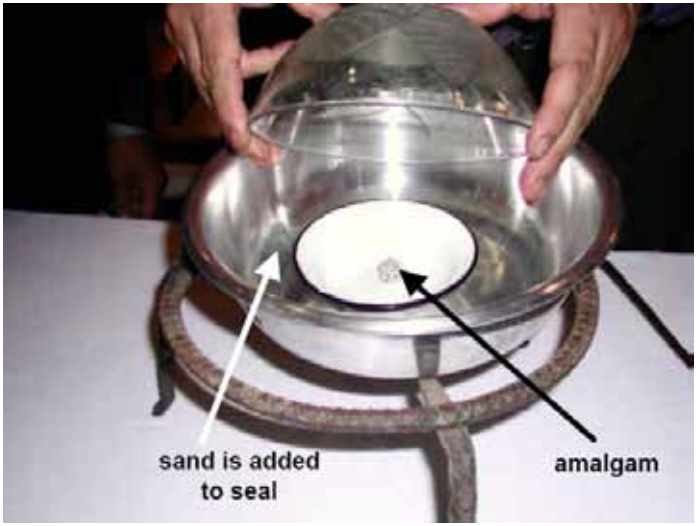


Figure 83: Kitchen-bowl retort

Caution

Once a retort or fume hood is used, it becomes contaminated with mercury and must be treated with care. They should be kept in a secure space and precautions must be taken if they are transported inside cars or in backpacks to prevent exposure.

Retorts should never be operated by children or by women of child-bearing age. They should only be used in very well-ventilated areas, preferably outdoors or inside of a fume hood. Use damp sand to make a good seal and keep the sand damp while heating the retort. Retorts also should not be opened until cool or else mercury gas can escape and cause exposure.

Fume hoods

Like retorts, fume hoods designed with mercury capture systems can reduce mercury emissions and exposure to mercury fumes. A well-designed but affordable system can capture 80% of emissions. Highly sophisticated systems can capture more, but are more expensive and complicated to operate.

The water box mercury condenser is an inexpensive and easy-to-manufacture add-on to small fume hoods like chimneys used in many gold shops. Mercury vapour is pushed through the system by a fan. The vapour is bubbled through

water in the plastic vessel and cools. This causes the mercury to condense as liquid mercury and sink below the water where it is isolated from the atmosphere. The mercury can be collected for re-use. Mercury is captured here in the water trap.

Recycled mercury must be treated with care to prevent contamination and exposure. Captured mercury needs to be collected and stored safely. A good way to store mercury is to tightly seal it in durable glass, steel, or plastic vessels under a layer of water, which prevents the mercury from evaporating.

Figure 84: Fume hood

Mercury activation

Mercury is less effective for amalgamation when it has become contaminated with other substances through use or has become oxidised. An effective method for cleaning and activating mercury uses a solution of table salt and a simple battery to clean and 'activate' the mercury. The following steps are carried out:

1. Pour the used mercury into a plastic, glass, or ceramic cup.
2. Mix a large spoon of table salt into a glass of water and when the salt is dissolved, pour the solution over the mercury.
3. Use copper wires to connect the battery to the mercury and the saltwater solution.

4. Using a copper cable, connect the negative pole of a 9V or 12V battery (a motorbike or car battery is good) to the mercury and the positive pole to the solution. The surface of mercury becomes clean of the dark-coloured oxidation product in 10 to 20 minutes

The resulting 'mirror clean' mercury amalgamates gold more effectively, lowering mercury use, and prevents miners from discarding used mercury into the environment.

Figure 85: Miner activating mercury using a radio battery

Improved concentration

Producing concentrates is an essential step in the gold mining process, and if done well, can enable reduction or even elimination of mercury use. The choice of technology (or technologies over several stages of concentration) to produce a concentrate depends on the type of ore, grain size and mineralogy of the gold, access to capital, and know-how to acquire and operate processing equipment. Many of the more costly interventions will only be accessible to formalised miners with access to capital.

Because concentrating gold is challenging, ASGM miners can lose 25 to 75% of gold during concentration due to poor practices. This inefficiency can result in tailings containing a significant amount of gold which can eventually be reprocessed, often using other methods such as chemical leaching.

Sluices

Sluices work on the principle that heavy particles sink to the bottom of a stream of water while lighter particles tend to be carried downstream and discharged. A rough surface, typically carpets, can trap the gold and other heavy particles. Like a ball rolling down a hill, flow and momentum increase with distance, making the trapping mechanism less effective further down the sluice, particularly for fine gold. For this reason, most gold is caught in the first meter of simple sluices like the one shown below. More sophisticated designs can avoid this problem.

Figure 86: Mobile sluice box

For efficient sluice operation, consistent water supply is important. When buckets are used to deliver sediment and water onto sluices, surges in flow can lift gold particles off the carpets, reducing gold recovery. This can be avoided by filling a small reservoir (like an oil barrel) to deliver consistent flow to the sluice.

Zigzag sluice configurations, where a top sluice drops material onto a second sluice, can be used to break flow velocity and therefore increase gold recovery.

Sluices are usually inclined at 5- to 15-degree angles. A combination of two sluice surfaces can be the optimal set-up. These are called primary and scavenger sluices.

Centrifugal concentrators

A centrifuge consists of a rotating bowl that has a series of ridges that trap gold as the bowl spins. Force applied to the feed material (milled ore, heavy mineral concentrate, alluvial sands, etc.) can be 50 to 200 times the force of gravity, providing more effective separation of gold from lighter minerals than systems that depend on gravity only. Ore is usually fed into the concentrating bowl in slurry of 60 to 75% water (40 to 25% solids). Inside the bowl, material moves upwards as the bowl spins, and heavy minerals including gold are trapped between the ridges while light minerals flow up and out of the bowl, ejected as tailings. For small-scale centrifuges an operating cycle typically lasts 0.5 to two hours, after which the concentrate must be cleaned out of the bowl from between ridges.

Centrifuges come in a variety of designs and cost ranges, with more expensive designs having better engineering and therefore higher efficiencies and throughput capacities.

Generally, centrifugal concentrating requires:

- Slurry feed with relatively uniform grain size (good milling and screening is important)
- Access to process water
- Access to a power supply
- Capital investment (beginning at several thousand dollars)

Centrifuges must be tuned to the ore being processed, and they must be operated with diligence. This is accomplished by adjusting feed grain size (milling control), rate of feed, rotation velocity, and cycle duration. One of the main challenges is to keep the concentrate bed active (avoiding compaction between the ridges); this ensures that heavy gold particles will replace lighter ones, which flow over the ridges and out of the bowl.

Figure 87. Centrifuge gold kacha, commonly used in Zimbabwe

Spiral concentrators

Spiral concentrates can help to enhance concentration. They are specialised pans with spiral grooves on their surface, mounted on a tilted axis. They can be useful to work concentrates from many kilograms down to a few hundred grams. The concentrate produced by a spiral concentrator may be suitable for zero-mercury treatments such as direct smelting. Typically, a small motor run by a battery turns the pan, and water showers the spirals. Concentrates are added to the bottom of the pan using a small scoop. Heavy minerals are carried upwards in the spirals as water washes lighter minerals back down. Heavy particles like gold remain in the spirals and are lifted up to drop through a hole in the centre of the pan into to a cup.

Vortexes

Vortexes can help to enhance concentration. During the final step of producing a high-grade concentrate, vortexes are particularly good at capturing fine gold. Water enters a 30 to 50cm bowl at a laterally angle from a hose causing the water to rotate creating a whirl-pool which drains out through an elevated hole in the centre. Concentrate is placed into the bowl and the spinning water suspends light particles, while heavier particles (e.g., gold) are left behind. The suspended particles flow through the elevated drain into a bucket below. Flow can be supplied by a small pump or a raised water vessel. For best results, use clean water. Vortexes are very cheap and simple to operate.

Shaking tables

Shaking tables are slightly inclined with a trough along the lower edge, and slightly raised ridges along their length. The mineral feed and water are added along the high edge of the table, and a motor is used to shake the table. Inclination, water flow, and shaking result in particle movement along the table towards the lowest corner. Light particles are more easily washed over the ridges than heavy particles separating them along the table and creating a heavy, gold rich concentrate.

Shaking tables can provide excellent separation of liberated gold from other minerals and produce high-grade concentrates greater than 50%. The gold must still be extracted from the concentrate using another process (gravity, chemical, or direct smelting, for example). Tables can be expensive, however, and require careful attention and training to operate effectively. As a result, they will likely only be accessible to organised small-scale miners with access to capital.

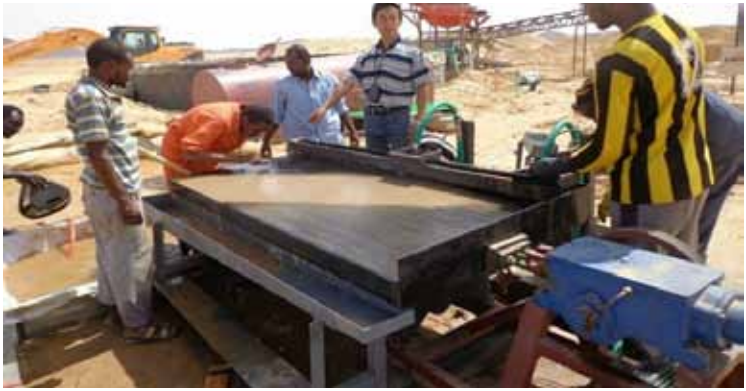


Figure 88: Shaking table

Flotation

Flotation separates different materials by taking advantage of differences in their surface properties. Chemical agents are used to float minerals and form mineral-rich foam, which is then separated from the surface of the bath to produce a concentrate. Flotation is one of the main processes used by large-scale mines to concentrate sulphides and gold, but can easily be done in small-scale mining, too.

This flotation system begins with a crusher, then a mill, then proceeds to a sluice to capture coarse gold, and then to the flotation cell. A sulphide concentrate rich

in gold is skimmed from the system using paddleboat skimmers. The gold in the concentrate is extracted with cyanide.

The principle behind flotation is the ability to attach bubbles or other buoyant materials to a mineral's surface—a function of the mineral's 'wettability'. A hydrophilic mineral is one that is easily wetted, while a hydrophobic mineral is one that is water-repellent. Many minerals such as silicates, sulphides, oxides, and carbonates can be separated by flotation—even minerals that have similar density and are difficult to separate by gravity. For this reason, flotation can enable the processing of complex ore types, including ores that are difficult to process using gravity methods.

Three main steps for flotation:

1. Add chemical reagent to slurry (crushed ore and water) to make minerals hydrophobic.
2. Bubble the slurry to transport desired minerals upwards and create a surface froth (a mineral-rich foam).
3. Skim (separate) the floating mineral foam from the flotation cell to produce concentrate.

Magnets

Magnets are often used as a tool to enhance concentration and to remove magnetic minerals (mostly magnetite). Magnetic minerals are typically dark in colour but some, such as pyrrhotite (a sulphide), can be bronze-coloured and can have a metallic lustre. A handheld magnet is used to remove unwanted minerals, with care taken to avoid losing gold. To do this, the magnet is used below the pan to separate magnetic from nonmagnetic minerals. Frequently, wet mineral concentrate is heated to dry the minerals before using magnets for this purpose. This also increases the strength of magnetism in some minerals. A piece of paper or plastic is often used to cover the magnet so that the minerals can be easily removed from it.

Magnets have also been used to form sluice beds by making a 'carpet of magnetite'. In certain cases, these magnetic sluices can improve the efficiency of recovering fine gold from concentrates. A thin magnetic sheet is placed on a small sluice. Magnetic mineral particles collect on the surface, forming a bed into which fine gold particles can settle. The sluice liner is comprised of polarised magnetic strips along its length.

Mercury-free methods of gold processing

Table 8: Summary of alternatives to the amalgamation of gold-bearing concentrates

Alternative processes	Limitations
Simple processes	
Panning gold nuggets	Only usable for coarse gold
Magnetic separation and panning	Only applicable for magnetic materials
Blowing	Used for small quantities
Friction separation on inclined rough surface	Used for small quantities of flaky gold
More advanced processes	
Direct smelting	Need highly enriched concentrates
Cyanide leaching	Slow process with health, safety, and environmental risks
Leaching water or other reagents (Cl, Br)	Technical complexity; high cost; slow process with health, safety, and environmental risks
Gold or oil agglomeration	Needs highly-enriched concentrates; technical complexity; high costs; health, safety, and environmental risks

Gravity methods are the most widely used method of concentrating gold in ASGM. Using gravity is effective because gold is heavy—approximately seven times heavier than an average rock of the same size. There are a wide variety of approaches to gravity concentration from basic (such as panning and sluicing) to more complex (such as centrifuges and shaker tables).

Panning: Pans or panning dishes are widely used for concentration in many ASGM sites. Panning with water causes lighter particles to flow over the edge of the pan while heavier particles, including gold, remain at the bottom. Gold is 19 times heavier than water, mercury is 13 times heavier than water, and the average rock is only three times heavier. Simple panning works best when gold is coarse and well-liberated. Naturally occurring alluvial gold grains are not pure 24-carat gold. They contain other metals and typically range from 85 to 95% gold.

Borax or direct smelting: Borax ($Na_2B_4O_7{\cdot}10H_2O$) is a component of many detergents. It reduces the melting point of all minerals, including gold. The melting point of gold is 1,063 degrees Celsius, which is a much higher temperature than can be obtained by inexpensive burners. By adding borax to the heavy mineral concentrate, the melting point temperature decreases, permitting small-scale miners to melt gold out of their concentrate. By using borax, mercury usage is eliminated, and borax is environmentally benign. A second advantage is that it recovers much more gold. The milled ore is washed

in a pan to concentrate the heavy minerals, including gold, a typical activity done by ASGM miners. Borax is then added to the concentrated heavy metals in a bowl and heat is applied. After a short while, the borax melts, and further heating for a few minutes will melt the heavy mineral concentrate. The molten gold drops concentrate in the bottom of the bowl.

However, this method is only efficient with very low sulphide content concentrates and in materials that are not ground too much. Studies indicate that for the process to be effective, the concentration process must achieve high gold grades (>30,000 ppm Au or 3% Au). The higher the concentrate grade, the lower the gold recovery. Enrichment to a 3% Au concentrate grade is much too high and will compromise gold recovery. The process seems useful for a narrow range of artisanal miners and types of ores (e.g., those without sulphides). It may be useful for the lowest level of ASM producing very small amounts of gold per day and working with alluvial ores in water streams. The process requires comparatively more resources than processing using mercury but is only useful when applied to a tiny pile of gold containing a tiny bit of sand, while mercury is effective when applied to a big pile of sand containing a tiny bit of gold. Borax merely makes some impurities—very small amounts of other minerals—melt at a lower temperature and become thinner so that the mineral melts and gold can be separated easily.

Chemical leaching of various types can be a viable alternative to using mercury in small-scale mining if it is done properly and is well-managed. This requires capital, training, monitoring, and innovation. Industrial gold mining, which once used mercury, moved away from it by adopting chemical leaching methods. The dominant method used by large-scale mines is chemical leaching using cyanide. While cyanide and mercury are both hazardous substances, cyanide is a degradable compound that can be destroyed, and is not persistent in the environment. Cyanide can obtain very high recovery rates—often 90% of the gold in the ore—and it is cheap. Innovations in cyanide leaching allowed large deposits of low gold grade to be processed, allowing formerly uneconomical ore deposits to be exploited[21]. For the same set of reasons, the use of cyanide has become increasingly adopted by small-scale miners. Unfortunately, misuse and poor management of cyanide in small-scale mining are common and have led to disastrous local pollution and safety hazards. In these cases, better practices or alternative methods need to be developed.

[21] United Nations Environment Programme. (2011). A practical guide: Reducing mercury use in artisanal and small-scale gold mining.

The Zimbabwe Code of Practice for mercury use, storage, and disposal in small-scale mining

The Standards Association of Zimbabwe (SAZ) has developed a Zimbabwe Code of Practice for mercury use, storage and disposal in small-scale mining[22], which specifies the minimum guidelines for the purchase, use, handling, storage, and disposal of mercury in small-scale-mining. Mercury can only be traded by persons licensed by EMA to do so. In addition, the Code of Practice specifies requirements for:

- **Storage, packaging, and labelling:** The code specifies safe handling, storage, proper packaging and correct labelling measures that include establishing systems and practices that not only protect miners but also the surrounding environment and community.
- **Training:** Workers are mandated to receive training on the proper mercury management safety systems to protect themselves and the environment from the deadly hazards posed by the use, storage, and disposal of mercury.
- **Worker safety measures:** Employees should always be protected from mercury exposure. This includes developing a thorough mercury hazard identification and risk assessment plan, which should periodically be reviewed. All operations need to be constantly monitored.
- **Emergency response capabilities:** All operations should be adequately resourced to combat any mercury releases. This entails crafting a feasible emergency response plan that is periodically reviewed by all personnel and stakeholders.
- **Decommissioning:** All decommissioning plans and procedures should be guided by the relevant regulatory stipulations to ensure a safe environment and protected community.
- **Stakeholder engagement:** All key affected stakeholders should be consulted and informed of the mercury management practices being employed, any intentions and/or methods used to dispose of mercury, and any environmental and operational information relating to the use of mercury in mining.

[22] SAZ. (2016). ZWS 1010:2016 Zimbabwe code of practice for mercury use, storage and disposal in small-scale mining.

Water

ASGM operations can harm the environment by polluting the surface water sources surrounding them. Miners tend to divert surface water and install boreholes to pump groundwater towards water-demanding mining and milling processes. This lowers the quantity and/or quality of water available downstream for terrestrial flora and fauna, aquatic plants, macroorganisms, and microorganisms, as well as depriving other industrial and municipal water users. Mining releases contaminated water into water bodies, thereby increasing the water turbidity and harming water-bound microorganisms that thrive on light (phytoplankton).

Measures to conserve water

Whenever new equipment is purchased, there is need to ensure its use promotes the water conservation. If the mine site is located within the municipal water reticulation system, it should ideally be set aside as backup water supply and the use thereof should be monitored on calibrated water meters installed at all points of municipal water inflow. Closed water systems, whereby effluent water is drained, collected, and reused or recycled, reduce demand for fresh water and minimise resultant pollution and should be constructed. This entails that all processes demanding water operate on recycled or processed water. As a result, surface and underground protection mechanisms should be developed to prevent and minimise any surface and groundwater pollution. All drainage channels in the closed system must be free of any blockages to prevent and minimise restrictions to water flow. This limits water being lost through evaporation and seepage. Miners should proactively deal with any observed faults to the water reticulation system, which might result in any water spillage or leaks. All employees on site should be made aware of this kind of conservation program.

Monitoring of effluent

In accordance with Statutory Instrument (SI) 6 of 2007 (Effluent and Solid Waste Disposal), water samples should be collected periodically (quarterly) to monitor their potential polluting effect through seepage into surface and groundwater bodies. To monitor potential seepage from slimes dams and treatment tanks at elution plants, the effluent water samples obtained are sent to the laboratory for chemical analysis. Where treatment is possible, effluent from the mining process should be treated to reduce the concentrations of pollutants in the effluent before discharging it into the environment. At least biannually, water samples should be obtained from the boreholes situated within the mining and milling area to monitor the effect of mine water discharged on groundwater. These samples should be sent to the laboratory for analysis as per the regulations, and

results should be filed for future comparison. If any abnormal results and trends are observed, an immediate investigation needs to be launched.

Acid mine drainage (AMD)

AMD is the result of the oxidation of sulphide minerals, chiefly iron pyrite or iron disulphide (FeS_2). This is a natural chemical reaction that can advance when minerals are exposed to air and water. Acidic drainage is found around the world as a result of both naturally occurring processes and activities associated with land disturbances, such as highway construction and mining, where acid-forming minerals are exposed at the surface of the earth. These acidic conditions can cause metals in geologic materials to dissolve, which can lead to the deterioration of water quality, which in turn has a detrimental effect on terrestrial or aquatic organisms.

Chemistry of AMD

The reaction of pyrite with oxygen and water produces a solution of ferrous sulphate and sulfuric acid. Ferrous iron can further be oxidised producing additional acidity. Iron- and sulphur-oxidising bacteria are known to catalyse these reactions at low pH, thereby increasing the rate of reaction by several orders of magnitude. In undisturbed natural systems, this oxidation process occurs at slow rates over geologic time periods. When pyrite is exposed to oxygen and water, it is oxidised, resulting in hydrogen ion release (acidity, sulphate ions, and soluble metal ions. The acidity of water is typically expressed as pH or the logarithmic concentration of hydrogen ion concentration in water, such that a pH of 6 has ten times the hydrogen ion content of neutral pH 7 water.

Acid mine drainage prevention and elimination techniques

Preventive techniques are those which have the objective of preventing the production of acid effluents from the small-scale mine. On the other hand, corrective or elimination techniques are designed to treat the acidic waters produced by mining, so that they stop being a threat to the environment.

When planning the mine abandonment, priority should be given to suitable preventive techniques. The use of corrective techniques is only justified for the most serious and unforeseen cases of acid water pollution. Therefore, a mine waste treatment must be included in the mining project to minimise the exposure of these materials to inclement weather and to reduce the mine waste volume to be processed and stored. In small-scale mining areas with high concentrations of pollutants, AMD treatment costs can have a significant impact on economic performance, even compromising the project viability, so AMD formation should be prevented.

Preventive techniques act on any of the three elements that are essential in the formation of acidic waters: oxygen, water and Thiobacillus ferrooxidans bacteria.

- **Surface water diversion** tries to reduce the water supply to those potentially acid-generating materials, by using safeguarding channels, pipes, waterproofed channels, or slope changes around the material area. The systematic application of this technique can be a mistake, however, because the effort to divert the surface water (which can be costly in time and money) to reduce large masses of water supply to areas where acid production is not extremely high can reduce the quantity of water entering other areas that are may have an extremely high production of acid and are therefore more dangerous. Even so, this is an inexpensive, easy to apply technique that works well in conjunction with other techniques.
- **Soil compaction:** Compaction of mining wastes decreases their permeability. This compaction reduces water flow, which remains longer in the tailings, hindering the oxidation of the materials and therefore the rate of acid production. It also decreases oxygen diffusion, which slows down pyrite oxidation and makes the tailings less habitable for ferro-oxidant bacteria.
- **Dry covers:** The application of dry covers can be done to achieve different objectives, including mining waste stabilisation to prevent erosion by wind and water, aesthetic appearance improvement, and both prevention and inhibition of pollutant release. There are a multitude of cover designs that cover the waste with soil or rock and use cementitious materials to form a crust. The effectiveness of the method increases when choosing a high and dry location for the dump. The cover should be stable and provide long-term protection. This generally requires at least two layers of different materials, as it is rare that the required properties are found together in the same material. First, a bottom sealing layer with low permeability is required to decrease the oxygen diffusion and to hold large amounts of water, acting as a barrier to oxygen. Clays are suitable materials for this layer, especially bentonite. However, clay barriers are particularly prone to breaking during dry conditions, letting in oxygen and water. Organic materials may be a good substitute to clay provided that the layer is thick enough.

Table 9: Advantages and disadvantages of materials used for dry covers[23]

Material	Advantages	Disadvantages
PVC Sheet	Completely impermeable Low installation costs	Capable of Boring Relatively Expensive
Grout	Lower Price Lower Installation Costs	Susceptible to weathering Undefined compaction/ permeability rate
Clays (Bentonite)	Durable Cheap and available	Undefined compaction/ permeability rate Dry conditions required for application
Asphalt	Fully permeable	Expensive Material High Installation costs Liable to deformation

Corrective techniques for AMD can be used to purify the acidic waters produced by a mine. They are conceptually opposite to the preventive techniques that aim to avoid the formation of those acid waters in the first place. Corrective techniques are applied without distinction in underground or surface mines.

Natural neutralisation with river waters ('synergistic' solutions) are very attractive and low-cost corrective methods to easily neutralise acidic waters. The method uses the neutralising capacity of a river. If the river flow is much larger than strictly necessary to neutralise the mining acid drainage of the area, a portion of the flow can be diverted into a branch, constituted by a set of ponds arranged in series to precipitate the metals and subsequently neutralise the water in a

[23] Santiago Pozo-Antonio et al, (2014). Techniques to correct and prevent acid mine drainage: A review.

controlled manner. The process then drives the acidic water coming from the mine to a circuit of staggered settling ponds, through which water circulates by gravity. In these ponds, if the flow is slow enough, the iron sulphate will precipitate, and a gradual increase of the water pH will take place. The system is designed so that water is clean and properly neutral in the pond before its discharge to the river (located downstream of the inlet), so that the riverbed will remain untainted in its entire course.

This is not a universally applicable technique, as there are factors that prevent its use in many cases. The necessary conditions for the application of this method are:

- River flow must be large enough to withstand the diversion of a portion of it to neutralise the acid drainage.
- Materials and slope of the terrain must be appropriate for the construction of the settling basins.
- Ponds must be designed so that there is no imbalance depending on maximum and minimum periods of precipitation and/or temperature, since the first of them influences the flow, and low temperatures make neutralization less effective.
- The size of the mine must be adequate to deposit the deposed metal hydroxides, which should be removed from the ponds periodically so that the system remains effective.

In any case, the conclusions to be drawn depend on the specific problem that occurs. Therefore, the natural neutralising action of river waters can help and even resolve the problem of the acidic water if the control of some key parameters is achieved and the initial conditions are adequate.

The Zimbabwe Standard for design, dewatering support of mining shafts in small-scale mining

SAZ has developed a mining standard that provides minimum guidelines for design and dewatering support of mining shafts in small-scale mining.[24] Mining operations have a potential to cause groundwater contamination and this potential depends on the geophysical properties of the soil and rock, with permeable lithologies being more prone to advancing contaminated water's access to the underlying water table. A desk study and follow-up hydrogeological survey is therefore pertinent prior to commencement of any mining activities and any environmental protection mechanisms clearly outlined in the EMP.

[24]SAZ. (2016). ZWS 1011:2016 Zimbabwe standard for design, dewatering support of mining shafts in small-scale mining.

Land and biodiversity

To varying extents, almost every stage of the mining cycle damages the environment. During the mineral exploration phase, land should be cleared and topsoil removed as the drill rigs manoeuvre to the potential mine sites, where initial work is used to gather data that defines the extents and qualities of the orebody. Similarly, to define eluvial mineral deposits, massive pitting and trenching exercises leave deep excavations that not only scar the landscape but also pose a threat to humans and animals. Mining indisputably has dire effects on biodiversity, as removal of vegetation negatively impacts the natural ecosystem if not managed well.

Effects of mining on the landscape and biodiversity

Removal of overburden as the minerals are being evaluated and exploited results in the following impacts on the landscape and biodiversity.

- **Siltation:** Mining results in topsoil loosening and ultimately leads to soil erosion. The loose soil, if washed by run-off, leads to siltation of rivers and subsequently water supply is decreased.
- **Loss of vegetation:** Deforestation is inevitable in mining but varies in intensity depending on the scale of operation with extreme cases leading to desertification. Where mining is prevalent, the vegetative canopy is barely- to non-existent due to the removal of the nutrient-rich topsoil. In ASM communities where there is an overlap in land use between mining and farming, a comparatively significant reduction in crop yield has been the next stage will be the process of extracting the noted following excavation. Reduction in crop yields is so because most plants but grasses cannot thrive well in heavy metal rich soils.
- **Ground subsidence:** As mineral-rich rocks are extracted from underground for further beneficiation on the surface, huge excavations remain underground. These excavations result in rock strain due to differential rock stresses. A common result of this deformation is the creation of sinkholes and, in even worse cases, ground subsidence causing loss of lives and infrastructure.
- **Biodiversity losses:** Mining results in the emission of heavy metals that can directly or indirectly poison biodiversity. Anthropogenic emissions of mercury unfortunately have a bioaccumulative effect on humans and biodiversity, meaning that they build up and continue accumulating over time. Mercury is easily transported in any water released from mining into the soil and water bodies, and therefore easily moves across the food chain as illustrated below. The natural ecology is affected by mining as the pH of soil and water are altered by chemicals released from mining and this leads to the extinction of endemic species of vegetation, animals, and

microorganisms in soil and water that required the original environmental conditions. Those that are not killed by the new environment migrate to new ecosystems that are free from contamination. With proper chemical management, some vegetation can survive on the rocky surfaces which characterise mine sites, as nutrient-deficient and heavy metal-rich boulders are laid bare on the earth's surface.

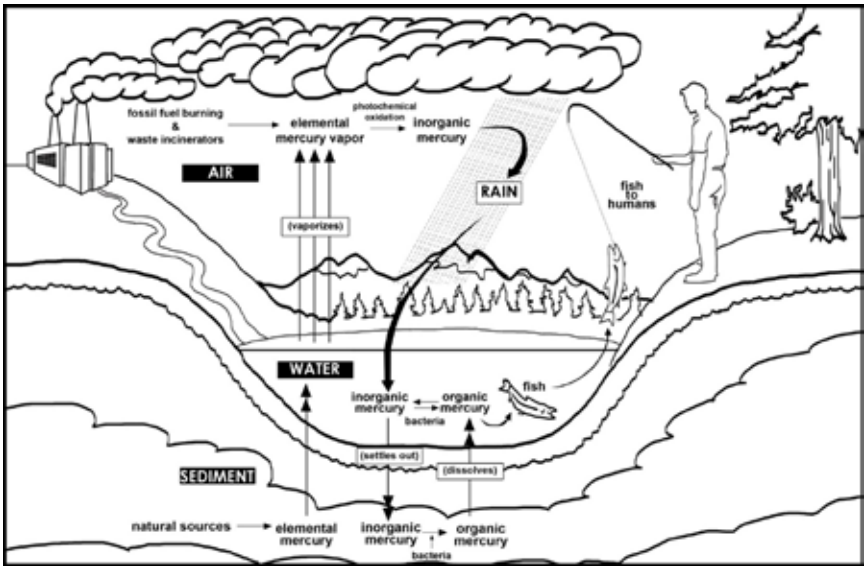


Figure 89. The flow of mercury in the ecosystem

Measures to reduce mining impacts on land and biodiversity

Mineral exploitation is finite—and therefore temporary—land use activity (although some mines can have very long lives), and each operation should close at some point in the future. Restoration of the ecology to its normal state post-mine closure, or as mining continues, therefore calls for appropriate environmental protection through mine reclamation. This is usually achieved through environmental rehabilitation.

Environmental rehabilitation (operation and decommissioning phases)

Rehabilitation aims to reinstate ecosystem functionality and land productivity, although it will probably assume a different land-use and species composition from the original ecosystem. This may comprise planting of vegetation (trees and shrubs) as well as re-introducing animals that used to occupy the area before

mining commenced. Environmental rehabilitation is also a legal requirement of the Environmental Management Act (20:27) and is enshrined in best practises and international standards, such as the ISO 14001 series. Any mine that follows these international standards has a competitive advantage and is likely to attract investors due to its progressive code of conduct.

Mine closure generally occurs when the resource is depleted or when the cost of production exceeds returns. Closure, therefore, provides opportunities for land disturbed by mining to be rehabilitated to one or more sustainable function. Successful rehabilitation requires a continuous improvement focus, based on site-specific knowledge, research, and monitoring. Opportunities and threats should be identified as early as the EIA stage so that mining operations do not reduce rehabilitation options.

Baseline environmental and social assessments, usually conducted as part of the EIA for mining projects, provide information that will be used during the monitoring of rehabilitation efforts. This information may include data on vegetation cover, soil quality, and water quality.

Surface roughness: Surface roughness is an important consideration in mine site rehabilitation. Roughness tends to trap water and seed, and it is generally accepted that a rough surface will provide better vegetation establishment than a smooth one. Rehabilitated areas should be ripped to remove compaction from heavy machinery, encourage infiltration of water. Once areas have been graded and contoured, each area should be ripped to provide a rough and furrowed surface to hold seed and moisture. Wherever possible, stripped topsoil should be placed directly onto an area being rehabilitated. This will avoid stockpiling and double handling of the soil. Topsoil containing viable seed, nutrients and microbes should be placed directly onto the rehabilitation area, allowing it to re-vegetate more rapidly than topsoil that has been in stockpile for long periods. Topsoil is often the most important factor in successful rehabilitation, particularly where the objective is to rehabilitate the natural ecosystem.

Self-sustainability: The initial revegetation effort must establish the building blocks for a self-sustaining system, so that successional processes lead to the desired vegetation complex. Seeds should be collected from indigenous plants that are present around the project site. These should be used immediately or stored appropriately and used at the start of the wet season. They should be broadcast onto the soil and applied in conjunction with measures to improve seedling survival, such as scarification of the soil surface or simultaneous application of mulch. A combination of ground cover, shrubs, and tree species should be used. It is usually more economical to establish plants by direct seeding than by planting seedlings.

Fauna: Animals will usually colonise rehabilitated areas if the composition and structure of the rehabilitated vegetation are similar to surrounding areas. This

is achieved by conserving and re-using vegetation by chipping or re-spreading it as mulch or branches to provide shelter for small invertebrates and reptiles, erosion protection and nutrients. It is also important because it provides shelter and breeding habitat for many bird and mammal species.

Rehabilitation monitoring

Monitoring and evaluation are essential to better understand and guide rehabilitation practices. Without the progressive evaluation of rehabilitation efforts, there is the risk of reducing the effectiveness and credibility of the mine rehabilitation plan. Monitoring approaches commonly used in the rehabilitation context include tracking water content and quality, soil surface stability and erosion, the hydrology of waste rock dumps and tailings ponds, air quality and gas emissions, the development of vegetation, colonisation by fauna, and the extent to which rehabilitation and final land use objectives are being met.

Typically, there are two strategies used to evaluate the progress of rehabilitation work:

- Direct comparison with adjacent sites.
- Attribute analysis comparing baseline data from the initial assessments with the current situation.

Reporting of monitoring results to regulators and other stakeholders such as EMA on a quarterly basis is part of the EIA compliance requirements.

Cyanide

Cyanide leaching has been the main industrial process used to extract gold from ores since it was invented in 1887. However, the use of cyanide is controversial due to its potential toxic effects on workers and the environment. There have been several accidents involving cyanide spills during transport or the accidental release of cyanide-contaminated tailings, which have resulted in killing of fish, birds, and other animals. Despite this, there are very few cases of people being poisoned from the use of cyanide in gold mining. The potential for such accidents, however, demands that gold miners use cyanide in a safe and environmentally-responsible manner.

The advantages of cyanide leaching include:

- Only a relatively small amount of cyanide is needed to recover gold, usually less than one kilogram of cyanide is used per tonne of rock.
- Cyanide is very selective at leaching gold and only minor amounts of other minerals in the ore.
- Cyanide leaches coarse and very fine gold, as well as gold that is attached to the rock.
- The process is quick; tank leaching normally takes less than one day.
- Cyanide remaining in the waste product (tailings) can be destroyed to minimise environmental impact.
- Cyanide degrades naturally in the environment, primarily from exposure to the sun's ultraviolet light, to less toxic forms and ultimately to non-toxic carbon dioxide and nitrates.
- If used responsibly in accordance with the Zimbabwe Code of Practice for cyanide use developed by SAZ, the risk of cyanide poisoning can be minimised.
- Cyanide does not accumulate in animals or plant life.

Disadvantages include:

- Cyanide is highly toxic, and at high concentrations it can kill fish, birds, and mammals (including humans).
- Cyanide reacts with mercury to produce soluble chemical compounds that are easily transported with water, thereby spreading mercury contamination to large areas.
- When cyanide reacts with mercury, it converts the mercury to a form in which it more easily enters the food chain and becomes more harmful.

Cyanide is a chemical compound used to leach out gold from low grade ore, particularly tailings. Cyanide inhibits the transfer of oxygen from the blood to the body tissues resulting in cyanide poisoning, characterised by rapid breathing, tremors, gasping, convulsions, and death in instances of severe exposure. Mild poisoning manifests in headache, dizziness, and thyroid enlargement.[25]

[25] Colina, P. (2006). Briefing on mining in the Philippines and the effects on occupational health and safety of mine workers. Presented at the Conference on Coal Mining in Renmin University, Beijing. Retrieved from: http://www.iohsad.org/.

The Zimbabwe Code of Practice for cyanide use, storage, and disposal in small-scale mining

SAZ has developed a Zimbabwe Code of Practice for cyanide use, storage, and disposal in small-scale mining, which specifies the minimum guidelines for the purchase, use, handling, storage and disposal of cyanide in small-scale-mining.[26] Cyanide can only be traded by persons licensed by EMA to do so. Additional requirements include:

- **Handling, storage, packaging and labelling:** The code specifies safe handling, storage, proper packaging and correct labelling measures that include establishing systems and practices that not only protect the miner but also the surrounding environment and community.
- **Decommissioning:** All decommissioning plans and procedures should be guided by the relevant regulatory stipulations to ensure a safe environment and protected community.
- **Worker safety measures:** Employees should be protected from cyanide exposure at all times. This includes developing a thorough cyanide hazard identification and risk assessment plan. This should periodically be reviewed, and all operations need to be constantly monitored.
- **Emergency response capacity:** All operations should be adequately resourced to combat any cyanide releases. This entails crafting a feasible emergency response plan that is periodically reviewed by all personnel and stakeholders.
- **Training:** All workers should be trained on cyanide management practices.
- **Stakeholder engagement:** All key affected stakeholders should be consulted and informed of the cyanide management practices being employed and any intentions and/or methods used to dispose cyanide as well as any environmental and operational information relating to the use of cyanide in mining.

Air

Mining activities and mining support companies discharge particulate matter into the ambient air. Grievances of affected communities have included airborne particulate matter, emissions of black smoke, noise, and vibration. Airborne particulates of major concern within small-scale gold mining include respirable dust, sulphur dioxide, nitrogen dioxide, carbon monoxide, and black smoke. This particulate matter is produced by site clearance and road construction, open-pit drilling and blasting, loading and haulage, vehicular movement, ore and waste

[26] SAZ. (2106). ZWS 1000:2016; Zimbabwe code of practice for cyanide use, storage and disposal in small scale mining – requirements.

rock handling, as well as heap leach crushing by companies during heap leach processing.

All fine dust at a high level of exposure has the potential to cause respiratory diseases and disorders and can exacerbate the condition of people with asthma and arthritis. Occupational exposure to respirable crystalline silica causes silicosis and lung cancer, chronic renal disease, and autoimmune diseases such as rheumatoid arthritis. Crystalline silica has been classified as carcinogenic to humans. Dust from gold mining operations has high silica content. Crystalline silica in the form of quartz is the most common component of soil, sand, and rocks. Exposures to respirable crystalline silica from large-scale gold mining operations have been documented in the past. Crystalline silica dust is released into the air when miners drill, transport, and crush ore in the effort to extract and process minerals. While some attention is paid to reducing crystalline silica exposures in some large-scale mines in developing countries, ASGM is generally unregulated or illegal and conducted without regard to health and safety considerations.

Social impacts

Even though mining in general is a vital economic activity for developing countries like Zimbabwe because of its potential to facilitate industrialisation along with creation of jobs, it can also be a source of social discontent, civil unrest, and other high social costs, such as displacement of communities, farmer-miner conflicts, substance abuse, and high cost of living. Additionally, large influxes of migrant miners can have negative social impact.

Displacement: In Zimbabwe, many communities have been completely displaced because of mineral deposits found in those communities. Some members of the affected communities had to migrate in search of farmlands while others were relocated to different communities by the mining companies. Relocation of communities leads to loss of social ties, psychological problems, and disturbance to the communal way of life. The mass displacement of people from affected communities to townships also has consequences on the town. There may be increased pressure for accommodation and an increase in unemployed youth, who as a result engage in illegal mining. A problem of this kind also has the tendency of generating other social problems such as teenage pregnancy, high levels of truancy, drug trafficking, prostitution, high school dropout rate, and disrespect among the youth.

Farmer-miner conflicts: Across Zimbabwe, tensions between farmers and miners often ensue after miners are awarded prospecting licences. Many face resistance while seeking to peg rights on disputed farmland. Several conflicts have recently been elevated to the status of legal battles. An example is an institution near Chinhoyi that demolished a gold milling project where about $200,000 had been invested, due to a conflict with its farming operations. The

miners' paperwork from the Zimbabwe Investment Authority (ZIA) and mining licences were reportedly in place, and the case has been taken to the high court.

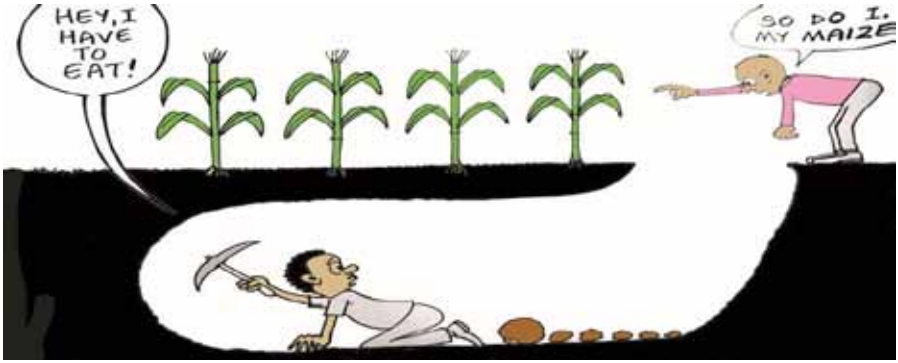


Figure 90: Farmer-miner conflicts

Mining and agriculture are directly linked through agriculture's dependence on mined inputs, land and water resources, and workers. They are also indirectly linked where mining firms have improved infrastructure in a way that supports agricultural development. The outcomes of this interaction appear mixed.

Common areas of conflict between miners and farmers include:

- **Land use:** Globally, the total amount of land used in mining is relatively small compared with agriculture. For example, in the United States, agriculture uses 52% of land area compared to mining's use of 0.02 to 0.1%. Despite the small footprint of mining as a fraction of total land use, conflict can arise at the local level where mining is perceived as competing with agriculture and livestock grazing or other traditional land uses. Displacement and resettlement of farmers from mining areas has also caused conflict where comparable land could not be purchased or share-croppers and farmers without land title were excluded.
- **Water use:** Conflict may also arise between agriculture and mining over access to water resources. Concerns relate to both the total amount of water used, especially in areas with limited fresh water resources, and changes in water quality due to mining activities. The total amount of water used by mining in Zimbabwe is difficult to estimate since water is recycled, gained and lost through subsurface flows, lost through evaporation, and discharged after treatment.
- **Water quality and pollution:** Quality concerns regarding mining's use of water are more complex to assess. Mining operations in Zimbabwe must comply with environmental legislation that normally requires an assessment of potential environmental impacts, and a plan for mitigation or remediation

of these impacts prior to a mine being permitted. In other countries, water discharged from mines during operations and following mine closure must also meet federal water quality standards. However, the capacity of developing countries to enforce environmental legislation is questionable and poor communication on the part of mining companies has led to mistrust in some areas.

- **Worker mobility from farms to mines:** Mining may adversely affect agriculture indirectly when workers switch from one industry to the other. Farmers may engage in artisanal mining seasonally, to supplement farm incomes, or leave farming for mining altogether. In Africa, the declining viability of agriculture has led to a large decrease in agrarian activities and increased mining activities. The discovery of large mineral deposits and the perceived income opportunities they represent can also lead to the abandonment of farmland.

Substance abuse: It is a very common experience among residents of mining communities that addictive substance abuse is on the increase in those areas. The use of drugs and alcohol is a growing problem among small-scale surface miners. The drugs are consumed with the notion that they stimulate them to work hard. The small-scale mining business, which involves excessive physical exertion, is taxing, energy consuming, and risky, hence the high levels of abuse of substances such as alcohol, marijuana, and cocaine. This has also resulted in health-related problems like mental disorders and skin problems among these workers.

High cost of living: The cost of living of mining communities in Zimbabwe is relatively high compared to communities without mining. Wages or incomes of mine workers are used as a decider for goods and services in those communities, which puts non-mine workers (e.g., government workers, farmers) at a disadvantage. For example, salaries of staff in the mine-related jobs are quoted in US dollar terms and as a result they have a higher income levels than those employed in the government sector. In addition, expatriate staff is paid internationally competitive salaries and even a small-scale miner's profit exceeds the salary of a government worker by tenfold. Given these disparities of incomes within the same community, pricing practices for goods and services tend to favour those with high incomes.

Migration: According to a report from the International Institute for Environment and Development[27], one of the most significant impacts that mining activities have on mining communities is the migration of people into those communities, especially in developing countries where mining has become the dominant viable economic activity in that area. For example, mining towns like Kadoma have had an influx of youth from other towns resulting from mining activities.

[27] IIED (2003) Artisanal and Small Scale Mining: Challenges and Opportunities

Environment management plans

Environmental protection refers to any activity to maintain or restore the quality of the environment through preventing the emission of pollutants or reducing the presence of polluting substances in the environment[28]. It may consist of:

- Changes in characteristics of goods and services
- Changes in resource consumption patterns
- Changes in production techniques
- Treatment or disposal of residuals in separate environmental protection facilities
- Recycling
- Prevention of degradation of the landscape and ecosystems

Environmental protection relies on three basic principles:

1. Preserve the existing natural environment
2. Conserve natural resources
3. Where possible, repair damage and reverse trends

In preparing EMPs to develop a mining site, the aim should be to minimise pollution and other adverse effects on the local and natural environment. The EMP emphasises the need to **rectify negative environmental impacts** through rehabilitation and restoration of the affected environment and should therefore focus on areas with the least environmental or amenity value for the siting of works. This is usually done during the EIA process. In accordance with the Environmental Management Act (20:27), mining activities require an EIA to be conducted by environmental consultants.

Environmental impact assessment

The processes and systems involved in the management of environmental issues are embedded in the National Environmental Policy and Strategies 2009, the Environmental Management Act (20:27), SI 7 of 2007 (Environmental Impact Assessment and Ecosystems Protection Regulations) and the EIA Guidelines. Mining is a prescribed activity according to Section 2 and 97 of the Environmental Management Act, which means it requires the miner to prepare an EIA report to be approved by EMA. The EIA report is used to identify and evaluate the environmental impacts of mining operations when carrying out bi-annual environmental audits.

[28] United Nations. (1997). Glossary of environment statistics. Studies in Methods, Series F, No. 67: New York.

The emphasis on the EIA process is a result of the need to ensure sustainable utilisation of natural resources. The EIA is a systematic process to identify, predict and evaluate the environmental effects of proposed projects to aid decision making regarding the significant environmental consequences of projects, developments and programmes. The EIA helps with the identification of all the environmental, social and economic impacts of a proposed development before a decision is taken on whether or not to proceed. Particular attention is given in EIA practice to preventing, mitigating and offsetting the significant adverse effects of proposed undertakings. The processes and systems include:

Submission of a prospectus by the project developer: According to the EIA General Guideline, before carrying out the EIA for a prescribed activity, the project developer must submit a prospectus to EMA containing information regarding the EIA and the project, including:

- A description of the proposed project.
- The status of the project (feasibility, planning, design, or implementation stage).
- A description of the known or predicted environmental impacts.

The prospectus should be reviewed by EMA within 20 days of submission. Upon approval, the developer must appoint an independent expert in environmental assessment to prepare the EIA report.

Preparation of EIA report by the developer: The developer is required to comply with any conditions that the EMA may issue for the development of the EIA report. The EIA General Guideline requires that EIA reports contain the following information:

- A detailed description of the proposed project and the activities which will be undertaken during its implementation.
- Reasons for the selection of the proposed project site.
- A detailed description of the direct, indirect, and cumulative short- and long-term impacts the project will have on various aspects of the environment.
- A specification of the measures proposed for eliminating, reducing, or mitigating the anticipated adverse effects of the project.
- Identification and description of methods for monitoring and managing the adverse environmental effects.
- An indication of whether the environment of any other country is likely to be affected by the project and the measures that will be taken to minimise any damage.
- How the developer plans to integrate biological diversity into the project (where applicable).

- A concise description of the methodology used by the developer when compiling the EIA report.

Review of EIA report and award of EIA certificate: According to the EIA General Guideline, EMA will review the EIA report or, if the agency does not have adequate expertise in an area, they may ask other government departments such as the Forestry Commission to review the document. On reviewing the report, the EMA can approve the project to which the EIA report relates, require the developer to conduct a further EIA for part or the whole project, or ask the developer to supply additional information or complete other tasks as EMA considers necessary.

Biannual environmental audit: According to Section 13(1) of SI 7 of 2007, the EMA must carry out bi-annual environmental audits to ensure that all projects being implemented are legally compliant. The audits focus on the implementation of conditions set out in the EMP that is contained in the EIA report.

Preparing an EMP

What is an EMP?

An EMP is a site- or project-specific plan developed to ensure that appropriate environmental management practices are followed during a project's construction and/or operation. An effective EMP should ensure:

- Application of best practice environmental management to a project.
- The implementation of a project's EIA including its conditions of approval or consent.
- Compliance with environmental legislation.
- That environmental risks associated with a project are properly managed.

Table 10: Checklist of a typical EMP

Does Your EMP Contain	[Yes	No
Background (EMP Guideline Section 4.3.1)		
Introduction		
Project Description		
EMP Context		
EMP Objectives		
Environmental Policy		
[Environmental Managem,ent (EMP Guideline Section 4.3.2)		
Environmental management Structure & Responsibility		
Approval and Licensing Requirements		
Reporting		
Environmental Training		
Emergency Contacxts and Response		
Implementation (EMP Guideline Section 4.3.3)		
Risk Assessment		
Environmental Management Activities and Controls		
Environmental Control Plans or Maps		
Environmental Schedules		
Monitoring and Review (EMP Guideline Section 4.3.4)		
Environmental Monitoring		
Environmental Auditing		
Correctivce Action		
EMP Review		

Note: This checklist highlights the main components of an EMP. It is not an EMP template.

Why prepare an EMP?

EMPs are valuable tools to:

- Define details of who, what, where, and when environmental management and mitigation measures are to be implemented.
- Provide government agencies and their contractors, developers, and other stakeholders better on-site environmental management control over the life of a project.
- Allow proponents to ensure their contractors fulfil environmental obligations on their behalf.
- Demonstrate due diligence.

In addition, EMPs are often required as part of tendering for projects and are essential for some types of government projects.

When should an EMP be prepared?

A mining EMP is generally developed about the same time as the detailed design and related activities are undertaken. Each process should influence the other. An operational EMP should be developed before commencing an activity or development.

Small Group Learning Activity

Break participants up into small groups. Give each group five minutes to identify and list as many environmental issues related to their site activities as they can think of and identify their likely impact on the surrounding environment. Groups should capture their ideas on a flip chart and report back in plenary.

What are some of the key steps?

Interaction matrices that indicate the severity and probabilities of occurrence of the identified environmental impacts should be developed as a first step. The following is an example.

	Probability of impact									
Impact	**Low**	**High**	**Duration**				**Extent**	**Intensity**	**Reversibility**	
			S	**M**	**L**	**P**			**Yes**	**No**
Air/noise pollution from air/vehicular traffic		☆			☆		**IS**	**M**	☆	
Increased water and energy usage.		☆	☆				**L**	**M**	☆	
Introduction of invasive alien species.		☆				☆	**IS**	**L**	☆	
Potential fire.	☆				☆		**IS**	**M**	☆	
Soil erosion	☆		☆				**L**	**L**	☆	
Waste generation		☆	☆				**IS**	**M**	☆	

Duration: (S) Short = 0-5 yrs; (M) Medium = 6-10 yrs; (L) Long = > 10 (P) Permanent
External: L = Local; IS = Immediate Surroundings; Intensity: L = Low; M = Medium; H = High

Figure 91: Example of an interaction matrix

As a second step, identify the local council and national legal requirements for the management of the impacts of mining on the environment (e.g., Environmental Management Act, Zimbabwe Parks and Wildlife Management Act, Public Health Act, Mines and Minerals Act, Forest Act, Pneumoconiosis Act, Housing Standards Control Act, Water Act, Factories and Works Act).

Next, write a series of instructions which will ensure compliance with these legal requirements, as well as minimise damage to the environment. For example, one clause of the EMP could stipulate that mining operations will only commence after the issuance of the EIA certificate by the EMA. You can structure your EMP according to the following phases, noting the environmental guidance in each one:

- **Planning:** This phase is characterised by the preliminary activities done to ensure that the project is a success. No ground work is done during the planning phase.
- **Construction:** Activities carried out during this phase may include vegetation clearance and road construction.
- **Operational:** The negative environmental impacts that will likely come during the operational phase include fires, degradation of natural areas (solid waste generation), and the pollution of the water and soil.
- **Decommissioning:** The decommissioning phase of a project includes removing project infrastructure, machinery, and equipment, and rehabilitating degraded areas.

Once you have drafted all the instructions, you'll need to prepare a monitoring schedule and monitor regularly. Note that monthly internal audits should

be performed, keeping records of changes that have occurred. Quarterly Environmental Audits must be submitted to EMA in accordance with Section 106 of the Environmental Management Act (20:27).

Role Play Activity

- Ask for volunteers to play the role of environmental officers assessing a site. Volunteers should look for weaknesses in the EMP.

Occupational Health and Safety

This module includes the following topics:

- International and national regulations on occupational health and safety in ASM
- Occupational health and safety hazards and risks
- Management of these risks

International and national legal frameworks

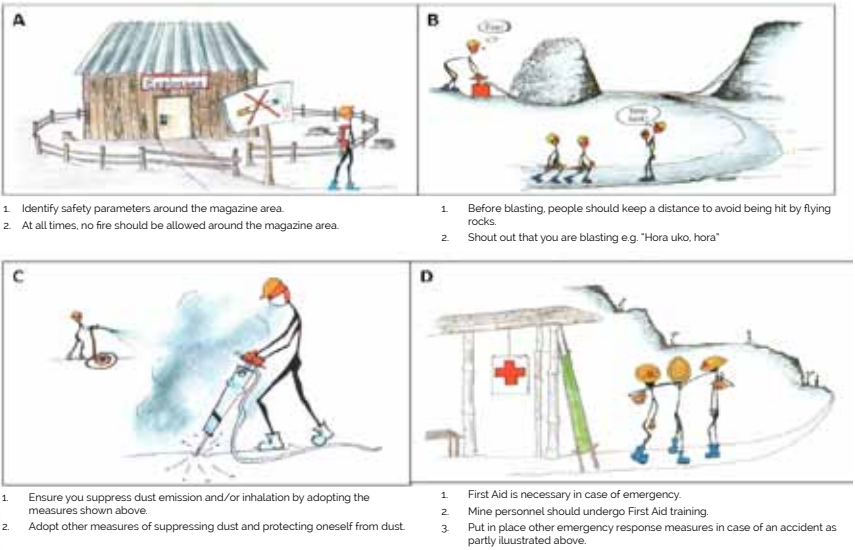
The ASM sector has generally operated with a blind eye to occupational health and safety. Very few ASM miners observe safety rules or have knowledge about hazards associated with their mining activities. This section introduces national and international regulations that miners should be aware of and adhere to ensure safe working in the mines. The International Labour Organisation (ILO) has developed a set of standards that govern all signatory nations' labour supervisory systems. Zimbabwe, which is party to the ILO stipulations, is not exempted and has correspondingly designed systems supporting minimum safety and health standards. Some of the specific pieces of legislation put in place are shown in the table below. For more comprehensive information about the law, see Annex A.

Table 11: Legislation relevant to occupational health and safety

.

Name of legislation	Description / relevant sections
Environmental Management Act, Chapter 20:27	Provides a framework for control of environmental issues, preventing pollution and environmental degradation, securing ecologically sustainable management, and the use of natural resources.
Explosives Act	States the requirements for proper storage, handling, and blasting of explosives.
Explosives Regulations SI 72	Covers the use, storage, possession, sale, transport, and manufacture of explosives.
Factories and Works Act, Chapter 14:08 (General; electrical; pressure vessels; building, structural, and excavation work; machinery)	Provides for the registration and control of factories, the regulation of conditions of work in factories, supervision of the use of machinery, precautions against accident to persons employed in structural work, and matters incidental to the foregoing.
Forest Act, Chapter 19:05	Stipulates the requirements to protect premises against fire outbreaks.
Harmful Liquids Act	Stipulates the requirements (and penalties for contravention) for the manufacture, supply, possession, and storage of harmful liquids.
Health and Sanitation Regulations	Provides for sanitary conditions and drainage, disposal of refuse, provision of latrines, medical examination, care and treatment of employees.
Labour Act, Chapter 28:01	General provisions supporting fair labour practices.
Labour Relations (HIV and AIDS) regulations SI 105 of 2014	Prohibits discrimination on the ground of HIV status and mandatory testing for HIV as a precondition of employment, stipulates duty to respect the confidentiality of HIV status of employees, and seeks for the provision of protective clothing and other safety measures to prevent the spread of HIV at the workplace, including mandatory education and information sharing programmes.
Mines and Minerals Act (MMA), Chapter 21:05 and its subsidiary regulations: The Mining (Management and Safety) Regulations SI 109 of 1990 The Mining (Health and Sanitation) Regulations SI 185 of 1995	Includes provisions for mine workplace safety, including appointment of competent persons and promotion of safe working practices.

Occupational health and safety hazards and risks



1. Identify safety parameters around the magazine area.
2. At all times, no fire should be allowed around the magazine area.

1. Before blasting, people should keep a distance to avoid being hit by flying rocks.
2. Shout out that you are blasting e.g. "Hora uko, hora"

1. Ensure you suppress dust emission and/or inhalation by adopting the measures shown above.
2. Adopt other measures of suppressing dust and protecting oneself from dust.

1. First Aid is necessary in case of emergency.
2. Mine personnel should undergo First Aid training.
3. Put in place other emergency response measures in case of an accident as partly illustrated above.

Figure 92: Basic Occupational health and safety procedures

Mining underground and/or in open pits poses a myriad of hazards, some of them potentially fatal. These hazards can cause injuries and ill-health, with social and economic implications for the victims, their families, and their communities. Both direct and indirect costs are inevitable when a mine accident or incident takes place. Some of the direct costs include treatment and compensation charges, costs associated with loss of equipment and/or property damage in the workplace and the costs translating to loss of production time. Indirect costs include the costs of reputational damage resulting in withdrawal of investment and loss of livelihoods, broadly compromising sustainable development, health, and safe working.

Table 12: Classes of hazards

Classes of hazards	
Safety	Moving machinery, working at heights, slippery surfaces, mobile equipment
Ergonomic	Material handling, organisation of work environment, accessibility to control panels shape and size of tools, repeated tasks lead to monotony, position and comfort of machine operators
Chemical agents	Acids, bases, heavy metals (e.g., lead), solvents (e.g., petroleum), fumes, noxious gases/vapours, highly reactive chemicals, fire explosion hazards
Biological	Bacteria (e.g., cholera), viruses, fungi, mould, blood-borne pathogens
Psychosocial	Work-related stress, which could be caused by factors such as excessive working hours and overwork, violence from inside or outside the organisation, bullying, sexual harassment, mobbing, burnout, exposure to unhealthy elements during meetings with business associates (e.g., tobacco, uncontrolled alcohol)
Physical agents	Noise, lighting, radiation, etc.

Common operational hazards in mining include

- Rock falls, shaft collapses, and cave-ins
- Landslide from vertical walls and un-benched surfaces
- Lack of or insufficient ventilation in shafts and/or tunnels
- Working at heights/elevated positions without safety harnesses
- Unsafe storage practices
- Slippery floors
- Sharp edges
- Flooding
- Fire
- Heat
- Insufficient illumination
- Lack of or insufficient latrines
- Lack or inconsistent use of PPE
- Confined spaces
- Snake bites and wild animal encounters
- Exposure to dust, triggering development of respiratory disease
- Exposure to hazardous chemicals
- Exposure to high noise levels emitted by old machinery without proper soundproofing, as well as general industrial machinery
- Exposure to industrial water
- Exposure to radiation (x-ray diffraction detectors)

Poor work practices, such as long working hours or working under influence of alcohol, also put the safety and health of mine workers at risk.

Occupational health and safety management

To address the hazards above, it is important to plan a **health and safety management system**, which is a framework that allows you to consistently identify and control health and safety risks at your mine, reduce the potential for accidents, help achieve compliance with health and safety legislation and continually improve performance. It involves:

1. Safety and health hazard identification, risk, and impact assessment.

2. Enforcing legal and other requirements and adhering to maintenance schedules.

3. Putting in place safety and health objectives, targets, and management programmes, including identifying, providing, and training workers on suitable equipment and personal protective wear and its maintenance.

The health and safety management system you put in place should combine the working environment, equipment, systems, and procedures and the people working for you in one body of elements all interacting with each other. An orderly and complete system is more effective and makes it easier to make improvements over time. A simplified, practical way to maintain a successful health and safety program at a small-scale mine would be to:

- Maintain a well-written health and safety plan.
- Employ and empower a skilled health and safety professional.
- Enforce health and safety standards and procedures.
- Train all the people who work on the site.
- Have safety meeting every morning with all employees and before any new or unusual activity.
- Practise incident control.
- Practise continuous performance improvement.
- Audit health and safety practices and procedures independently.
- Bar anyone from the site who violates health and safety procedures.

Components of a health and safety management system

Policy: A health and safety policy is a statement of owner/employer commitment to the well-being of the people working at the mine and the vision of where you want to be or achieve in the long run. It spells out who is responsible and accountable for health and safety and is signed by senior management and representatives of the employees. Everyone's participation in upholding safe work practices at the mine is paramount for the achievement of the policy's goals.

Organisational structure: The purpose of this element is for the employer to define and establish the roles and formal relationships among people and allocate resources for the management of health and safety to achieve objectives. The owner establishes the organisational structure to manage the system and its budget, communication channels, and competencies and necessary training.

Planning: The planning stage will help you develop the objectives of your health and safety management system. At this stage you develop:

- A list of responsibilities and who they are assigned to.
- A list of hazards based on the results of a risk assessment.
- Control measures including safe work procedures and procedures to monitor compliance with specified safety procedures (see section 4.2.1).
- Plans to deal with emergencies that may occur at the mine.
- Provision for training staff to oversee implementation of the health and safety management system.
- Procedures to monitor implementation of the system.

Evaluation: Evaluation is how you measure the performance of the whole system to check whether it is working well and identify improvements needed.

Audit: Periodic audits in addition to active and reactive monitoring of the management system or any of its elements help you to determine whether the system in place is adequate and working well in achieving your goals.

Risk management: It is important that mine owners and their management have in place ways to:

- Identify all hazards in their mine
- Assess the risks from these hazards or dangers
- Implement ways to remove or control risks
- Deal with incidents or emergencies
- Consult and communicate with people working at the site on health and safety matters

Dealing with emergencies

Mines need to be prepared in advance for emergency situations that may arise and require prompt action. These situations may be mine fires, explosions, entrapments, or inundations. The actions and procedure required are outlined in a Mine Emergency Response Plan (MERP). Its aims are to save lives and protect financial investments through advance preparation for potential emergencies. A MERP outlines the following:

- What should be done to prevent an emergency
- How to minimise the effects of an emergency
- How to contain and control an emergency
- What skills are needed to carry out the procedures in the MERP

- Responsibilities in case of an emergency
- What kind of assistance may be required from other nearby mines
- How information will be disseminated for quick decision-making
- Requirements, rules, and processes for training emergency response teams
- Plan for reviewing and updating the MERP
- Plan for practice drills (e.g., flood or fire drills)
- Costs

The contents of a MERP, including procedures and information on equipment, training, and personnel, are unique to each mine. It is the responsibility of the Mine Manager to ensure that a MERP is put in place, maintained, and complied with, and that it has the necessary resources, trained personnel, and firm commitment from management. MERPs must be regularly reviewed to identify and address any gaps or areas for improvement.

Cooperation and collaboration with other nearby mines, including large mines, to pool resources is advisable.

Personal Protection

It is imperative for miners to stay protected from workplace hazards by using complete and appropriate protective clothing at all times. Personal protective wear guards against both minor and major injuries as well as fatalities caused by exposure to the multiple hazards posed by mining. At every point of entry to mining operations, mining sites are mandated to erect a signboard or clear visual communication tool that outlines all types of personal safety gear that should be worn by miners and any visitors on site. For example, at the entrance of an area where a safety helmet and ear protection are required, a large label should be erected. Abiding by this principle promotes a safe working environment and easier monitoring of adherence to safety rules.

Employers should provide relevant PPE for every situation. It is also the responsibility of every employee to wear the appropriate equipment for any working environment.

Table 13: PPE for different environments

Environment	PPE
All working environments	Overalls/work suits
Possibility of falling objects on toes	Steel-capped safety shoes
Wet conditions with the possibility of falling objects on toes	Steel-capped gumboots
Possibility of falling objects on head	Hard hat
Noisy	Ear protection (e.g., ear plugs, ear muffs)
Flying objects that can get into the eye	Eye protection (e.g., safety goggles)
Dust and fumes	Dust masks
Possibility of injury on hands	Gloves
Wet and oily (e.g., during drilling)	Sinking suit
Small openings	Knee guards
Dark areas	Cap lamp
Possibility of falling	Safety chain

Recommended safe PPE handling

Basic guidelines for handling and caring for PPE include:

- Wash PPE clothing before initial use and after every use.
- PPE should always be kept clean.
- PPE should be stored in a dry storage area away from dust, direct sunlight, and moisture.
- PPE should never be shared to avoid the spread of disease.
- Never tear or slit PPE (for example, for smoking or drinking).
- PPE should never be used beyond its designed lifespan. Consult the manufacturer or retailer to find out the lifespan of each PPE product that you have purchased for use in mining.

If you need further information related to the use of PPE, it is covered extensively in the Mining (Health and Sanitation) Regulations SI 185 of 1995.

Common types of PPE

Respiratory protection

Many health-related impacts of mining result from inhaling dust from the mines. The dust usually contains silica, which is found in gold mines. If silica is inhaled, it may cause inflammation, fibrosis, and pulmonary silicosis. The early symptoms of silicosis include dry cough, shortness of breath, difficulty breathing (dyspnoea on exertion), and pulmonary inflammation, while the last stage entails generalised weakness and weight loss. Some of the disease associated with silica include pulmonary tuberculosis which has symptoms that include persistent cough, constant fatigue, weight loss, loss of appetite, fever, and chills.[29]

Figure 93: Protective dust mask

Respiratory protection provides protection from dust, fumes, mist, vapours, and any toxic gases that affect the respiratory (breathing) system. It typically takes the form of disposable dust masks and respirators (cartridge-type with replaceable filters). Proper care and use of these entails replacing filters as per the manufacturer's specifications. Disposable dust masks should be disposed at the end of every mining shift or as soon as they become visibly dirty or torn within the course of the mining shift. Miners should ensure the mask or respirator is appropriately sized to fit comfortably without causing any form of breathing resistance. It is advisable that respiratory protection be worn on a cleanly shaven face to ensure a snug fit.

[29] Artisanal Gold Council. (2014). Health issues in artisanal and small-scale gold mining: Training for health professionals,

Eye protection

Miners must protect their eyes from flying objects, the sun, sparks, mist and splashes. The most common forms of eye protection are safety goggles/ glasses, welding shields, and face masks (full or partial). Though some protective equipment is scratch-resistant, there is great need to guard eye protection from dust exposure, dropping, and rubbing to avoid scratches, which limit visibility and generally weaken the material, thus reducing its ultimate effectiveness. This type of equipment is best stored either hung or in a cloth pouch.

Figure 94: Eye protection devices

Hearing protection

Exposure to noise above the World Health Organisation (WHO) limit of 90 decibels causes sudden and, more commonly, gradual and pain-free hearing loss. Exposure to high noise levels damages hair cells found within the inner ear. These unfortunately cannot regenerate once they have been damaged, thus resulting in permanent hearing loss. In Zimbabwe, the first action level of hearing protection is 85 decibels, which complies and aligns with international law and practice.

Miners should wear ear plugs that fit properly to reduce the noise levels and by so doing avoid damaging the ears. In areas of extreme noise, double ear protection is advisable (e.g., ear plugs together with ear muffs). Signs should be posted at the entrance to any work area where noise levels exceed 85 decibels, requiring anyone entering the area to wear hearing protection. All equipment that produces noise levels above 85 decibels should also be appropriately labelled.

Figure 95: Ear plugs and ear muffs

Protection of the full body

Full body protection guards against cuts, burns, slipping, bruises, and damage from heavy falling objects, typically through appropriate use of safety helmets, steel toe-capped safety shoes/boots, overalls, gloves, work suits, sinking suits, and rain suits. Full body protection commonly has reflectors to aid visibility in dark and dusty environments. Some acid-proof overalls and work suits have been designed for environments prone to chemical spillages. SAZ has also developed standard measures of quality for the manufacturing and use of safety helmets.[30]

[30] SAZS. (1993). Zimbabwe standard specification for safety helmets for industrial use and for firemen.version 1.0.

Mineral Processing

This module includes the following topics:

- 🕮 Mineral processing methods
- 🕮 Mineral processing equipment

Mineral processing is concerned with the concentration or separation of valuable solid materials or metal bearing components from unwanted minerals by physical methods. Mineral processing (which is sometimes called ore dressing, ore beneficiation, mineral dressing, or milling), follows mining and prepares the ore for extraction of the valuable metal in the case of metallic ores. It produces a commercial end product such as coal, diamond, quarry and cement.

Mineral processing comprises of two steps:

- Size reduction to liberate the grains of valuable mineral (or pay mineral) from gangue minerals.
- Physical separation of the particles of valuable minerals from the gangue, to produce an enriched portion, or concentrate, containing most of the valuable minerals, and a discard, or tailing (tailings or tails), containing predominantly the gangue minerals.

Gold occurs in two general forms, **free gold** and **finely disseminated gold,** in a matrix of gangue material. The free gold can be extracted by physical separation methods like grinding and mercury amalgamation or gravity separation, while finely disseminated gold requires chemical separation using cyanide.

Free gold: Miners in ASM are only able to recover free gold, while millers or those who own both mines and mills can also treat finely disseminated gold. Free gold is extracted in two stages, grinding and either mercury amalgamation or gravity separation. In ASM, a range of equipment is used for grinding, including small metal mortars and pestles for high grade ores of little quantity.

Figure 96: Mortar and pestle grinding in ASM

Figure 97: Stamp mill

Figure 98: Ball mill

Other milling options commonly used include the ball mill, rod mill, round mill, and the stamp mill. Miners who process their own ores may prefer the ball mill because of its high efficiency of scoring recoveries of free gold, estimated at 90% efficiency. Stamp mills are mostly used by custom millers who are not concerned about high free gold recoveries, since they retain the tailings for further processing on site.

Following grinding, free gold is recovered by copper plates, a centrifuge, or shaking tables. Mercury is used at the copper plate to form a gold amalgam that is then burnt to evaporate the mercury leaving the gold behind. The recovered gold is shared among the miners after paying for milling services. For custom mills, FPR gold buying agents and a police officer will be there to make sure all the gold goes to the country's sole buyer.

Selection of a recovery method should take into consideration the associated environmental impact. The use of mercury in amalgamation by small-scale miners has been extensively documented as a cause of severe environmental impact. On the other hand, it has been noted that cyanidation and froth floatation have less negative impact compared to amalgamation if proper measures are taken so that cyanide and froth floatation reagents do not enter the environment.

Finely disseminated gold: Practice has shown that 30 to 40% of gold in the ore is recovered as free gold and the remainder goes to the tailings.[31] It is this remainder that the miller recovers through cyanide leaching. About four tanks constructed in the ground on a sloping terrain are used to leach the gold and then collection by carbon takes place below the last tank. The carbon is taken to the elution plant where it is heated to recover the adsorbed gold, a process which is overseen by FPR agents.

Processing methods and equipment

There are many methods used by ASM miners, including panning, ground sluicing, and some mechanical processing techniques, such as screening, comminution, spiral concentrators, and shaking tables. These methods have varying levels of efficiency.

Comminution

Comminution processes involve crushing and grinding to liberate valuable minerals from the gangue.

Crushing

Most ASM miners now employ crushers as the first stage in size reduction. For crushing of hard rock, a small hard rock impact crusher (one with an 800- or 1,000-millimetre rotor beater bar circle of 500- or 600-millimetre width) has found wide applications. The crusher has the capacity to produce 20 to 30 tonnes per hour, which is the one of the smallest in the range of impact crushers.

[31] Marsden, J. and House, C. (2006). The chemistry of gold extraction, 2nd edition.

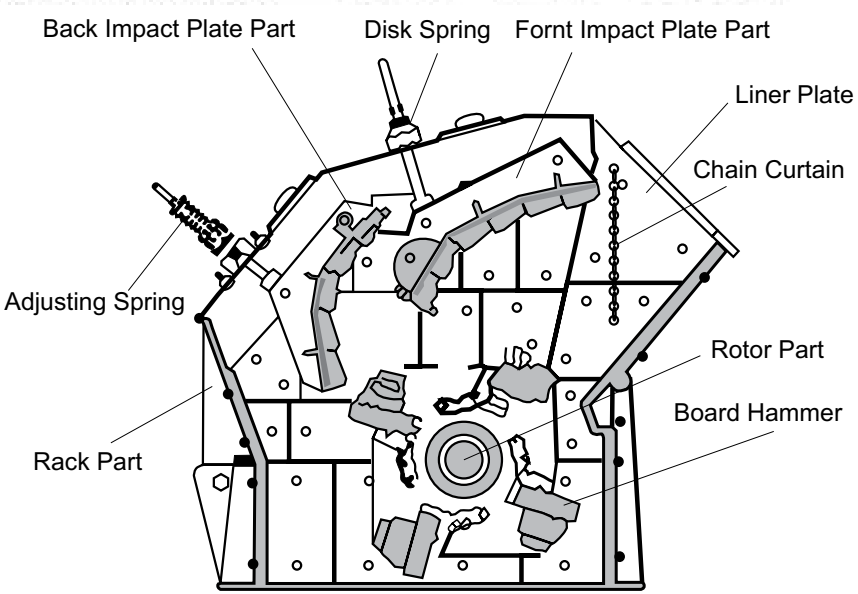


Figure 99: Impact crusher

The advantage of impact crushers is that they produce cubical or spherical-shaped grains unlike the platy or elongated pieces produced by jaw crushers. They are also cheaper, simple to maintain, and can be manufactured locally, as is done in Zimbabwe.

Grinding

Ball mills have become common in most ASM operations and are used for fine grinding. They start at sizes of 1-tonne capacity batch mills and are used as custom mills. The feed material is either manually crushed or it first passes through a jaw crusher for size reduction. The parameters vary, but not to great extents, depending on availability and prices of capital equipment and reagents on the local market, among other things.

Sluice boxes

Some of the gold-processing methods used around the continent that may be considered best practices, such as sluice boxes, which have been used in the Insiza Riverbed Mining Project, financed by GIZ, operated by the Department of Mining Engineering of the University of Zimbabwe, and implemented by the Insiza Rural District Council. A sluice box is one of the oldest types of gold-processing equipment described by Agricola in 1556 in his famous book, De Re Metallica. Well-designed and operated sluice boxes have been shown to offer recoveries of up to 98% of gold coarser than 100 micrometres.[32] In the Insiza Riverbed, improvements in the sluice box design generated high productivity of around four tonnes per miner/shift and recoveries of around 70%.

Figure 100: Typical sluice box

The efficiency of sluice boxes has also been tested by a combination of laboratory and field experimentation carried out by the British Geological Survey on small-scale gold mining.

Field tests conducted on several ores with varying gold grain size distributions in Guyana showed that the perceived problem of major losses of very fine-grained gold had no factual basis. It was concluded that sluice boxes can achieve 80% gold recovery. The following recommendations for improving gold recovery using sluice boxes are based on the field test results:

- Wet screening is recommended to remove material coarser than 500 micrometres (which should be passed over a sluice box to recover gold coarser that 500 micrometres);
- Material finer than 500 micrometres should be passed over a second sluice to recover gold coarser than 200 micrometres.
- Tailings from this should be wet screened to remove material coarser than 200 micrometres (ideally free of gold) and then passed over a shaking table (to recover gold up to 50 micrometres).

[32] Appleton, J. and Williams, T. (1998). Mitigation of mining-related mercury pollution hazards: Project summary report. British Geological Survey, Technical Report WC/98/34..

- The time interval between cleaning-out operations should be short to enhance recovery of fine gold, which would otherwise be lost due to solids packed around the riffles.
- The inclination angle of the box should be increased by particle size. Experience elsewhere has shown that angles of seven to 12 degrees and 12 to 14 degrees are suitable for materials finer and coarser than one millimetre, respectively.
- The feed and wash water rates should be high enough to enable efficient separation of coarse-grained gold without excessive loss of fine-grained gold.
- Gold ore with a significant proportion of clay-bound and weakly-cemented material should be washed ('scrubbed') and screened prior to sluicing to liberate gold trapped in clay.
- Ore should be screened prior to sluicing and the resulting coarse and fine streams should be diverted down different sluices (as described above) to improve overall gold recovery.
- The use of alternative riffles can enable a higher recovery of gold. Expanded metal riffles are recommended for gold finer than one millimetre and angle iron riffles for gold coarser than one millimetre.

Shaking tables

Shaking tables consist of a plate with riffles that is inclined with the lower edge in opposite of the feed side. An engine moves the plate back and forth. Frequency and amplitude of this movement can be adjusted. Cross-flow water is fed onto the table from water hoses, from which the intensity can be adjusted as well. This water stream creates flow energy across the table, which leads slimes (very small and low-density particles) to be suspended from the table, following the water flow. Light particles flow to the light and middling section of the table, whereas heavy particles are less affected by the water flow and therefore follow the shaking direction of the table. Generally, apart from slimes, small particles move further lengthwise than coarser particles of the same density. This can lead to overlapping of coarse dense and small light particles. To avoid this effect, it is crucial to create narrow grain size fractions before feeding the shaking table. For using shaking tables efficiently, proper calibration is mandatory. The whole plate should be moistened with water and stay moistened throughout process.

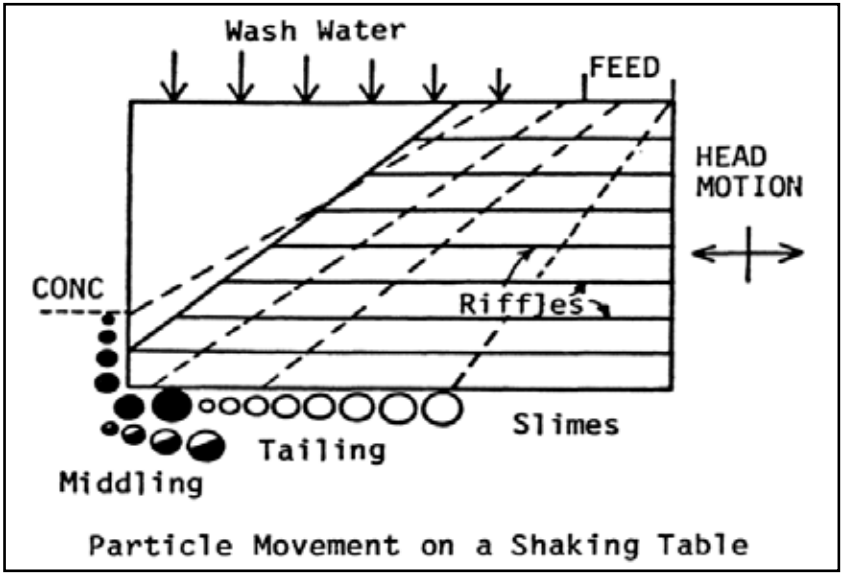


Figure 101: Particle movement on a shaking table

In general, there are a few options to adjust the shaking table with respect to the feed. If these parameters are adjusted correctly and the feed is of the right grain size the streams of slimes, light/middling fraction and concentrate are flowing separately from each other along the plate. The size of the gap between the slimes and the heavy fraction might differ. Therefore, the capturing of the concentrate is the last crucial adjustment. This is usually done with a slide plate or cone, which can be moved to different positions, to recover different amounts of the heavy fraction. The adjustment of a shaking table requires some experience. With multiple attempts a proper adjustment might even be performed by trial and error.

Changfa method

The changfa method originated from the name of a Chinese-made diesel-powered rock crusher (changfa) that is used for crushing excavated auriferous deposits. The unit is mostly fabricated and welded. The method typically involves excavating ore deposits manually with simple tools such as pickaxes, shovels, or spades. Head-loads of the materials are then carried in wheelbarrows to the changfa location for processing. The materials are re-handled by shovelling into the crusher for comminution. A water pump connected to the crusher continuously pumps water, mostly from a sump onto a sluice board (usually lined with a blanket) connected to the crusher chute for washing. After a

while, the changfa motor is shut down and the blanket is removed and washed in a drum containing water to obtain the trapped gold for further processing.

'More blade' method

This method is a modified form of the 'dig and wash' method. It involves the use of excavators for mining in the pit. It is usually done close to a stream or river where the water can be directed into the pit. The site owner typically hires a gang of people. A small crew is assigned a sluice board in the pit. The excavated products are re-handled with shovels onto the sluice boards where the materials are washed, as some members of the crew manually fetch water and pour it onto the sluice board. Other members of the group may also use pans to wash the materials, complementing the sluice board washing. It is labour-intensive, and the employees typically work for six hours per day.

Gravity concentration

Spiral concentrators

These are commonly used for density separation of particles smaller than one millimetre. The feed material is mixed with water to produce a so-called 'liquid pulp'. The pulp gets fed onto the spiral and runs downwards in three to five circles depending on the type of spiral. Due to their inertia, heavy particles accumulate on the inside of the spiral while lighter particles are pushed to the edge of the spiral. In the spiral two streams can be identified which occur rectangular to the main stream, which runs down in the middle of the spiral.

A second stream is located at the bottom of the spiral directing to the inside and a third stream flows on top of the pulp directing to the outside of the spiral. Because of centrifugal forces, the thickness of the pulp stream is rather low on the inside (two to three millimetres), while it is rather turbulent and high on the outside (seven to 16 millimetres). In the inner side of the spiral, there are 'splitters' collecting particles with a higher density. The splitters are manually or automatically adjusted to split right between the heavy and the light fraction.

The separated fraction collected by the splitters runs towards the middle of the spiral and gets recovered. The border of the two fractions is usually not clear cut, as coarser particles of higher density overlap with smaller particles of lower density. Therefore, most spirals have the option to create a third, middling fraction between heavy and light material, which might be recirculated to gain additional concentrate. The feed should consist of grains that are the same size to increase the efficiency of this process. Comminution and screening should be used before feeding a spiral to produce a narrow variation of grain sizes.

Knudson bowl

This is one of the centrifugal concentrators that has found wide application for the recovery of fine gold in small-scale mining in Zimbabwe since the 1990s. The popularity of the bowl can be associated with its simplicity and lesser reliance on water quantity and pressure. It consists of a rotating steel open-topped bowl fitted with a ribbed rubber insert. The material is usually fed from the top and overflows the sides, allowing gold to collect between the ribs. It is operated in a batch mode, with the rubber insert removed periodically for cleaning.

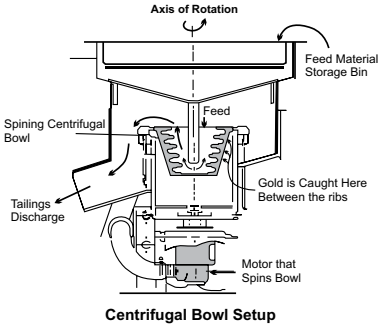


Figure 102: Knudson bowl

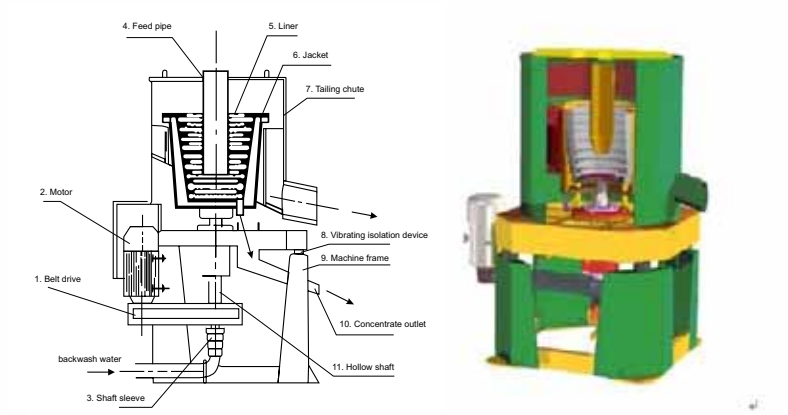


Figure 103. Knelson separator and Centrasep concentrator

Plane table

Small-scale miners use plane tables to treat mill and discharge material. The unit consists of two inclined tables covered with strakes (ribbed rubber sheets with ribs arranged in the line of pulp flow). The tables are arranged such that the first is slightly elevated and overlapping the other with the concentrate launder located between the two. With the pulp flowing over the top table, water is added to wash the gold particles collecting in the strakes down to the concentrate launder. From the launder, the concentrate is directed to a collection box for later treatment.

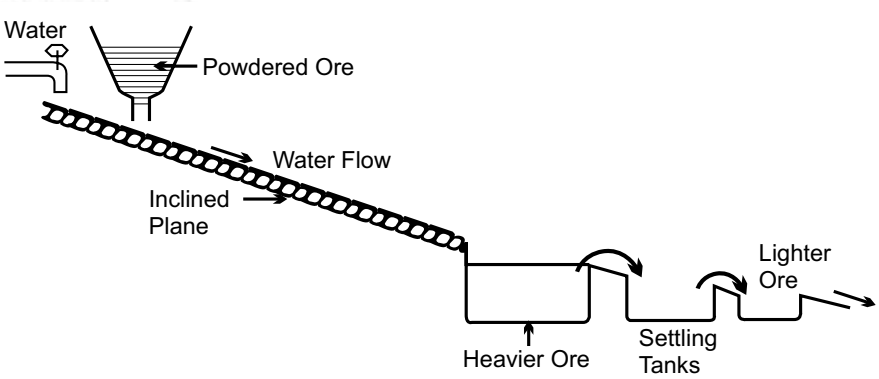


Figure 104: Arrangement of gravity concentration plane table

These yield recoveries of between 30 to 70% at throughputs between 2.6 to 10.5 tonnes per hour per metre in inclined plane width depending on the ore type.

Floatation methods

Concentration of fine sulphide minerals can be easily achieved using floatation methods. A good application of the technique was found in one small-scale Zimbabwean gold mine treating 50 tonnes per day of sulphidic ore grading approximately four grams per tonne of gold, 1% copper (as chalcopyrite) and some arsenopyrite[33]. The mine developed a Jameson-type cell to produce a gold-copper concentrate (10% Cu, 20 grams per tonne Au) suitable as feedstock for a nearby smelter. The cell consists of a feed pipe made from empty cyanide drums, which contains a nozzle through which pulp from the carbon-in-pulp tailings is pumped. The pulp is conditioned to reduce pH, and collectors and froth are added. The nozzle allows the jet impingement of the pulp into the froth column in the feed pipe. This creates a tall froth column, which allows effective particle cleaning and separation. The concentrate overflows the launder and can dewater in settling ponds prior to transportation to the smelter. The unit can be operated with very little supervision and only basic maintenance of the feed nozzles.

[33] Hosford, P. (1993). Innovations in mineral processing technology for small- and medium-scale mining operations. United Nations Seminar on Guidelines for the Development of Small- and Medium-Scale Mining, Harare, Zimbabwe.

Cyanidation

Cyanidation methods are widely used in small-scale gold mining in Zimbabwe. The advantage of this technique is that cyanide decomposes very rapidly in solution, especially when exposed to sunlight. In addition, despite the high toxicity of cyanide, it is not a cumulative poison like mercury.

Figure 105: Typical leach tanks used in ASM

Cyanidation methods have a low accident rate; in Zimbabwe, where nearly 6,000 tonnes of cyanide is imported annually for gold mines, there have been only two accidental fatalities in 40 years[34].

Heap leaching

Heap leaching is the process to extract precious metals like gold, silver, copper and uranium from their ore by placing them on a pad (a base) in a heap and sprinkling a leaching solvent, such as cyanide or acids, over the heap. This process dissolves the metals and they collect at the bottom of the pad.

[34] Hollaway, J. (1993). "A Review of Technology for the Successful Development of Small-scale Mining". United Nations Seminar on Guidelines for the Development of Small- and Medium-scale Mining, 11-19 February 1993, Harare, Zimbabwe

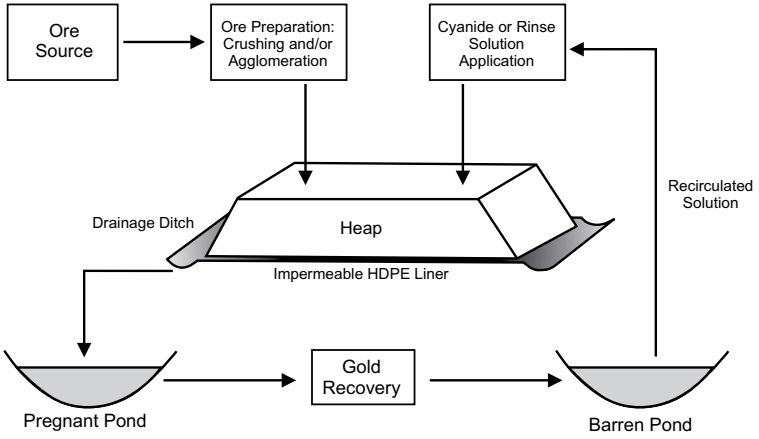


Figure 106: Heap leaching

Mining Laws and Regulations

This module includes the following topics:

- The legislative framework and laws that govern mining
- Understanding mining rights and land rights
- Licences and permits
- Mining claims and tribute agreements
- Taxes and other payments that miners must make

This chapter will provide existing and prospective ASGM miners with information about the laws and policies that govern the ASM sector. Although it focuses on gold mining, is also useful for mining of other minerals.

Discussion activity

As a group, discuss the following questions:

- What laws do you know of that relate to mining?

- What mining activities are perceived as illegal?

- Do you have any examples of you or someone you know being arrested or penalised by the police because of mining activities?

- What should ASM miners do to avoid harassment, raids, or arrests by the police, local authorities, and the EMA?

Conclude by emphasising the importance of laws and compliance.

Mining laws are not about stopping or preventing development. In fact, they can help maximise benefits to the miner and the country and enable miners produce as much gold from a deposit as possible. Laws regulate mining activities so that disputes are minimised, mining can proceed in an orderly and efficient manner, and harmful effects such as pollution and accidents are reduced to a low level.[35] They are important for keeping away unscrupulous mine operators, promoting investments by companies that mine responsibly and sustainably, and providing clear roles for companies, governments, and other stakeholders.[36]

[35] Coats, J.S. et al. (1998). An affordable exploration and mining license administration system for developing countries.

[36] World Bank. (2009). Sector licensing studies: Mining sector.

- Effective mining laws strike a balance between the interests of communities, landholders, and miners. Without laws that are enforced and complied with, miners might not follow EIA procedures, pay taxes, rehabilitate the land, or develop mine closure plans—all of which negatively impacts the community.

Key stakeholders in the mining legal framework

Stakeholder	Role(s)
District Administrator	Coordinates inputs of all government departments into mining applications and operations Gives supportive letter after verifying absence of conflict on landuse
EMA	Ensures environmental safety through environmental monitoring and audits Approves/rejects EIAs
Rural District Council/local authorities	Gives supporting letters for mining and special grants applications Collects levies from legal miners Monitors illegal mining
Mining Commissioner	Issues out mining registration documents Assists with loans for equipment through the mining industry loan fund
Zimbabwe Republic Police (ZRP)	Enforces mining and environmental laws Raises awareness of illegal mining activities
Councillors	Promotes mining-related developments in ward Assists in conflict resolution
Village Heads	Resolves disputes
Ministry of Women Affairs, Gender, and Community Development	Responsible for the implementation of the National Gender Policy Promotes and advocates for the economic empowerment of women
Large-scale mining companies	Issues tributes to individual miners Carries out mining
Zimbabwe School of Mines	Provides courses on mining at a cost
Women Miners Association	Provides linkages to markets and microfinance Lobbies and advocates for training of women miners

Land rights and mining rights

The MMA outlines how mining rights are acquired, limited, and cancelled. It also includes protections for landowners. It is important to note that the law makes distinctions between land and subsoil rights. The State owns or controls mineral rights in the subsoil. In communal areas, it holds both land and mineral rights.

Land rights

The land tenure system in Zimbabwe includes several categories of land:

- **State and communal lands:** Ownership of state and communal lands, as well as land classified as parks, wildlife estates, forest areas, and reserves, is vested in the President. Land, mineral, and water rights are also vested in the President.
- **Communally-owned land**: Land can also be under the stewardship of a community led by a headman or traditional leader.
- **Resettlement areas:** Under the A2 settlement scheme[37] some settlers who have been on a piece of land for more than three years have been given offer letters for 99-year leases. It is important to note that these leases cannot be transferred without the written consent of the relevant Minister.
- **Privately-owned, titled land**

Land rights in most resettlement and communal areas are insecure in that there are no title deeds to the land. Farmers enjoy use rights such as livestock grazing, growing crops and trees, and making permanent improvements like building a home.

Grazing and cultivation: The MMA (Section 179) states that the owner or the occupier of land on which a registered mining location is situated retains the right to graze livestock or cultivate the surface of the land if this does not interfere with the proper working of the location for mining purposes. If a mining location is adjacent to pasture land, a miner is required to fence the mining location as directed by the Mining Commissioner.

Compensation payable to the landowner: Under the law (MMA Section 188), holders of mining rights must pay compensation to private landowners where there are mining operations. The rights of communal farmers or residents are not protected by this provision. On communal lands, compensation is paid to the Rural District Council, which acts on behalf of the President as the landowner. However, there have been instances where communal farmers have been compensated by mining companies through the building of social infrastructure such as clinics and schools.

Mineral rights

Mineral rights entail searching for minerals and their extraction, processing, and disposal. They are granted independent of the landowner/farmer. Mineral rights

[37] Zimbabwe's land reform created two 'models' for resettlement farms – one for relatively small-scale farms (A1) and one for medium to large-scale farms (A2).

or "mineral interest" are considered as immovable property. This means that the owner of a claim has a right to exploit, mine, and/or produce minerals such as gold that lie on and below the surface of the property. Mineral rights include the right to use the surface as is reasonably necessary to access minerals and the right to receive royalties. Every holder of a registered block of claims (other than precious metal reef claims) has the exclusive right of mining any ore or deposit within the vertical limits of his or her block.

Land open for prospecting includes private land, communal land, state land, town land, and demarcated forests. Under the MMA, a landowner cannot refuse or grant permission for prospecting on his or her land, because the mineral rights are vested in the State, and the landowner or farmer does not own resources that are underneath the land. The consent of the farmer is required for mining if the land is less than 100 hectares. If a farm is more than 100 hectares, a miner can peg and notify the landowner of his or her actions through a registration notice, using a registered letter.

However, prospecting and pegging are prohibited in certain areas by Section 31 of the MMA. This includes areas that are:

- On or within 15 metres of land under cultivation
- Within 450 metres of the principal homestead or the site of the intended homestead
- Within 90 metres of any area where brick or concrete housing has been erected for farm employees
- Within 90 metres of any permanent cattle dip tank
- Within 9 metres of any other permanent bona fide farm building

Prospecting and pegging also cannot be carried out on any site which is on town lands but outside the surveyed limits; on a state rifle range, railway reserve, or any cemetery; or on a small holding of than 100 hectares, except with the consent of the owner in writing.

Likewise, Section 377 of the MMA prohibits mining within the surveyed limits of any city, town, township, or village, or beneath (or within a prescribed distance from) several things, including roads, railways, pipeline reserves, electric power lines, pipelines, wells or boreholes, rivers or lakes, and land under cultivation. See Annex A for a full list.

Surface rights of miners

Land under cultivation has a specific definition under the MMA. It includes:

- Land that has been cleared, or ploughed or prepared for growing farm crops, orchards, or tree plantations
- Ploughed land on which farm crops, orchards, or tree plantations are growing
- Ploughed land from which farm crops have been reaped in the last three years
- Ploughed land on which grass has been planted and maintained for harvesting, crop rotation, or livestock feeding. This applies for a period of six years from the date of planting.

Surface rights are regulated by Section 178 of the MMA, which states that a miner of a registered mining location can:

- Use any of the surface within the boundaries of the block for all necessary mining purposes.
- Use soil, waste rock, or indigenous grass situated within the block for all necessary mining purposes free of charge.
- Sell or otherwise dispose of waste rock recovered during actual mining operations.
- Take water for primary purposes only.

The Water Act requires a permit to use water for mining purposes or to conduct operations in public streams.

A miner can use timber from firewood or for mining purposes provided that the timber is removed from within the boundaries of the block only and an agreement has been reached with the landowner. When the agreement is negotiated it should include the area where timber may be cut, the period within which the timber may be taken, the quantity and type of wood to be cut, and the price to be paid.

Cancellation of mining rights

Mining rights can be cancelled under Sections 271, 399, and 400 of the MMA if:

- The mining location has been forfeited.
- Mining has not commenced within a reasonable period.

A miner has knowingly submitted a false return or declaration regarding the output from his or her mining location.

- Sections 5 or 6 of the Gold Trade Act have been contravened.

Small group activity

In small groups, ask participants to discuss the following questions and list examples on flip charts:

- What do mining rights entail?

- What do land rights entail?

- Have each group present their examples in plenary.

Licences, claims, and permits

Mineral rights are granted through prospecting and mining permits issued by the Ministry of Mines and Mining Development, which regulates the exploration and mining of mineral resources. The law prohibits anyone from mining on a mining location without a permit issued in terms of the MMA. The Regional, Town, and Country Planning Act further defines 'mining operations' to include quarrying and other surface mineral workings.

The law allows a person who is granted mineral rights to transfer the right to search for and to mine the minerals to a third person. This can be done through a prospecting contract or a mineral lease agreement. The holder of mineral rights can claim compensation from the third person to whom the rights are transferred.

Prospecting licences

A prospecting licence provides the right to search for minerals and peg claims. It entitles the holder (represented by a pegger or approved prospector) to peg

one block of claims or precious or base metals. Applications for prospecting licences are made at the local Provincial Mining Director (PMD). This can be done by any person over the age of 18 years, and the licence is valid for two years. An approved prospector or pegger (the PMD has register of them), who will do the prospecting and pegging, is designated as the agent of the licence holder. The appointment is done in writing on the back side of the prospecting licence. The licence is kept by the appointed approved prospector together with his or her registration certificate as an approved prospector. The prospecting licence is not transferable to another party either as a donation or marketable paper.

Obtaining a mining claim

Once a miner is in possession of a prospecting licence, the process for acquiring a mining claim is as follows:

1. Obtain a map from the PMD (at a scale of 1:25,000), showing the area where the miner intends to prospect and all registered claims, exclusive prospecting orders, reserved boundaries, and homesteads.
2. Inform the landowner in writing of the intention to prospect. The letter must be delivered in person or by registered post. The latter is preferable because it affords the opportunity to create rapport with the landowner at an early stage. The party to be informed depends on the type of land:
    - Private land: Owner or occupier
    - Communal Land: District Administrator
    - State land: Regional Lands Inspector
    - Town land: Local authority/municipality
    - Demarcated forests: Zimbabwe Forestry Commission
3. Undertake prospecting for 120 days. If no successful pegging is done within this period (i.e., no discovery is made), the written notification will have to be renewed to continue prospecting in that area.
4. For detailed prospecting such as drilling and trenching, post a Prospecting Notice (PN). The prospector should work within a 300-metre radius of the PN and pegging in that specific area must be done within 31 days. At this stage, production (extraction) is not allowed. The prospector can use water, dead wood, etc. within this radius.
5. Send a copy of the PN and the map (at a scale of 1:25,000) showing the position of the PN to the PMD and the landowner.
6. After discovery of any mineral, erect a discover peg within a 300-metre radius. Pegging of the block (not exceeding 500 metres length and 200 metres breadth) must be done within the 31 days of the PN. A block contains

no more than 10 standard claims of 10,000 square metres.

7. After pegging, post a registration notice and apply for registration with the PMD. Once a block is registered, the prospector is given a certificate of registration, which is the mining title to the block of claims. The following are required to apply for registration of a block:
    - Prospecting licence used for the discovery
    - PN (though already with the PMD)
    - Copy of discovery notice (in case of base metals)
    - Site plan or map in triplicate
    - Registration fee
8. Within two months of receiving the registration certificate, replace the wooden pegs with metal pegs.
9. Erect permanent pegs with a concrete base after six months of continuous production.

Tribute agreements

A tribute agreement is when the holder of a registered mining location (a grantor) agrees to let another person (a tributor) work on that location in return for a portion or percentage of the minerals won or the proceeds of their sale. In Zimbabwe, the guiding principle is that the tributor pays the grantor a royalty of 5% of the total gross value of the gold and/or other valuable products from the specified mining location. The tribute agreement documents the terms and outlines how the tributor must operate and should be completed using the MMA Standard Tribute Agreement Form. The tributor must apply for registration and approval of the tribute agreement by the Mining Director or by the Mining Affairs Board. The Board authorises the Mining Director to approve standard agreements; if there are special conditions, it is approved by the Board.

Discussion activity

After explaining what tribute agreements entail and why they are important, hand out copies of the standard tribute agreement form. Walk through it with participants and answer any questions they have. Possible questions for discussion include:

- What area the pros and cons of a tribute agreement?

- In what situations might a miner enter into a tribute agreement?

- Under a tribute agreement, who do you think bears the responsibility for compliance with all regulations and ensuring environmental management and rehabilitation of the mining sites?

Required mine permits and other documentation

The following permits are required during various stages of the mining operations.

Table 14: Required mine permits and documentation

Permit / document	What is it?	Who needs one?	How do you get one and how long is it valid?
Prospecting permit / licence	Provides the right to search for minerals and peg claims. There two types: Ordinary Prospecting Licences and Special Prospecting Licences.	Under the Wildlife Act, prospecting in parks and wildlife estates requires a permit.	Anyone above the age of 18 years can buy a prospecting license from the mines office in the province he or she wishes to register the block/ mine. The permit is valid for two years.
Exploration permit	Provides authorisation to conduct a geological evaluation of a mineral deposit.	Anyone who has registered claims with the Ministry of Mines and Mining Development through the PMD office to obtain blocks or a concession.	The permit valid for an indefinite period upon continued payment of a prescribed fee.

Permit / document	What is it?	Who needs one?	How do you get one and how long is it valid?
EIA report	An evaluation of a project to determine its impact on the environment and human health and to set out the required environmental monitoring and management procedures and plans.	Any natural resource occurrence, infrastructural development, project, or construction in contact with the environment.	A certificate issued by the Director General is valid for two years from the date of its issue after submitting an EIA report.
Permit to cut down trees	Authorisation given to a miner to clear land by cutting down trees to develop a mine.	Under the Forest Act, any miner requires a permit from the Mining Timber Permit Board to cut down trees.	Applications are made to the Mining Timber Permit Board, which has discretionary powers to renew a permit after an indefinite period.
Land use permit	Authorisation for specific land uses that are allowed and encouraged by the ordinance and declared harmonious with the applicable zoning district.	Where a person proposes to conduct a specific land use activity.	Applications are made to the Land Commission, which grants permit to hold a portion of gazetted land for an indefinite period.
Mining lease	A contract to mine for a period of time for a price, rental, and royalties.	Under the Mines and Minerals Act, anyone aged 18 years and above may apply and obtain a mining lease.	The holder of a mining location or contiguous registered mining locations may make written application to the PMD. A lease is valid for a year if one obtains an inspection licence and pays an annual prescribed fee.

Permit / document	What is it?	Who needs one?	How do you get one and how long is it valid?
Air emission license	Permit for an owner or operator of a trade or establishment that emits a substance or energy which may cause air pollution.	Miners and gold processing centres using back-up generators during load-shedding or when there is power outage.	Applications are made on a quarterly basis to the EMA board.
Effluent discharge license	Authorises the discharge of any effluents or other pollutants into the environment.	Any local authority operating a sewerage system or owner or operator of any trade or industrial undertaking operating within the jurisdiction of two or contiguous local authorities, including miners and millers.	Applications are made to the EMA board and licences are valid indefinitely.
Hazardous substance handling permit	Authorises the discharge of any hazardous substance, chemical, oil, or a mixture containing oil into waters or other parts of the environment.	Any miner using mercury, cyanide, or other hazardous substances during processing.	Applications are made to the EMA board. Licences must be renewed through payment of a prescribed fee.

Permit / document	What is it?	Who needs one?	How do you get one and how long is it valid?
Water abstraction permit	Authorises abstraction of water from underground or surface water sources.	Any small- to medium-scale mining operation for both domestic and industrial purposes	Applications are made through the sub-catchment council. Licences are valid for one year and must be renewed annually.

Fees, royalties, taxes, and levies

The MMA lays out the different forms of fees, royalties, taxes, and levies that a gold mining operation is obliged to pay.

Fees

Miners and mining companies are required to pay administrative fees to various government departments based on different policies and legislation. Some are related to the permits and licenses described above.

Table 15: List of required Mine administrative fees

Type of fee	Legal basis
Application fees for mining licences and registration fees	SI 56 of 2014 Mining (General) (Amendment) Regulations (No. 18) and SI 10 of 2016
EIA fees (see below)	Environmental Management (EIA and Ecosystems Protection) Regulations enacted under the Environmental Management Act, SI 7 of 2007
Discharge of hazardous waste (e.g., slimes dumps, liquid effluent, and rock waste dumps)	Environmental Management (Effluent and Solid Waste Disposal) Regulations, SI 6 of 2007
Permit fees for water and waste disposal	Environmental Management Act (Part IX: Environmental Quality Standards)

EIA fees: EIA fees are based on the type of project and its level of environmental and social impact. The fees are either paid in full at the time of EIA submission, or split across three payments (at EIA submission, start of implementation, and end of implementation). At the time of writing, fees range from US$210 up to US$2 million, as shown in the table below:

Table 16: EIA fees

Fee	Type of project	Payment schedule
$210	Small-scale projects with minimal impact (e.g., small-scale mining, small-scale infrastructural development)	100% at time of EIA submission
1.2% of the project cost	Extremely high negative impacts (e.g., mining, ore processing, oil and gas exploitation). Impact can continue after decommissioning (e.g., acid mine drainage)	0.4% of the project cost at EIA submission, start of implementation, and end of implementation
Maximum fee of $2 million	EIA fee cap for all categories	20% of the total at EIA submission, 20% at start of implementation, and 60% at end of implementation

Small group activity

In small groups, ask participants to list out the different permits required in ASM, the corresponding fees, and the permitting authorities. Each group should report back in plenary.

Royalties

In mining, royalties are payments to the owners of mineral resources for the right to extract the minerals from the ground. Since mineral rights in Zimbabwe vested in the President, mining companies and entities are required to pay royalties to the State, based on the amount and value of the mineral produced. Royalties and rentals are payable to the ZIA, the Zimbabwe Revenue Authority (ZIMRA), and the Ministry of Mines and Mining Development. They are collected by agents for the Commissioner General of ZIMRA, which include:

- Minerals Marketing Corporation of Zimbabwe (MMCZ)
- Any entity (legal person) authorised by MMCZ to export gold in its own right

- Reserve Bank of Zimbabwe (RBZ) or its subsidiaries, such as FPR
- Chamber of Mines

Royalties are payable on all minerals or mineral-bearing products obtained from any mining location and disposed of by a miner or on his or her behalf. The royalties are chargeable whether the disposal of these products is done within or outside of Zimbabwe. They are not deducted for income tax purposes, and the amount is calculated as a percentage of the gross fair market value of the minerals produced as opposed to the quantity of the minerals extracted. The percentage varies by type of mineral and miner, as shown below.

Table 17: Royalty tax for different mineral commodities

Category	Royalty
Precious stones	10%
Precious metals from LSM	3%
Precious metals from ASM	1%
Base metals	2%
Industrial minerals	2%
Coal bed methane gas	2%
Coal	1%

If royalties are not paid by the due date, interest is charged on the outstanding amounts from the due date until the date they are paid, at a rate fixed by the Minister of Finance. The Commissioner General of ZIMRA can also institute recovery measures for any amounts not charged or remitted as prescribed. Under Section 253(1) of the MMA, non-payment of royalties may result in an order prohibiting the disposal of any minerals or mineral-bearing products from any location being worked by the miner in question.

Taxes and levies

ASM miners should be aware of which taxes affect their mining activities. They are subject to:

- Income tax
- Presumptive tax
- Additional profit tax
- Pay As You Earn (PAYE)
- Value Added Tax (VAT)
- Customs duty
- Withholding tax
- Non-residents' shareholder's tax
- Capital gains tax

Section 252 of the MMA gives power to the Commissioner General of ZIMRA or any person duly authorised by him to inspect all books of accounts and records, reports, and other documents related to mineral acquisition, disposal, or removal to ascertain or verify any return, details, solemn declaration, certificate, or document.

Income tax

Taxation on mining operations is covered under Section 15(2)(f) of the Income Tax Act (Chapter 23:06). Income tax is applied when minerals are sold locally or exported. A miner's taxes are calculated based on all his or her income derived from the sale of minerals extracted, minus relevant deductions and allowances. For example, surface rentals are deducted for income tax purposes. They are charged at different rates or levels during the prospecting or exploration phase and the development or mining phase of mining project. Likewise, there are capital allowances calculated from all capital goods purchased or constructed (such as clinics or schools) that are first used for mining operations. Income from mining operations is also not subject to the 3% AIDS levy.

There are two important percentages for calculating income tax: 1) the percent of income which is taxable and 2) the tax rate. The taxable income of holder of a special mining lease is 25% and for a general mining operation is 15%. Income tax on mining operations uses a flat rate of 15%.

PAYE

PAYE is a form of income tax levied on the income of employees. Mining companies are required to deduct PAYE from the salaries, allowances, and other benefits accruing to employees and pay this amount to ZIMRA. The rate is in accordance with the tax bands provided by the Minister of Finance in the National Budget for each year.

VAT

The Value Added Tax Act deals with the administration of VAT, which is tax charged on value addition at every stage in the production chain of goods and services. Value addition results from further processing or a change in shape, quality, or packaging of manufactured goods traded as intermediary goods, assessor goods, and component goods, semi-finished and finished goods in the value chain. A business must be registered with ZIMRA to charge, collect, and remit VAT.

The VAT rate on minerals is 0%; for other sales it is 15%. To claim refunds, the taxpayer should complete the forms provided by ZIMRA even when the mineral is zero rated. Capital goods that are imported for operations are charged VAT at the rate of 15%, though there is no duty payable. Where a mine exports minerals, the VAT charged on imported capital goods is refundable.

Customs duty

Mines and mining operations often import raw materials and finished goods, as well as capital goods, into Zimbabwe. While other imported materials attract customs duty at specified rates according to the Customs and Excise Act, capital goods can be exempted from paying duty if an application for rebate is made. A rebate is a concession, reduction, or complete waiver of duty on certain goods due to their nature and the purpose for which they are imported. This applies to capital goods for mining operations. The Commissioner General of ZIMRA can grant a complete waiver of duty (rebate).

Withholding tax

Withholding tax is a tax on services or goods. It is withheld on behalf of the Government by agents appointed by the Commissioner General in accordance with the Income Tax Act (Chapter 23:06). A 10% withholding tax is levied on dividends for residents and non-residents for companies listed on the Zimbabwe Stock Exchange. All other companies are levied at a rate of 20%.

Levies

Miners are also subject to several levies. These include:

- Annual or quarterly contribution to the Zimbabwe Manpower Development Fund (ZIMDEF) established under the Manpower Planning and Development Act.
- Levies to local authorities in terms of the Rural District Councils Act and Urban Councils Act.

- Quarterly water levies, payable to the Zimbabwe National Water Authority as per the Water Act, for the benefit of the Water Fund. Anyone with a permit for the use of ground or surface water is subject to this levy, which should be paid to the catchment council from which the permit was obtained or the sub-catchment council (if one exists) for the area to which the permit relates.

Possessing and dealing in gold

The possession of gold is controlled by the Gold Trade Act (Chapter 21:03). It is illegal for anyone to possess or trade in gold as a principal or as an agent unless that person:

- Is a holder of a licence or permit
- Is a holder of a tribute
- Is the holder of an authority, grant, or permit issued under the MMA authorising him or her to work an alluvial gold deposit
- Is the employee or agent of any of the persons mentioned above and is authorised by that employer or principal to deal in or possess gold that is in the lawful possession of the employer or principal.

There are three different types of licences issued to gold dealers:

- Gold dealing licence
- Gold recovery works licence
- Gold assaying licence

Every holder of a licence must keep a register of all gold deposited with, received, dispatched or otherwise disposed of by him or her. Milling centres are also required to maintain a register of all received and recovered gold. The Gold Trade Act is enforced by the Criminal Investigation and Border Control Department under the ZRP. This unit is regulated by the Mines and Minerals (Minerals Unit) Regulations SI 82 of 2008. In conjunction with the Mines Inspector, it carries out random compliance inspections on mines and milling centres.

The Gold Trade Act further authorises dealing and possession of gold between miner and person authorised to deal in gold and that the miner or tributor can only possess gold which has been owned by him or his employee acting on his behalf from the mining location upon which he has mining rights. Additionally, no person is allowed to smelt or change the form of any manufactured article containing gold unless he or she has received the permission of the Minister to do so.

Exporting base minerals from Zimbabwe also requires a permit. The conditions for this kind of permit are outlined in the Base Minerals Export Control Act (Chapter 21.06).

Labour rights

Labour rights are human rights; they apply across sectors, including ASM. While some labour rights are enshrined in international laws and agreements, every country also has its own specific legislation governing employment. The right to work is internationally recognised, and the United Nations Human Rights Committee underscores that it is closely related to other fundamental rights.

Discussion activity

Ask participants to share any labour-related issues they have come across. Then ask:

- What are some important workers' rights?

- Where do these rights come from?

- Conclude by emphasising that workers' rights are human rights.

The right to work is important for an individual's survival and dignity and for that of his or her family. It also has a collective dimension with respect to the right to form and join a trade union.

The right to work is enshrined in several international instruments:

- Universal Declaration of Human Rights
- International Covenant on Civil and Political Civil Rights
- International Covenant on Economic, Social and Cultural Rights
- Convention on the Elimination of All Forms of Discrimination against Women
- Convention on the Rights of the Child
- International Convention on the Protection of the Rights of All Migrant Workers and Members of their Families
- ILO Conventions

The Labour Act is the principal legislation for incorporating these international agreements, and its preamble gives effect to the ILO Conventions. It provides for

the establishment and functions of the Labour Court. It further covers:

- Unfair labour practices
- Conditions of employment
- Control of wages and salaries
- Appointment and functions of workers' committees
- Formation, registration, and functions of trade unions, employers' organisations, employment councils, and employment agencies;
- Negotiation, scope, and enforcement of collective bargaining agreements
- Prevention of trade disputes
- Regulation and control of collective action

There are relevant provisions in several other laws as well, including the Constitution of Zimbabwe, the NSSA Act, the Pneumoconiosis Act, and the Disabled Persons Act, as well as the various Labour Relations Regulations.

It is important for both employers and employees to be aware of key elements of the law. The Constitution states that every person has the right to fair and

What does the Constitution say?

There are several constitutional provisions that are significant to the mining sector, mainly drawn from the objectives and fundamental rights and freedoms. These objectives influence the development of the national mining legal and policy framework.

For example, Section 13(4) promotes **equitable national development** and requires the State to ensure that local communities benefit from the resources in their areas.

Section 14 promotes **economic empowerment** through affirmative action-type measures, while Section 17 promotes **gender balance** in all institutions and agencies of Government at every level. This means there should be a gender balance in public institutions and enterprises including the Mining Affairs Board, the MMCZ, and ZMDC.

Freedom of profession, trade, or occupation and **labour rights** are covered in Sections 64 and 65, respectively. Sections 84 and 92 safeguard the **right to work**.

safe labour practices and standards and to be paid a fair and reasonable wage, and the Labour Act provides a framework for ensuring fair labour standards and employee participation in decisions affecting their interests in the workplace. More information on key laws can be found in Annex A.

Small group activity

Break participants into groups of no more than five people and assign each group a different topic. Using the information in Annex A, each group should outline the processes and procedures related to their topic, noting which laws address the issue. Each group should present back in plenary. Some possible topics include processes for:

- Retrenchment
- Maternity leave application
- Disciplinary hearings

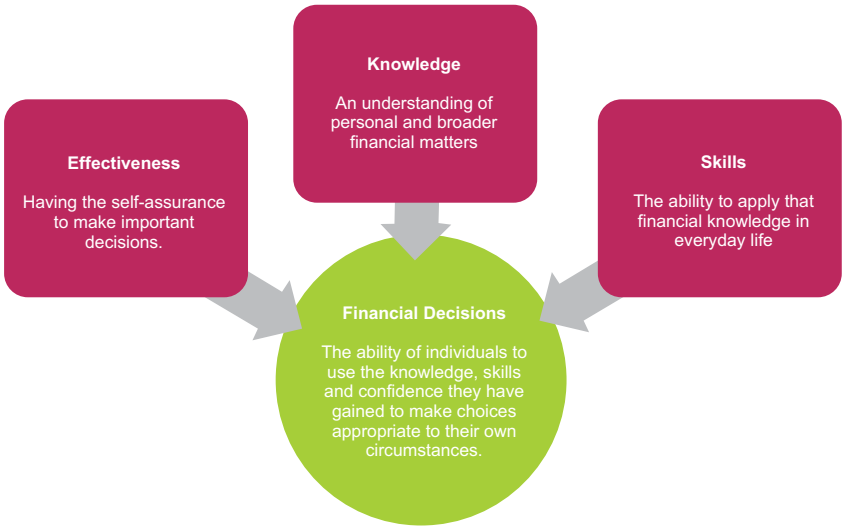
Business Skills and Markets

This module includes the following topics:

- Goal-setting, budgeting, and financial planning
- Sources of finance
- Cost of finance
- Sources of capital, expenses, and debt management
- Financial agreements
- The market to SELL outputs of ASM
- The market to BUY inputs like explosives and equipment

Financial literacy

Financial literacy is having the knowledge, skills and confidence to make responsible financial decisions.



Being financially literate helps ASM miners to:

- Decide how they will spend their money and meet their financial obligations.
- Make sense of the mining and financial marketplace so that they buy the products and services best suited to their needs.
- Manage their personal finances and plan for life events, such as home ownership or retirement.
- Understand how they can prepare for and benefit from local, provincial, and national government programs and systems.
- Assess the financial information and advice they receive from relatives and friends, professionals, or the media.
- Maximise the use of the resources to which they have access, including investments and credit[38].

Goal-setting, financial planning, and budgeting

Goal-setting

Goal-setting is a powerful process that helps you state your envisioned life in a specified period and sets the action steps that need to be taken to achieve the intended goals.

Why set goals?

- Setting goals gives you a long-term vision and short-term motivation.
- Goals motivate and help to focus on the desired outcome.
- Goals can help to manage resources (e.g., finances, time) more effectively and efficient.

Characteristics of 'SMART' financial goals:

- **Specific:** Goals must be clear and well-defined.
- **Measurable:** Goals should include precise details (e.g. amounts, dates).
- **Attainability:** Goals should be challenging, but set a goal that you have hope of achieving.

[38] Task Force on Financial Literacy, Canadians, and Their Money (2010). Building a brighter financial future.

- **Relevance:** Goals should be relevant to the direction of the ASM operations and your personal life.
- **Time-bound:** Goals must have deadlines; this creates a sense of urgency.

Long-term goals (typically one to five years) consist of plans you make for your future. Long-term goals are set by envisioning what you want to do and where you want to be. Short-term goals (usually more than three months but less than one year) can be considered enabling goals, because accomplishing these goals will enable you to achieve the long-term goals.

Financial planning

Financial planning is the task of determining how an ASM miner's business will achieve its strategic goals and objectives, which are created after setting a vision. A financial plan describes each of the activities, resources, equipment, and materials required to achieve the set objectives. The tasks undertaken when carrying out financial planning include:

- Assessing the business environment
- Confirming the business vision and objectives
- Identifying the types of resources needed to achieve these objectives
- Quantifying the amount of resources required (labour, equipment, and materials)
- Calculating the total cost of each type of resource
- Summarising the costs to create a budget
- Identifying risks and their respective mitigatory strategies

Budgeting

Budgeting is a tool used to track and record projected and actual income and expenses over a period of time. A budget is a road map to help reach financial goals and can help develop accountability. Budgeting can make it easier to:

- Put aside money for savings for the purchase of desired goods and services.
- Prepare for regular expenses such as wages, school fees, protective clothing, or equipment.
- Prepare for unexpected expenses such as medical expenses or funerals.
- Curb excessive spending and control how you spend money.

- Reduce stress and increase confidence at both personal and business levels to achieve intended goals and objectives.

The consequences of not budgeting can include:

- Lack of accountability about where money that has been earned has been spent
- Bad spending habits are unidentified and may go unchecked
- Being unprepared for emergencies
- Strained relationships at both the family and mining operational levels
- Lack of a savings plan
- Wasted money
- Stress

Prior to creating a budget, it is useful to track your current expenditure patterns. You may want to spend a couple of weeks recording everything that you have spent your money on. This enables you to see clearly where your revenue is going, and this becomes the basis of changes to your earning and expenditure patterns.

Budgeting needs to be flexible to change in line with the environment and changes to the organisation. An example of this is increasing the amount required to purchase explosives to enable increased blasting over a period of time, while reducing expenditure on food required to feed staff members. Budgets must be reviewed monthly to ensure that they are in line with changes that are taking place in the organisation.

Budgeting is not difficult, but it requires time to develop the budget, as well as commitment to implement it. To make a budget:

- Assess your personal financial situation (needs, values, life situation).
- Set personal and financial goals.
- Create a budget for fixed and variable expenses based on projected income.
- Monitor current spending (saving, investing) patterns.
- Compare your budget to what you actually spent.
- Review financial progress and revise budget amounts.

Below is an example of a budget format.

Table 18: Budget format example

	Plan	Actual	Explanation
Monthly income			
Earned income			Money generated from employment or retirement funds
Unearned income			Money received for no exchange, such as a gift
Total income			Earned plus unearned income
Monthly expenses			
Fixed expenses			Fixed expenses occur every period and are typically about the same amount. Items listed are examples.
'Pay yourself first' (savings)			The idea that savings should be a regular part of a spending plan and should happen before variable expenses
Claims Licensing and Registration			
Housing			
Other			
Total fixed expenses			Sum of all fixed expenses
Variable expenses			Variable expenses may or may not occur every period and do not have a constant value. The items listed are examples and should be tailored to your situation.
Fuel			
Food			
Protective clothing			
Entertainment			
Other			
Total variable expenses			Sum of all variable expenses
Total expenses			Fixed expenses plus variable expenses
Profit or loss			**Total income minus total expenses**
Adjustments for next month			

An essential part of being financially independent is spending less than you earn. If expenses are more than income, this is known as negative cash flow, and typically results in debt. To reduce negative cash flow, you'll need to do one or both of the following:

- Reduce spending by cutting down on expenses, starting with the 'nice to haves' and eliminating impulse purchases.
- Increase income through production

It is important to remember that budgets can and should change from time to time. After following a budget for a month, re-evaluate it and make changes as necessary.

Tools to help in budgeting

- **Envelope system:** Have an envelope for each category of spending and label it accordingly. Each pay period, place the budgeted amount of money in the envelope. Each time money is spent from an envelope, record the transaction details (date, vendor, amount, etc.) on the outside of the envelope. When the envelope is empty, stop spending!
- **Computer programs and apps:** There are many programs, some free or inexpensive, that can be used for budgeting found on computers as well as smartphones
- **Paper tracking:** You can record transactions in a notebook or register of expenses incurred for each category**.**

Sources of capital, expenses and debt management

Capital is the lifeblood of any business; it enables the business to meet its cash flow requirements and in ASM, it takes care of the initial gold production. If it is used inefficiently, it may be eroded through losses. A company's capital base may also be increased through profit and/or sourcing new capital from various types of financiers. It is in the ASM miner's best interests to ensure that his or her operation is profitable and thus sustainable. This also enables it to attract the appropriate type of capital. Capital can be raised from the following sources.

Equity financing

Equity financing means exchanging a portion of the ownership of the business for a financial investment in the business. The ownership stake resulting from an equity investment allows the incoming investor to share in the company's profits. Equity involves a permanent investment in a company and is not repaid by the company later.

Personal savings

The first place to look for money is your own savings or equity. Personal resources can include profit-sharing or early retirement funds, real estate equity loans, or cash value insurance policies.

Friends and relatives

Founders of a mining business may look to private financing sources such as parents or friends. This may be in the form of a loan at a low interest rate. It could also be in the form of equity financing, in which the friend or relative receives an ownership interest in the business. However, these investments should be made with the same formality that would be used with outside investors. This means creating and executing a **formal loan document** that includes the amount borrowed, the interest rate, specific repayment terms (based on the projected cash flow of the start-up business), and collateral (an asset which the lender can attach to satisfy the loan in case of default by the borrower).

Equity offerings

In this situation, the business sells stock directly to the public. Depending on the circumstances, equity offerings can raise substantial amounts of funds. The structure of the offering can take many forms and requires careful oversight by the company's legal representative.

Venture capital

Venture capital refers to financing that comes from companies or individuals that are the business of investing in young, privately-held businesses. They provide capital to young businesses in exchange for an ownership share of the business. Venture capital firms usually don't want to participate in the initial financing of a business unless the company has management with a proven track record. Generally, they prefer to invest in companies that have received significant equity investments from the founders and are already profitable.

Debt financing (loans)

Debt financing involves borrowing funds from creditors with the stipulation of repaying the borrowed funds plus interest at a specified future time. For the creditors (those lending the funds to the business), the reward for providing the debt financing is the interest on the amount lent to the borrower.

Debt financing may be **secured** or **unsecured**. Secured debt has collateral. Conversely, unsecured debt does not have collateral and places the lender in a less secure position relative to repayment in case of default.

Debt financing may be short-term or long-term in terms of repayment schedules. Generally, short-term debt is used to finance current activities such as operations, while long-term debt is used to finance assets such as buildings and equipment.

Bank lending

Banks are an important source of finance to companies. Bank lending is still mainly short-term, although medium-term lending is quite common these days.

Short-term lending may be in the form of:

- An overdraft, which a company should keep within a limit set by the bank. Interest is charged (at a variable rate) on the amount by which the company is overdrawn from day to day.
- A short-term loan, usually for up to two years.

Medium-term loans are loans for a period of from two to five years. The rate of interest charged on medium-term bank lending to large companies will be a set margin, with the size of the margin depending on the credit standing and riskiness of the borrower.

When a banker is asked by a business customer for a loan or overdraft facility, he will consider several factors, known commonly by the acronym PARTS.

Purpose	What is the purpose of the loan? A loan request will be denied if the purpose of the loan is not acceptable to the bank
Amount	What is the amount of the loan? The customer must state exactly how much he or she wants to borrow. The banker must verify, as far as he or she is able to do so, that the amount required to make the proposed investment has been estimated correctly
Repayment	How will the loan be repaid? Will the customer be able to obtain sufficient income to make the necessary repayments?
Term	What would be the duration of the loan?
Security	Does the loan require security? If so, is the proposed security (e.g., collateral) adequate?

Miners' incentives and associations

There are several miners' associations in the country that have in the past assisted ASM miners to finance their operations. These associations include Zimbabwe ASM Council as well as Zimbabwe Miners' Federation.

Over and above the associations, the Reserve Bank of Zimbabwe (through FPR) constantly rolls out gold production initiative funds in the tunes of millions to help ASM ramp up gold production.

Savings groups

As alluded to above, obtaining loan finance from financial institutions isn't a walk in the park for ASM miners. However, alternatively ASM miners can group themselves together into clusters, in which they will contribute funds saved from the revenue they have earned, to create a pool of funds that will enable them to lend to each other. Such groups are known as Internal Savings and Loan Groups (ISALs), MaRound, or Umkando, and have proven to be a reliable source of capital for informal sector participants. Financial institutions, particularly microfinance institutions (MFIs), have been supporting savings groups, particularly where the group lending schemes are no longer able to provide capital for the purchase of large assets by the individual members. The group lending and pooled funds concept works as collateral for the MFIs.

Leasing

A lease is an agreement between two parties, the 'lessor' and the 'lessee'. The lessor owns a capital asset but allows the lessee to use it. The lessee makes payments under the terms of the lease to the lessor, for a specified period. Leasing is, therefore, a form of rental. Leased assets are typically plant and machinery, cars and commercial vehicles, but might also be computers and office equipment. There are two basic forms of lease:

- **Operating leases:** These are rental agreements between the lessor and the lessee whereby:
    - The lessor supplies the equipment to the lessee;
    - The lessor is responsible for servicing and maintaining the leased equipment; and
    - The period of the lease is short, less than the economic life of the asset, so that at the end of the lease agreement, the lessor can either lease the equipment to someone else, and obtain a good rent for it, or sell the equipment second-hand.

- **Finance leases:** Also known as capital leases, these are lease agreements between the lessor and the lessee for most, or all, of the asset's expected useful life. For instance, if a company decides to obtain a company car and finance the acquisition by means of a finance lease, a car dealer will supply the car. A finance house will agree to act as lessor in a finance leasing arrangement, and so will purchase the car from the dealer and lease it to the company. The company will take possession of the car from the car dealer, and make regular payments (monthly, quarterly, six monthly, or annually) to the finance house under the terms of the lease.

Microfinance

Microfinance is the provision of financial services to low income groups in the form of savings and credit. Microfinance can be a significant enabler for the ASM sector to formalise, purchase property, obtain mining rights, adopt technological innovation, and embark on human and economic development for themselves and their families.

Zimbabwe has a mature and well-developed microfinance sector, though it has provided very limited financing to ASM. Microfinance is delivered through different channels, including:

- MFIs and microfinance banks: Private companies that are registered and licensed with the RBZ with specific capital requirements and governed operations.
- Savings and Credit Cooperative Organisations (SACCOs): Registered as cooperatives with the Ministry of Small and Medium Enterprises and Cooperatives Development. They are self-regulating community-based initiatives governed by agreed by-laws.
- ISALs: A small group of people having a mutual agreement to contribute a certain amount of money regularly into a group fund, with the hopes of seeing the fund grow. Members within the group can request to take out a loan to invest. He or she is then required to pay back the loan at an agreed time, with a low interest rate. This allows the members to not only develop and strengthen their entrepreneurial skills, but also serves to pay for any difficult situations they may face, with additional money to pay back the loan and interest.[39] Apart from mobilising savings, they also serve as platforms to promote developmental agenda.

[39] Freer, G. (2015). Zimbabwe: When I say ISALS, you say, internal savings and lending schemes, Progression: Harare.

Markets

Minerals that are produced by miners are sold to both the formal and informal markets. The informal market is often called the 'black market'. In Zimbabwe, the formal market, at the time of writing, is FPR (for gold and silver) at the local level and MMCZ (for all other minerals). However, the MMCZ is not a market in the proper sense of the word, but a facilitator for the marketing of the other minerals to world market. The functions of the MMCZ are elaborated later under this section.

FPR is a government subsidiary that has been mandated to purchase all gold mined and processed in the country, and to further refine and export it to international off-takers. All gold produced in the country, particularly from ASM, is therefore expected to eventually end up at FPR. ASM miners might not necessarily deliver the gold to FPR directly themselves, but are expected by statute to sell to millers, who in turn are expected to make deliveries to FPR.

Gold price determination

Gold is an international commodity that is traded on several exchanges, such as the London OTC, the New York GLOBEX, China, and Hong Kong. The price of the precious metal is determined by the London Bullion Market Association (LBMA). The LBMA is an international trade association, representing the London market for gold and silver bullion, which has a global client base. This includes most of the gold-holding central banks, private sector investors, mining companies, producers, refiners, and fabricators. The LBMA Gold Price is published twice a day and provides a benchmark price that is widely used across the globe by producers, consumers, investors, and central banks.

Payments for gold deliveries are done by FPR, which ensures timeous payments to miners. Miners can elect to be paid cash on the spot or through transfers into their bank accounts. FPR's prices for gold and silver are benchmarked to the previous day's LBMA afternoon fixing price. Upon purchasing gold delivered to it, FPR makes the following deductions:

- Royalties of 1% on the value of gold delivered to FPR
- Refining handling charges of $29 per kilogram
- Handling charge of 1%, inclusive of bank charges, fuel expenses, and insurance

The price of gold that is paid to the miners is determined by the purity of the gold and considers the factors mentioned above. The higher the purity of the gold, the higher the revenue the ASM miner earns.

The formal market for gold and silver

FPR has the sole mandate to buy gold. As noted above, FPR buys gold from the ASM sector through custom millers, which are required by law to retain the gold they process on behalf of FPR. The miller then sells the gold to the nearest FPR offices on behalf of the ASM miners. By law, millers are not allowed to keep gold for more than 48 hours and cannot keep gold that exceeds 100 grams for more than 24 hours, meaning that ASM miners receive the payment for the gold they produce within three days of processing it (oftentimes on the day after they extract it).

Aside from custom millers, FPR also buys gold from licensed dealers who hold permits to purchase and possess gold.[40] These dealers only buy from ASM miners from a specific mining province. They are strictly required to sell to FPR. These gold buying permits are not transferable.

A key challenge for the formal ASM gold value chain has been that in times when there are cash shortages in the economy, FPR's ability to pay the miners and gold dealers promptly becomes hamstrung. At such times, the informal market gains market share as ASM miners are more likely to prioritise prompt payment over the price received or the legality of the sales they make.

Most artisanal miners mine and trade gold informally. Pact's scoping study of the ASGM sector revealed that most artisanal miners do not hold licenses to mine and trade in gold, making their livelihood a crime. Most artisanal miners do not produce the one kilogram of gold per month threshold required for eligibility for a gold trading license.

The formal market for other minerals

To export any other mineral, one must get approval from the MMCZ, which is also a state-owned entity. MMCZ was established by the MMCZ Act and it operates under the Ministry of Mines and Mining Development.

The functions of the MMCZ are: [41]

- To act as the sole marketing and selling agent of all minerals (except gold and silver).
- To investigate and cause to be investigated marketing conditions, whether

[40] Ministry of Mines and Mining Development. (2018). Procedures of acquiring licenses and permits (MMA, Chapter 21:05).

[41] This sub-section is based on the MMCZ website http://www.mmcz.co.zw/about-us/

inside or outside Zimbabwe for minerals in general or for any particular mineral.

- To purchase and acquire any minerals for its own account and to sell or dispose of such minerals.
- To encourage the local beneficiation and utilisation of any minerals.
- To advise the minister on all matters connected with the marketing of minerals.

MMCZ keeps a record of buyers and sellers dealing in each particular mineral. This database is available to any buyer or seller. Sellers can approach any buyer they want and negotiate transactions, the terms of which should be approved by MMCZ. Once the agreement is reached and approved, MMCZ drafts a sales contract/agreement which formalises the seller-buyer relationship.

The agreement normally includes specification of the minimum volume per export consignment. When the supplier meets this minimum, he/she arranges for sampling of the mineral and analysis by a competent laboratory. The mineral consignment is then packaged in accordance with the terms of the agreement by the competent laboratory. Sample analysis costs are normally borne by the seller.

After the sample analysis and packaging have been done, the supplier applies for an export permit for the consignment from the Ministry of Mines and Mining Development, which will authorise MMCZ to process the export of the consignment. Based on the analytical results and weight of the consignment, MMCZ then prepares the export documentation, including invoices, which it sends to the buyer.

The export documentation is cleared by Customs, after which MMCZ liaises with the two transacting parties on movement of the consignment (as per the agreement terms). Payment of export proceeds is received through MMCZ. MMCZ will release the proceeds to the seller after deducting statutory obligations including royalties and the MMCZ commission, which is 0.875% of export revenue.

The informal capital market for ASM minerals

Informal financing is common in the sector. However, it is often exploitative and encourages informal trading in gold. Sponsorship is the main form of informal financing. Sponsorship is when an individual or organisation purchases all inputs for a group of ASM miners and then is given a share of the output (usually between 25% and 30%). The expenses incurred by the sponsor are deducted

from the revenue before the profit is shared. Sponsors own 16% of equipment used by ASM miners.

Financing plays a key role in whether ASM miners sell their gold to the formal sector or not. Artisanal gold is often effectively 'owned' even before it comes out of the ground because of pre-financing and other debt relationships that miners have with local traders or financiers. Because of the risky nature of mining, securing funding is a constant challenge for most ASM producers, and buyers often pre-finance miners by loaning them money against future production or in exchange for miners' agreement to sell at preferential prices. Where loans are made as an investment in a site's production, security can be placed on site to prevent theft and to monitor production. Lessors of equipment also do the same, placing security, staff, or relatives at mine sites where their equipment is being used to monitor production and use of the equipment. This however, often leads to child labour, whereby children are employed to do this monitoring.

In countries such as Côte d'Ivoire, well-established trader norms specify that only those who have pre-financed a site may buy from it. In places like Colombia, organised crime has been known to prevent ASGM from accessing the formal trading system. However, it would be wrong to frame these relationships in a purely negative manner. As explained by Professor Gavin Hilson, 'Middlemen fill the gaps that are left by the absence of formal services. Although these creditor-debtor relationships may be exploitative, they may also have a range of important, positive features: lenient repayment terms, availability of extra credit even when production is low, and provision of food, medication, or other essential items.'

Access to markets for inputs

Common ASM inputs include:Explosives

- Mercury
- Equipment (sale and hire)
- Cyanide
- Caustic soda
- Borax

A lot of equipment and supplies for ASM can be procured locally, though this does not mean they are manufactured locally. Local suppliers are mostly importers with little local content. The Chamber of Mines has a list of these suppliers. A smaller list can be found in Mlambo (2016) [42]

[42] Mlambo, L. (2016). Extractives and sustainable development in Zimbabwe I: Minerals, oil and gas sectors in Zimbabwe. Friedrich Ebert Stiftung: Harare.

Access to investment

Access to investment can allow miners to better manage their finances, address debt, improve the efficiency and productivity of their mining activities and develop alternative or supplementary livelihoods. The **capital market** is a market that links investors and companies seeking to raise investment (long-term) capital. The miner receives money or inputs from an investor in exchange for a share of the profits. The capital market for the mining industry takes different forms, from unofficial markets such as sponsorship to listing of large-scale mining houses on the Zimbabwe Stock Exchange and foreign direct investment.

Small Group Activity

Divide participants into three groups. Each group should address the

following questions on a flip chart:

- What are the three main reasons why the informal market for gold has fallen?
- What are the three main reasons why miners sell to the informal market?
- What proportion of gold produced by artisanal markets is sold to the informal market?

Social Issues

This module includes the following topics:

- 🕮 Gender issues in ASM
- 🕮 Opportunities for women
- 🕮 Child labour and children's rights

Around 2016, out of the 500,000 Zimbabweans involved in ASM, 153,000 were women and children.[43] These women and children face distinct challenges and are particularly vulnerable to exploitation, even though there are law in place to protect them.

In ASM, there are more formal and advanced miners who comply with all legislative principles that govern the sector. On the other hand, there are also tax evaders and illegal operators. Among those not complying with regulations are the more primitive artisanal miners who do so simply because they cannot afford to formalise themselves. The fees and taxes required for them are too exorbitant for their levels of earnings. Corruption has been reported, with public office bearers receiving bribes from ASM miners in return for avoiding certain fees or penalties for non-compliance with regulations.

Gender

The ways in which men and women behave in every aspect of their lives is not necessarily based on 'biology or nature' but rather the lifetime process of learning how to be a man or woman, often referred to as socialisation. The girls, boys, men, and women who do not conform to dominant expectations face social disapproval from their family, community, and society. Conceptions of gender shape the power dynamics between men and women; the norms around the roles they play in the home, in social situations, and the workplace; and the opportunities available to them.

Small Group Activity

Return to the three small groups, and give each group a question to discuss:

- **Group 1:** How can government ensure artisanal miners access explosives legally?
- **Group 2:** Where do miners currently get their explosives from?
- **Group 3:** What is the price of mercury and where do miners get it from?

[43] Mondlane, S. (2016). Artisanal and small-scale mining.

ASM is a male-dominated industry. Most of the women in ASGM are involved in gold panning, since it's a lighter form of gold mining, and because they are prevented from going underground due to a myth that this may lead to the disappearance of gold reefs. They often must rely on the benevolence of male miners, who usually donate a 20-litre bucket of ore to the women as payment for the general errands they undertake. Women who fail to get menial jobs end up sweeping up scraps of ore from the ground, which they pile up for days before they can send them for milling. In this way, women can send their children to school, purchase groceries and maintain a stable lifestyle despite the prevailing harsh economic environment. In a good month, women can make about $300 after going to the mill with donated and scrap ore, while their male counterparts pocket as much as $2,000 over the same period. In addition, ore must be guarded at night, when women are expected to remain home for their reproductive duties. It is in this time that male counterparts steal some of the ore, to the disadvantage of women.

As they fight for equal opportunities in terms of income and participation in the mines, women also find themselves exposed to the health hazards associated with using mercury in processing gold. A pilot study conducted by the Centre for Natural Resource Governance in Kadoma showed that the women tested had 25% higher mercury level in their breast milk than is considered safe by the WHO.

Gender-based violence (GBV)

A study undertaken by Pact in mining areas in 2014 uncovered high rates of GBV.[44] GBV refers to any act that is perpetrated against a person's will and is based on gender norms and unequal power relationships. It encompasses threats of violence and coercion. It can be verbal, physical, emotional, psychological, or sexual in nature, and can take the form of a denial of resources or access to services.[45] Male violence against women is often accepted as a form of controlling their behaviour.

The environment of ASM work is often unfavourable and risky for women. While working together, women have to contend with men dressed in undergarments in some cases. The language used at mining sites is often crude and abusive towards the women. Alcohol and marijuana use are prevalent. The lure of money has also resulted in young girls becoming pregnant by often uncommitted and migrant men who have families back home. While consensual sex is a feature of the mining sites, the rise of transactional sex itself is a major moral and health concern.

[44] Pact. (2015). A Golden Opportunity: A scoping study of ASGM in Zimbabwe. Washington, D.C.: Pact.

[45] UN General Assembly. (1979). Convention on the elimination of all forms of discrimination against women.

Men are often in control of all the operations within mining, meaning female miners cannot access tools, information, or even mining sites easily. Access is usually through sexual exploitation or through women offering a significant amount of the profits they make to male intermediaries. Women's subservient position makes them vulnerable to GBV, sexually transmitted infections, and economic dependence on men. Moreover, if a woman who works in mines fall pregnant, tension in her home may increase as her husband may claim he does not know who the father of the child could be. Ultimately, these conditions constrain women's ability to work in the mining sector, thereby limiting their access to the potentially high income. This has negative consequences for their wellbeing, as well as that of their families and communities.

For men, the expectation that they must be leaders—strong and in control at all times—places stress on their mental and emotional wellbeing. In tough economic times with lack of employment, men may unable to provide for their families. Instead of expressing emotion through dialogue, men may tend towards violence, which causes conflict in the home and in the community. While leadership is an important quality in the workplace, in the mining sector, men use their leadership power to exploit women's vulnerability. Instead, they should be challenged to use this power to increase women's access to opportunities and resources to support their economic independence and the wellbeing of their families. This section calls upon men to examine their own use of violence against women and girls and encourages men to make a commitment towards ending physical and sexual violence in their community.

Addressing gender inequality and GBV

Zimbabwe has laws that prohibit discrimination against women in any area of life. Most notable is the **2013 Constitution of Zimbabwe** which is the supreme law of the land and which states in Chapter 56.2 that 'Women and men have the right to equal treatment, including the right to equal opportunities in political, economic, cultural and social spheres'. The **Labour Act** complements the Constitution by also prohibiting discrimination in any area of work based on gender. Thus, women have the legal right under the law to work in the mining sector in any role. Because women are vulnerable to discrimination, Zimbabwean protects them and entitles them to their fundamental rights as a vulnerable group.

It is illegal to commit any acts of violence against any person, including domestic violence, rape, sexual assault, sexual exploitation and physical assault, among others. Committing such acts can result in jail time. These are contained in the:

- Criminal Law Act of 2006
- Sexual Offences Act of 2001
- Domestic Violence Act of 2007

Violence against women has been labelled as a criminal offence, where offenders can face imprisonment. Women, or anyone who experiences violence is entitled to justice under the law by reporting the cases to the police.

To foster gender equality in the mining sector, it takes every miner's personal commitment in addition to full implementation of relevant legislation. Simply arguing that gender equality and women's empowerment is a fundamental human right has shown to be minimally convincing, particularly to men, in terms of enabling gender transformation. By highlighting the socio-economic benefits of rejecting gender stereotypes and myths, however, men and women are more likely to accept gender equality more readily. When women have more money and financial independence, spending on children's health and nutrition is improved and there are greater the opportunities for a family's overall wellbeing to be enhanced.[46]

Opportunities for women in mining

All over Africa, more and more women are engaged in ASM. In Zimbabwe, around the year 2008, 50% of the workforce in ASM was women clearly indicating that mining is not work only for men.

Table 19: Women in ASM in Africa[47]

Country	Number and proportion of women in ASM
Burkina Faso	90,000 (45%)
Ghana	112,500 (45%)
Guinea	70,000 (70%)
Kenya	80,000 (80%)
Malawi	6,000 (10%)
Mali	200,000 (50%)
Mozambique	60,000 (30%)
South Africa	500 (5%)
Tanzania	375,000 (25%)
Uganda	90,000 (60%)
Zambia	18,000 (30%)
Zimbabwe	250,000

Because of the economic benefits, and the rising demand for gender equality all

[46] Organization for Economic Cooperation and Development. (2012). Gender Equality in Education, Employment and Entrepreneurship. Retrieved from: http://www.oecd.org/employment/50423364.pdf

[47] Hayes, K. & Perks, R. (2012). Women in the ASM of the Democratic Republic of the Congo. In Luaja, P. and Rustad, S.A. (Eds), High-value natural resources and peacebuilding. London: Earthscan.

over the world, the Government of Zimbabwe has developed mechanisms to support women who work in the mining sector, including the women's mining programme spearheaded by the Ministry of Women Affairs, Gender, and Community Development to formalise and empower women who are involved in mining. Government has also developed several programmes and gender-responsive policies that support women's economic development, including:Women's Fund in the Treasury

- Gender-Responsive Economic Policy Management Initiative
- Broad-Based Women's Economic Empowerment Framework
- Medium-Term Economic Recovery Plan, in which the government expressly commits to advancing women's participation

Numerous career opportunities are available for women in mining. Even without prior experience, skilled women can find jobs as geologists; engineers (mining, electrical, chemical, mechanical and metallurgical); mine surveyors; Safety, Health and Environment officers; and Human Resources Officers. They can also get into managerial positions that range from general management, accounting, law, human resources and occupational health and safety. There are also opportunities for women in other unskilled to semi-skilled positions such as caterers, gold buyers, sponsors, cleaners, lashers, panners, ore transporters, drillers, blasters and as team leaders/supervisors among a myriad of opportunities. Several organisations are also encouraging women to apply for their own gold claims so that they can more actively participate in mining.

Discussion Activity

You will need:

- Paper
- Markers
- Action sheets (see appendices)

Ask participants to reflect on the information they have been provided. Ask some probing questions, such as:

1. What are your thoughts on government efforts to support women miners and the attainment of gender equality in the workplace?
2. What role can men play in supporting women miners?
3. For women in the room, how can the community, including other male miners, support your efforts to become economically empowered?

Next, ask participants how they will personally pledge and make a commitment to creating a more gender-equal community by changing their behaviour towards each other irrespective of their gender. Hand out an action sheet to each person to record their commitments. They can keep these as a reminder of what they have committed to after the workshop has ended. Ask those who are willing to share their commitments to do so.

Child Labour

An estimated 100,000 children (aged 17 years and younger) work in ASM in Zimbabwe.[48] This number has increased dramatically in the last two decades, from 16,500 children (almost all of them boys) in 1999.[49] Worst case scenarios show children as young as 11 years old work in and around mining sites. Some children do not attend school and work assisting their parents at the mining sites, while others join work after school.

Small Group Activity

You will need:

- Flip chart paper
- Markers

Divide participants into groups and task each group to discuss the following questions, capturing their responses on flip chart paper. Come back to plenary so that group can share their responses and relevant to each topic under discussion. For instance:

- What is child labour?
- Why do children engage in child labour?
- How are children involved in mining? What are the tasks given to children?
- What is the environment in which children work in?
- Who benefits from child labour?
- What are the effects of child labour on children's health and education?
- Are there other effects of child labour on children?
- What are some alternative after-school activities?
- What else can be done to end child labour?
- Who is responsible?

[48] Pact. (2015). A Golden Opportunity: A Scoping Study of ASGM in Zimbabwe. Washington, D.C.: Pact.
[49] Ibid

Childminers are often called mamheri ('transporters') because many of them carry ore from mine sites to processing plants in sacks on their backs. Children are also engaged in riverbed panning, processing ore using mercury, and underground mining, because they are perceived to be small enough to work in confined spaces. However, child labour in ASM often is well-hidden from outsiders who visit mine sites. In a 2014 scoping study conducted by Pact, only 5% of miners reported working with children. However, in 2017, after trust had been built with the miners, 52% admitted to working with children.

There is a common Shona phrase used by child miners: 'Toidya toikonewa nei ma form 6 akati vavava', which translates to, 'We make and spend money while those who completed A level are broke.'

Why do children work in ASM? In some cases, adult miners have limited awareness of child labour laws and/or see children as cheap labour. Others believe that employing children from child-headed households or families with elderly guardians is an act of kindness. Children may feel pressure from peer who are engaged in ASM and making money, or from parents and guardians who see other children engaging in ASM and adding to the household income. Some children drop out of school due to poverty and see ASM as a livelihood source, but a growing number of children no longer see the benefits of continuing with education due to high youth unemployment rates. [50]

Harm to children

ASM is hazardous work for children. Child miners are more vulnerable to health and safety risks than adults. They are exposed to high levels of toxins such as mercury. Exposure is often proportionally higher for children given their lower body weight and is compounded childhood behaviours (e.g., playing with mercury or putting their hands in their mouths). Children also face risks such as cave-ins, rock-falls, and asphyxiation. An estimated 22,000 of children engaged in hazardous child labour across the world die every year at work while more are injured and fall sick.[51] While statistics are not readily available in Zimbabwe, media reports show that children often fall victim to accidents in ASM. [52]

Beyond the direct health and safety risks of mining itself, child miners are often involved in sexual relationships and drug use. In focus group discussions conducted by Pact, adult miners have revealed that both male and female child

[50] Ibid

[51] https://www.ilo.org/ipec/facts/WorstFormsofChildLabour/Hazardouschildlabour/lang--en/index.htm

[52] Tsoroti, S. (2017, August 12). Disaster looms at deserted Mashava gold mines. Newsday. Retrieved from: https://www.newsday.co.zw/2017/08/disaster-looms-deserted-mashava-gold-mines/

miners are frequently sexually involved with older miners. They also revealed that child miners often outspend them in local drinking spots. Additionally, child labour in ASM and child prostitution are closely interlinked. Child prostitution, which is prevalent in Zimbabwe, is another form of hazardous child labour as defined by the ILO. Many underage girls engage in prostitution in and around ASM sites. Poverty is a driver of both child labour in ASM and child prostitution. For example, in Gwanda, many of the child miners and commercial sex workers come from Binga, one of the poorest districts in Zimbabwe located hundreds of kilometres away.

Figure 107: Children working in ASM

Children's rights

Children's rights include all basic human rights such as decent shelter, education, adequate food, health care and clean water. These are things every child should have to survive and grow to reach their full potential. Children also have specific rights to protect them from the dangers, exclusions, and discrimination to which they are vulnerable. These rights are enshrined in both international and national legal instruments, such as the United Nations Convention on the Rights of the Child, the African Charter on the Rights and Welfare of the Child and the Constitution of Zimbabwe. In Zimbabwe, the Mines and Minerals Bill which is yet to be passed at the time of writing, proposes to specifically prohibit the use of children at all mining sites in the country. More information on the specific legal provisions related to child rights and child labour is included for reference in Annex A.

Organisational Development

In general, there are two basic models for organising ASM operations:

Under an **employment model**, claim owners pay miners a monthly salary of $150-350 (compared to official national minimum wage for mining of $238.41 per month).[53] Some miners prefer this model as it amounts to guaranteed money and some claim owners opt for it when they are working rich ore because it allows them to avoid sharing large profits. However, because most claim owners dislike the idea of fixed labour costs in an environment in which gold production and prices fluctuate, the model is uncommon. It is typically utilised by claim owners with relatively high investment and good quality ore deposits.

The **partnership model** is a system in which different production units share profit. In a typical arrangement, the claim owner, miners, sponsor, and equipment provider each gets 25% of the profit. As implied by the profit sharing agreement, the sponsor is remunerated for all consumable costs prior to dividing profit. The partnership model remains the more common model, as it limits risk for claim owners and ties labour payments to production levels.

Informality in the ASM sector

The majority of ASM miners mine informally in one of the following ways:

- Mining illegally on an area that is not licensed for mining.
- Mining illegally on an area licensed to another individual or company for mining.
- Mining informally on an area licensed for mining with the 'un-standardised' permission of the owner (i.e., the agreement is not in the form of a Tribute Agreement submitted to the Ministry of Mines and Minerals Development).
- Mining informally for a mineral on an area licensed to mine another mineral.

Mining informally makes artisanal miners ineligible to trade in gold formally through FPR. Artisanal miners who mine informally will either trade their gold formally through gold millers or through the licensed mine owners, or on the informal market. No records are maintained of artisanal miners' production if

[53] NEC Zimbabwe 2014-2018 national minimum wage

gold is sold informally. Without records of their past production and delivery to FPR, artisanal miners become ineligible for financing opportunities. In contrast, claim owners and millers, who barely do any actual mining, are recorded as the gold producers and have access to such financing opportunities.

Financing for the ASM sector

Formal financing

In Zimbabwe, efforts have been made to finance the sector with limited success. In the late 1990s, the Austrian Foundation for Small Mines (AFSM) provided financial and technical assistance to miners (initially to chrome miners but later to gold producers as well. However, the project was not successful overall. The attempt to provide soft loans and grants to small-scale miners and set up a sustainable revolving loan scheme failed due to three factors:[54]

- The loan requirements were so complex and inflexible that ordinary miners in the target group could not comply.
- There were low rates of repayment.
- The administrative and management costs for AFSM associated with disbursing the loans were much higher than the capital provided by AFSM.

- In the late 1990s and early 2000s, banks such as ZB (formerly Zimbank),

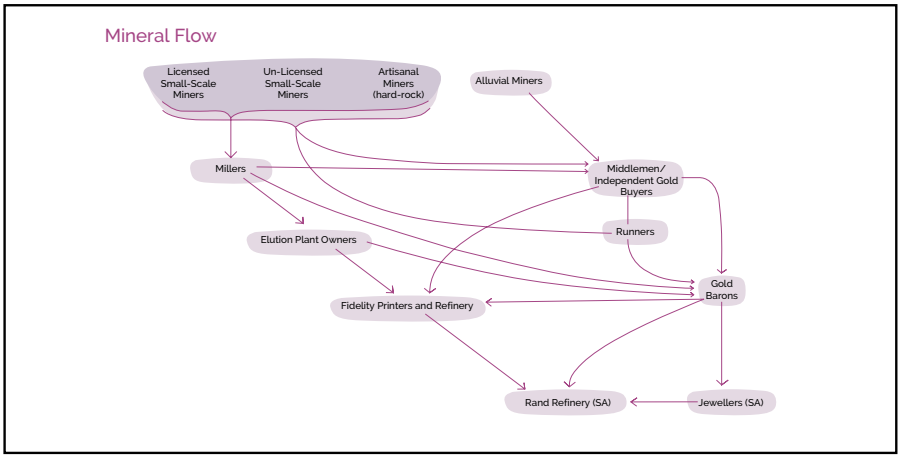


Figure 108: Formal and informal gold trade

[54] Dreschler, B., 2001, Small-scale Mining andSustainable Development within the SADCRegion, Country Study commissioned byMMSD

> Barclays, and the Commercial Bank of Zimbabwe offered loans to small-scale miners amounting to less than ZW$300,000 (approximately US$6,000) per miner—not enough to get a miner into production. This contributed to the poor success rate of the loan schemes. With their minimal collateral, the miners have not been able to borrow more.[55]

The RBZ launched the Gold Mining and Minerals Development Trust (GMMDT) in 2001 to improve gold production and stem leakages (i.e., smuggling). The vision was that the GMMDT would lend money to gold miners, promote environmentally-friendly mining methods, assist in environmental rehabilitation, advocate for balanced mining legislation, and finance the establishment of milling centres.

The Ministry of Mines and Mining Development created the Mining Investment Loan (MIL) Fund, to be administered by the Mining Affairs Board, to offer a variety of cash loans tailored to the needs of small-scale miners. At the time it was established, the fund stood out as a rare example of an entity that could integrate sector-specific training and credit delivery to miners. It was heralded as a model worth emulating in other African countries. However, hyperinflation crippled the fund, which amounted to around ZW$2 million in 2006 (approximately US$19,800)—an amount that was barely adequate to capitalise four mines at ZW$500,000 each. Accusations of corruption within the MIL Fund intensified in 2006.[56]

Before its closure in 2013, Tetrad Bank's gold buying unit considered giving out loans based on the sponsorship model,[57] which is common in the ASM sector in Zimbabwe.

Artisanal miners are not considered credit-worthy by microfinanciers for several reasons, such as migratory lifestyles, lack of land tenure, marginal legal status, limited financial and business planning skills, and social challenges associated with artisanal mining. Mining areas are often remote, mines have limited lifespan, and the sites often fall outside areas targeted by development programs. ASM is generally carried out with little geological knowledge that could be used to convince financiers of the credit-worthiness of a mining operation. Female artisanal miners face even greater challenges in accessing financing facilities compared to their male counterparts.[58] Microfinance has been applauded for directly reducing poverty among excluded groups, including women.

---

[55] Ibid.

[56] Spiegel, S. J. (2012). Formalisation Policies, Informal Resource Sectors and the De-/Re-Centralization of Power: Geographies of Inequality in Africa and Asia. http://www.cifor.org/fileadmin/subsites/proformal/PDF/RSpiegel1212.pdf

[57] Sponsorship is when an individual or organisation purchases all inputs for ASM miners and then is given a share in the output (usually between 25 and 30%). The expenses incurred by the sponsor are deducted from the proceeds before the net profits are shared.

Informal financing

Informal microfinance exists in Zimbabwe's ASM sector through a practice called sponsorship, in which a sponsor pays for services extended to an ASM miner (or syndicate of miners) that enable ore production. The critical players in the sponsorship model are:

- A sponsor who provides working capital and pays for services such as food, explosives, mercury, milling and transportation
- A claim owner who holds the license to the mining claim
- An equipment supplier who provides the equipment used in the mining such as compressors, jackhammers, and water pumps
- A miner or syndicate of miners who provide the labour

Sponsorship works well because it considers several of the constraints to extending micro-loans to ASM miners. The miners do not receive any of the working capital invested as cash. The sponsor provides explosives, mercury, equipment and a daily supply of food for a production cycle. In addition, sponsors provide money for school fees, healthcare, and other costs, and recover the money when the ASM miners receive payment for the gold produced. Sponsors often have good relationships with millers or are the millers themselves, and they manage risk by investing in only one production cycle. However, in sponsorship, ASM miners do not receive a fair share of the proceeds, and gold is often then informally traded by the miners.

[58] Pact. (2015). A Golden Opportunity: A Scoping Study of ASGM in Zimbabwe. Washington, D.C.: Pact.

GLOSSARY

A

Abandoned mine

See: abandoned workings.

Abandoned workings

1. Excavations, either caved or sealed, that are deserted and in which further mining is not intended.
2. Open workings that are not ventilated and inspected regularly. U.S. Bureau of Mines[59]

Access road

A route constructed to enable plant, supplies, and vehicles to reach a mine, quarry, or opencast pit. In remote and isolated regions, the provision of an access road may be very costly. U.S. Bureau of Mines

Acid mine drainage

Drainage with a pH of 2.0 to 4.5 from mines and mine wastes. It results from the oxidation of sulphides exposed during mining, which produces sulphuric acid and sulphate salts. The acid dissolves minerals in the rocks, further degrading the quality of the drainage water. U.S. Bureau of Mines

Acid mine water

Mine water that contains free sulphuric acid, mainly due to the weathering of iron pyrites. Pit water, which corrodes iron pipes and pumps, usually contains a high proportion of solids, principally the sulphates of iron. Where sulphide minerals break down under chemical influence of oxygen and water, the mine drainage becomes acidic and can corrode ironwork. If it reaches a river system, biological damage may also result. U.S. Bureau of Mines

[59] U.S. Bureau of Mines, 1996, Dictionary of Mining, Mineral, & Related Terms. U.S. Department of the Interior

Activated carbon

Carbon, mostly of vegetable origin, and of high adsorptive capacity. Synonym: activated charcoal. U.S. Bureau of Mines

Activation

1. In the flotation process of mineral dressing, the process of altering the surface of specific mineral particles in a mineral pulp to promote adherence of certain reagents.
2. The changing of the passive surface of a metal to a chemically active state. The opposite is known as passivation**.**
3. In the flotation process of ore beneficiation, the process of altering the surface of specific mineral particles in an ore pulp to promote adherence of certain reagents. U.S. Bureau of Mines

Active fault

A geological fault that is liable to further movement. U.S. Bureau of Mines

Active workings

All places in a mine that are ventilated and inspected regularly. U.S. Bureau of Mines

Adit

1. A horizontal or nearly horizontal passage driven from the surface for the working or dewatering of a mine. If driven through the hill or mountain to the surface on the opposite side, it would be a tunnel. Synonyms: drift; adit level. See also: tunnel.
2. A passage driven into a mine from the side of a hill. U.S. Statistical Research Bureau[60]

Advance

1. The work of excavating as mining goes forward in an entry and in driving rooms; to extract all or part of an area; first mining as distinguished from retreat.
2. Rate at which a drill bit penetrates a rock formation.
3. Metres drilled in any specific unit of time.

[60] U.S. Bureau of Mines, 1996, Dictionary of Mining, Mineral, & Related Terms. U.S. Department of the Interior

4. The linear distance (in metres) driven during a certain time in tunneling, drifting, or in raising or sinking a shaft. U.S. Bureau of Mines

Advance development

Development to provide an ore reserve in advance of mining operations. U.S. Bureau of Mines

Advance per round

The length, measured along the longitudinal axis of the working, tunnel, of the hollow space broken out by each round of blasting. For raises, it is upward advance; for sunk shafts, downward advance. U.S. Bureau of Mines

Aerial mapping

Taking aerial photographs for making maps and for geologic interpretation. U.S. Bureau of Mines

Aerial photograph

Any photograph taken from the air, such as a photograph of a part of the Earth's surface taken by a camera mounted in an aircraft. U.S. Bureau of Mines

Aerial survey

A survey using aerial photographs as part of the surveying operation. U.S. Bureau of Mines

Air leg

1. A cylinder operated by compressed air, used for keeping a rock drill pressed into the hole being drilled.
2. A device, incorporating a pneumatic cylinder, providing support and thrust for a jackhammer. U.S. Bureau of Mines

Air-leg support

An appliance to eliminate much of the labour when drilling with handheld machines. It consists of a steel cylinder and air-operated piston, the rod of

which extends through the top end of the cylinder and supports the drilling machine. The air leg and machine can be operated by one worker. U.S. Bureau of Mines

Alluvial deposit

1. In relation to precious stones, any deposit, either non-coherent or consolidated, of any geological age, which has been formed by the agency of water or wind.
2. In relation to any other mineral, any accumulation of sand, gravel, or clay deposited by surface water containing valuable minerals. Synonyms: alluvium, placer. Mines and Minerals Act of Zimbabwe (Chapter 21:05)

Alluvial mining

The exploitation of alluvial deposits.

ANFO

An explosive material consisting of ammonium nitrate (AN) and fuel oil (FO), with approximately 94.5% industrial-grade AN and 5.5% diesel for a nearly oxygen-balanced mix; available in bulk form for onsite mixing of the AN and fuel or in premixed bags as pourable forms. SME Mining Engineering Handbook[61]

Angle of dip

The angle at which strata or mineral deposits are inclined to the horizontal plane.

Approved beneficiation plant

A bank assay department, factory, refinery, smelter, or treatment plant that has been declared to be an approved beneficiation plant in terms of section 247 of the Mines and Minerals Act of Zimbabwe (Chapter 21:05).

Approved prospector

A person who is registered in the Register of Approved Prospectors by the Ministry of Mines. Mines and Minerals Act of Zimbabwe (Chapter 21:05)

[61] Darling, P., & Society for Mining, Metallurgy, and Exploration (U.S.). (2011). SME mining engineering handbook. Englewood, Colo.: Society for Mining, Metallurgy, and Exploration.

Aquifer

A water-bearing bed of porous rock, often sandstone.

Argillaceous ore

Ore in which the gangue is mainly clay. U.S. Bureau of Mines

Assay

To analyse the proportions of metals in an ore; to test an ore or mineral for composition, purity, weight, or other properties of commercial interest. U.S. Bureau of Mines

Assay grade

The percentage of valuable constituents in an ore, determined from assay. Synonym: assay value. U.S. Bureau of Mines

B

Back

The roof or upper part in any underground mining cavity.

Backfill

1. Waste sand or rock used to support the roof or walls after removal of ore from a stope.
2. Sand or dirt placed behind timber, steel, or concrete linings in shafts or tunnels.
3. The process of sealing and filling, and/or the material used to seal or fill, a borehole
4. Material excavated from a site and reused for filling, for example, the use of stones or coarse gravel for filling draining trenches. U.S. Bureau of Mines

Backfilling system

Filling lower or older workings with the waste from newer workings. U.S. Bureau of Mines

Back holes

In blasting, the holes that are fired last.

Ball mill

A rotating horizontal cylinder with a diameter almost equal to the length, supported by a frame or shaft, in which non-metallic materials are ground using various types of grinding media such as quartz pebbles or porcelain balls. U.S. Bureau of Mines

Bar grizzly

A series of spaced bars, rails, pipes, or other members used for rough sizing of bulk material passed across it to allow smaller pieces to drop through the spaces. U.S. Bureau of Mines

Barren

Rock or vein material containing no minerals of value.

Barricading

Enclosing part of a mine to prevent inflow of noxious gasses from a mine fire or an explosion.

Barring down

1. Loosening ore in a bin by means of a bar so it will flow through the chute.
2. Prying off loose rock after blasting to prevent danger of fall. U.S. Bureau of Mines

Base charge

The charge loaded into the bottom of vertical holes in surface mining. U.S. Bureau of Mines.

Base metals

1. A classification of metals usually considered to be of low value and higher chemical activity as compared to the noble metals (e.g., gold, silver, platinum). This non-specific term generally refers to the high-volume, low-value metals copper, lead, tin, and zinc. Synonym: base minerals. U.S. Bureau of Mines

2. Under Zimbabwean law, all minerals and mineral substances, other than nuclear energy source material, precious metals, precious stones, mineral oils, natural gases, and coal. Includes all such slimes, concentrates, slags, tailings, and residues as are valuable and contain base minerals. Mines and Minerals Act

Belt

An elongated area of mineralisation. U.S. Bureau of Mines

Belt conveyor

A looped belt on which materials can be carried. Generally constructed of flame-resistant material or of reinforced rubber or rubber-like substance.

Beneficiation

The treatment of mined material, making it more concentrated or richer.

Bit

The hardened and strengthened device at the end of a drill rod that transmits the energy of breakage to the rock. The size of the bit determines the size of the hole. A bit may be either detachable from or integral with its supporting drill rod.

Blasting agent

Any material consisting of a mixture of a fuel and an oxidiser.

Blasting cap

A detonator containing a charge of detonating compound, which is ignited by electric current or the spark of a fuse. Used for detonating explosives.

Blasting circuit

Electric circuits used to fire electric detonators or to ignite an igniter cord by means of an electric starter.

Block

A claim or a group of claims that may be registered in terms of the Mines and Minerals Act under one certificate of registration.

Borehole

Any deep or long drill-hole, usually associated with a diamond drill.

Bottom

Floor or underlying surface of an underground excavation.

Brattice

Fire-resistant fabric or plastic partition used in a mine passage to confine the air and force it into the working place. Synonyms: brattice cloth, line brattice, line canvas, line curtain.

C

Collar

The timbering or concrete around the mouth or top of a shaft. The beginning point of a shaft or drill hole at the surface.

Comminution

The breaking, crushing, or grinding of coal, ore, or rock.

Competent rock

Rock that is capable of sustaining openings without any structural support, except pillars and walls left during mining, because of its physical and geological characteristics. Stalls, light props, and roof bolts are not considered structural support.

Contour

An imaginary line that connects all points on a surface having the same elevation.

Core sample

A cylinder sample generally one to five feet in diameter drilled out of an area to determine the geologic and chemical analysis of the rock

Course of a reef

A line on the surface marking the intersection of the centre of a reef with such surface and, in cases where the whole or any portion of a reef is situated below the surface of the ground, the course of such reef shall be ascertained by projecting vertically to the surface the various points at which the centre of such reef approaches nearest to the surface, when the various points thus obtained shall be deemed to constitute the course of such reef. Mines and Minerals Act

Cover

The overburden of any deposit.

Cross entry

An entry running at an angle with the main entry.

Crusher

A machine for crushing rock or other materials. Examples include ball mills, gyratory crushers, Handsel mills, hammer mills, jaw crushers, rod mills, rolls, stamp mills, and tube mills.

D

Demonstrated reserves

A collective term for the sum of coal in both measured and indicated resources and reserves.

Deposit

Mineral deposit or ore deposit is used to designate a natural occurrence of a useful mineral, or an ore, in sufficient extent and degree of concentration to invite exploitation.

Depth

1. Vertical distance below the surface.
2. In the case of incline shafts and boreholes, the distance reached from the beginning of the shaft or hole, the borehole depth, or the inclined depth.

Detonator

A device containing a small detonating charge that is used for detonating an explosive, including, but not limited to, blasting caps, exploders, electric detonators, and delay electric blasting caps.

Development mining

Work undertaken to open up coal reserves as distinguished from the work of actual coal extraction

Dip

The inclination of a geologic structure (bed, vein, fault, etc.) from the horizontal; dip is always measured downwards at right angles to the strike.

Drift

A horizontal passage underground. A drift follows the vein, as distinguished from a crosscut that intersects it, or a level or gallery, which may do either.

Dump

1. Any aggregate of rock fragments or tailings that contain valuable minerals and have been accumulated by mining on a mining location. Mines and Minerals Act
2. To unload; specifically, a load of coal or waste
3. The mechanism for unloading (e.g., a car dump, sometimes called tipple)
4. The pile created by such unloading (e.g., a waste dump, also called heap, pile, tip, spoil pike, etc.).

E

Entry

1. An underground horizontal or near-horizontal passage used for haulage, ventilation, or as a main way.
2. A coal heading.
3. A working place where the coal is extracted from the seam in the initial mining. Synonyms: gate, roadway.

Eluvial deposit

A residual concentration of minerals in the immediate vicinity of the outcrop of the vein or lode from which it is derived. Mines and Minerals Act

Exploration

1. All activities involved in the discovery and evaluation of a mineral deposit, i.e., establishing the size, grade, initial flowsheet, and annual output of the new extractive operation.
2. The search for mineral deposits and the work done to prove or establish the extent of a mineral deposit. Synonym: prospecting and subsequent evaluation.

Exclusive prospecting order

1. A large-scale exploration licence. Mines and Minerals Act
2. Exclusive prospecting reservation.
3. The area covered by an exclusive prospecting order. Mines and Minerals Act

Explosive

Any rapidly combustive or expanding substance. The energy released during this rapid combustion or expansion can be used to break rock.

Extraction

The process of mining and removal of ore from a mine.

Extra-lateral right

The legal right of following a reef underground beyond the vertical limits of a mining license. Mines and Minerals Act

F

Face

The exposed area of a coal bed from which coal is being extracted.

Fall

A mass of roof rock or coal that has fallen in any part of a mine.

Fan, auxiliary

A small, portable fan used to supplement the ventilation of an individual working place.

Fan, booster

A large fan installed in the main air current, and thus in tandem with the main fan.

Fault

A slip-surface between two portions of the Earth's surface that have moved relative to each other. A fault is a failure surface and is evidence of severe earth stresses.

Fault zone

A fault, instead of being a single clean fracture, may be a zone hundreds or thousands of feet wide. The fault zone consists of numerous interlacing small faults or a confused zone of gouge, breccia, or mylonite.

Fill

Any material that is put back in place of the extracted ore to provide ground support.

Floor

The part of any underground working upon which a person walks or upon which haulage equipment travels; the bottom or underlying surface of an underground excavation.

Friable

Easy to break, or crumbling naturally. Descriptive of certain rocks and minerals.

Fuse

A cord-like substance used in the ignition of explosives. Black powder is entrained in the cord and, when lit, burns along the cord at a set rate. A fuse can be safely used to ignite a cap, which is the primer for an explosive.

G

Geologist

One who studies the constitution, structure, and history of the Earth's crust, conducting research into the formation and dissolution of rock layers, analysing fossil and mineral content of layers, and endeavouring to fix historical sequence of development by relating characteristics to known geological influences (historical geology).

Grizzly

Course screening or scalping device that prevents oversized bulk material from entering a material transfer system; constructed of rails, bars, beams, etc.

H

Haulage

The horizontal transport of ore, coal, supplies, and waste. The vertical transport of the same is called hoisting.

Haulage way

Any underground entry or passageway that is designed for transport of mined material, personnel, or equipment, usually by the installation of track or belt conveyor.

Headframe

The structure surmounting the shaft which supports the hoist rope pulley, and often the hoist itself.

Hoist

A drum on which hoisting rope is wound in the engine house, as the cage or skip is raised in the hoisting shaft.

Hoisting

The vertical transport coal or material.

Horizon

In geology, any given definite position or interval in the stratigraphic column or the scheme of stratigraphic classification; generally used in a relative sense.

Hydraulic

Of or pertaining to fluids in motion. Hydraulic cement has a composition that permits it to set quickly under water. Hydraulic jacks lift through the force transmitted to the movable part of the jack by a liquid. Hydraulic control refers to the mechanical control of various parts of machines, such as coal cutters or loaders, through the operation or action of hydraulic cylinders.

I

Incline

Any entry to a mine that is not vertical (shaft) or horizontal (adit). Often incline is reserved for those entries that are too steep for a belt conveyor (+17 degrees -18 degrees), in which case a hoist and guide rails are employed. A belt conveyor incline is termed a slope. Alt: Secondary inclined opening, driven upward to connect levels, sometimes on the dip of a deposit; also called 'inclined shaft'.

Incompetent

Applied to strata, a formation, a rock, or a rock structure not combining sufficient firmness and flexibility to transmit a thrust and to lift a load by bending.

Indicated coal resources

Coal for which estimates of the rank, quality, and quantity have been

computed partly from sample analyses and measurements and partly from reasonable geologic projections. The points of observation are one half to 1.5 miles apart. Indicated coal is projected to extend as a half-mile wide belt that lies more than a quarter mile from the outcrop or points of observation or measurement.

Inferred coal resources

Coal in unexplored extensions of the demonstrated resources for which estimates of the quality and size are based on geologic evidence and projection. Quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repletion of which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence. The points of observation are 1.5 to six miles apart.

In situ

In the natural or original position. Applied to a rock, soil, or fossil when occurring in the situation in which it was originally formed or deposited.

Intake

The passage through which fresh air is drawn or forced into a mine or to a section of a mine.

J

Jackleg

A percussion drill used for drifting or stopping that is mounted on a telescopic leg with an extension of about 2.5 metres. The leg and machine are hinged so that the drill need not be in the same direction as the leg.

Joint

A divisional plane or surface that divides a rock and along which there has been no visible movement parallel to the plane or surface.

L

Load

1. To place explosives in a drill hole.
2. To transfer broken material into a haulage device.

M

Manhole

A safety hole constructed in the side of a gangway, tunnel, or slope in which miner can be safe from passing locomotives and cars. Synonym: refuge hole.

Measured coal resources

Coal for which estimates of the rank, quality, and quantity have been computed from sample analyses and measurements from closely spaced and geologically well-known sample sites, such as outcrops, trenches, mine workings, and drill holes. The points of observation and measurement are so closely spaced and the thickness and extent of coals are so well defined that the tonnage is judged to be accurate within 20% of true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of the coal differs from region to region according to the character of the coal beds, the points of observation are no greater than half a mile apart. Measured coal is projected to extend as a quarter-mile wide belt from the outcrop or points of observation or measurement.

Methane

A potentially explosive gas formed naturally from the decay of vegetative matter, similar to that which forms coal. Methane, which is the principal component of natural gas, is frequently encountered in underground coal mining operations and is kept within safe limits through the use of extensive mine ventilation systems.

Mine development

The term employed to designate the operations involved in preparing a mine for ore extraction. These operations include tunneling, sinking, cross-cutting, drifting, and raising.

Miner

One who is engaged in the business or occupation of extracting ore, coal, precious substances, or other natural materials from the Earth's crust.

Mineral

An inorganic compound occurring naturally in the Earth's crust, with a distinctive set of physical properties, and a definite chemical composition.

Mining engineer

A person qualified by education, training, and experience in mining engineering with knowledge of the science, economics, and arts of mineral location, extraction, concentration and sale, and the administrative and financial problems of practical importance in connection with the profitable conduct of mining.

Misfire

The complete or partial failure of a blasting charge to explode as planned.

N

Natural ventilation

Ventilation of a mine without the aid of fans or furnaces.

O

Outcrop

Coal that appears at or near the surface.

Overburden

Layers of soil and rock covering a coal seam. Overburden is removed prior to surface mining and replaced after the coal is taken from the seam.

Ore

All forms of minerals or mineral aggregates that are of economic value. Mines and Minerals Act

P

Peg

1. An artificial post or rod, other than a metal peg, of a height of not less than 1.2 metres above the ground and not less than 10 centimetres in diameter or of such other dimensions as may be prescribed.
2. A metal peg of a height of not less than one comma two metres above the ground or such other height as may be prescribed and not less than 10 millimetres in cross-section.
   Mines and Minerals Act

Percussion drill

A drill, usually air-powered, that delivers its energy through a pounding or hammering action.

Pillar

An area of coal left to support the overlying strata in a mine; sometimes left permanently to support surface structures.

Placer deposit

Any form of mineral deposit that does not fall within the definitions of a reef, dump, alluvial deposit, eluvial deposit, or rubble deposit. Mines and Minerals Act.

Pneumoconiosis

A chronic disease of the lung arising from breathing coal dust.

Precious metals

Gold, silver, platinum, and platinoid metals in an unmanufactured state. Mines and Minerals Act

Precious stones

Rough or uncut diamonds or emeralds or any substances which may, in terms of subsection (2), be declared to be precious stones for the purposes of the Precious Stones Trade Act

Primer (booster)

A package or cartridge of explosive designed specifically to transmit detonation to other explosives and which does not contain a detonator.

Prospecting

The direct search for surface signs of the presence of a mineral deposit. Often inter-changed with exploration, but there is the implication that prospecting is less technical and usually carried out by an individual.

R

Raise

A secondary or tertiary inclined, vertical, or near-vertical opening driven upward from a level to connect with the level above, or to explore the ground for a limited distance above one level.

Ramp

A secondary or tertiary inclined opening, driven to connect levels, usually driven in a downward direction, and used for haulage.

Reclamation

The restoration of land and environmental values to a surface mine site after the coal is extracted. Reclamation operations are usually underway as soon as the coal has been removed from a mine site. The process includes restoring the land to its approximate original appearance by restoring topsoil and planting native grasses and ground covers.

Recovery

The proportion or percentage of coal or ore mined from the original seam or deposit.

Reef

Any form of ore deposit contained within defined boundaries occurring in the Earth's crust that has been deposited in the enclosing country rocks, and includes a true fissure vein, contact vein, segregated vein, gash vein, bedded vein, or metalliferous blanket, and all such deposits as conform generically to the above classification and any bed of any mineral, such as ironstone or limestone, but does not include alluvial deposits, eluvial deposits, placer deposits, rubble deposits, or coal.

Registered mine manager

The person registered in terms of the regulations as the mine manager of the mining location concerned.

Reserve

That portion of the identified coal resource that can be economically mined at the time of determination. The reserve is derived by applying a recovery factor to that component of the identified coal resource designated as the reserve base.

Resources

Concentrations of mineralisation in such forms that economic extraction is currently or may become feasible. Mineral resources broken down by identified and undiscovered resources. Identified mineral resources are classified as demonstrated and inferred. Demonstrated resources are further broken down as measured and indicated. Undiscovered resources are broken down as hypothetical and speculative.

Retreat mining

A system of robbing pillars in which the robbing line, or line through the faces of the pillars being extracted, retreats from the boundary toward the shaft or mine mouth.

Roof

The stratum of rock or other material above a coal seam; the overhead surface of a coal working place. Synonyms: back, top.

Roof bolt

A long steel bolt driven into the roof of underground excavations to support the roof, preventing and limiting the extent of roof falls. The unit consists of the bolt (up to four feet long), steel plate, expansion shell, and pal nut. The use of roof bolts eliminates the need for timbering by fastening together, or 'laminating', several weaker layers of roof strata to build a 'beam'.

Roof fall

A coal mine cave-in, especially in permanent areas such as entries.

Roof support

Posts, jacks, roof bolts, and beams used to support the rock overlying a coal seam in an underground mine. A good roof support plan is part of mine safety and coal extraction.

Room and pillar mining

A method of underground mining in which approximately half of the coal is left in place to support the roof of the active mining area. Large 'pillars' are left while 'rooms' of coal are extracted.

Round

Planned pattern of drill holes fired in sequence in tunneling, shaft sinking, or stopping. First the cut holes are fired, followed by relief, lifter, and rib holes.

Royalty

The payment of a certain stipulated sum on the mineral produced. It is a form of rent paid to the State for use of a natural resource.

Run-of-mine

Raw material as it exists in the mine; average grade or quality.

Rubble deposit

Any natural deposit of rock fragments accumulated at or near the surface of the ground.

S

Sampling

Cutting a representative part of an ore (or coal) deposit, which should represent its average value.

Shaft

A primary vertical or non-vertical opening through mine strata used for ventilation, drainage, and/or for hoisting of personnel or materials; connects the surface with underground workings.

Shaft mine

An underground mine in which the main entry or access is by means of a vertical shaft.

Shift

The number of hours or the part of any day worked.

Sinking

The process by which a shaft is driven.

Specific gravity

The weight of a substance compared with the weight of an equal volume of pure water at four degrees Celsius.

Special grant

1. A special grant issued under Part XIX

2. A special grant which was acquired before the 1st November, 1961, under any law relating to mines and minerals and which was held immediately before that date.
3. Any mining right or any right in connection with mining which was acquired before the 1st September, 1935, and was registered in terms of section 86 of the Mines and Minerals Ordinance, 1903, and which was held immediately before the 1st November, 1961.

Strike

1. A horizontal line drawn at right angles to the dip of a reef.
2. The direction of the line of intersection of a bed or vein with the horizontal plane. The strike of a bed is the direction of a straight line that connects two points of equal elevation on the bed.

Stripping ratio

The unit amount of overburden that must be removed to gain access to a similar unit amount of coal or mineral material.

Solid waste

Discarded materials other than fluids and gases. It includes municipal garbage, agricultural refuse, demolition and industrial waste as well as mining residues.

Subsidence

The gradual sinking, or sometimes abrupt collapse, of the rock and soil layers into an underground mine. Structures and surface features above the subsidence area can be affected.

Sump

The bottom of a shaft, or any other place in a mine, that is used as a collecting point for drainage water.

Support

The all-important function of keeping the mine workings open. As a verb, it refers to this function; as a noun it refers to all the equipment and materials

(e.g., timber, roof bolts, concrete, steel) that are used to carry out this function.

Surface mine

A mine in which the coal lies near the surface and can be extracted by removing the covering layers of rock and soil.

T

Timbering

The setting of timber supports in mine workings or shafts for protection against falls from roof, face, or rib.

Timber set

A timber frame to support the roof, sides, and sometimes the floor of mine roadways or shafts.

Tunnel

A horizontal, or near-horizontal, underground passage, entry, or haulage way, that is open to the surface at both ends. A tunnel (as opposed to an adit) must pass completely through a hill or mountain.

U

Underground mine

Also known as a 'deep' mine. Usually located several hundred feet below the Earth's surface, an underground mine's coal is removed mechanically and transferred by shuttle car or conveyor to the surface.

V

Valuation

The act or process of valuing or of estimating the value or worth; appraisal.

Ventilation

The provision of a directed flow of fresh and return air along all underground roadways, traveling roads, workings, and service parts.

W

Waste

The rock or mineral that must be removed from a mine to keep the mining scheme practical, but which has no value.

Winze

Secondary or tertiary vertical or near-vertical opening sunk from a point inside a mine for the purpose of connecting with a lower level or exploring the ground for a limited depth below a level.

Wire rope

A steel wire rope used for winding in shafts and underground haulages. Wire ropes are made from medium carbon steels. Various constructions of wire rope are designated by the number of strands in the rope and the number of wires in each strand. Common types include: airplane strand, cable-laid rope, cane rope, elevator rope, extra-flexible hoisting rope, flat rope, flattened-strand rope, guy rope, guy strand, hand rope, haulage rope, hawser, hoisting rope, lang lay rope, lay, left lay rope, left twist, non-spinning rope, regular lay, reverse-laid rope, rheostat rope, right lay, right twist, running rope, special flexible hoisting rope, standing rope, towing hawser, transmission rope.

Working face

Any place in a mine where material is extracted during a mining cycle.

Workings

The entire system of openings in a mine for the purpose of exploitation.

Units of Measure

Acre
A measure of surface area, usually of land. It is equivalent to 4,047 m2.

Block
A piece of mineral bearing land consisting of 10 claims. A block also measures 200m by 500m.

Claim
A piece of mineral bearing land measuring 1 hectare

Decibel
A measure of sound intensity

Tonne
A measure of weight which is equivalent to 1,000 kilograms. Also referred to as a metric ton in the Unites States of America.

Parts per million
A unit used to measure the concentration of a substance commonly in soil or a liquid. It is otherwise expressed as mg/L

Hectare
A unit of area equal to 10 000 square meters.

Ounce
A unit of weight approximately equal to 28 grams. A troy ounce is equivalent to 31.1grams. Troy weight is a system of units of mass customarily used for precious metals and gemstones.

Parts per million
A unit used to measure the concentration of a substance commonly in soil or a liquid. It is otherwise expressed as milligrams per litre.

Tonne
A measure of weight which is equivalent to 1,000 kilograms. Also referred to as a metric ton in the U.S.

Annex A: Summary of Relevant National & International Legislation

Contents

Overview

This annex contains summaries of ASM-related provisions of key legislation. More than six ministries directly interact with and govern the ASM sub-sector through various Acts and statutory instruments (SIs) listed below. However, the primary legislation governing ASM is the Mines and Minerals Act (MMA), with other legal documents supporting its enforcement. The table below summarises where to find information on specific issues.

Table 20: Mining related legislation

Issue	Legislation
Child labour	Children's Act Constitution of Zimbabwe Labour Act, Chapter 28:01 United Nations Convention on the Rights of the Child African Charter on the Rights and Welfare of the Child ILO Minimum Age Convention (No. 138) ILO Convention on the Worst Forms of Child Labour (No. 182) ILO Worst Forms of Child Labour Recommendation (No. 190)
Environmental protection	Environmental Health Practitioners (Professional Conduct) Regulations, SI 142/98 Environmental Management Act, Chapter 20:27 Forest Act Hazardous Substance and Articles (Waste Management) Regulations, SI 37/00
Fees, levies, and taxes	Manpower Planning and Development Act, Chapter 28:02 Mines and Minerals Act Rural District Councils Act Urban Councils Act Zimbabwe National Water Authority (Water Levy 2000), SI 2000

Issue	Legislation
Health and safety	Environmental Health Practitioners (Professional Conduct) Regulations, SI 142/98 Environmental Management Act, Chapter 20:27 Explosives Act Explosives Regulations, SI 72/89 Factories and Works Act Harmful Liquids Act Hazardous Substances, Pesticides, and Toxic Substances Regulations, SI 12/07 Hazardous Substance and Articles (Waste Management) Regulations, SI 37/00 Health and Sanitation Regulations Labour Relations (HIV and AIDS) Regulations, 1998 Labour Relations (Retrenchment) Regulations, SI 404/90 (amended by SI 252/92) Mines and Minerals Act Mining (Health and Sanitation) Regulations, 1977 Mining (Management and Safety) Regulations, 1990 National AIDS Council of Zimbabwe Act National Social Security Authority (Accident Prevention and Workers' Compensation) Scheme, SI 68/90 Pneumoconiosis Act, Chapter 15:08 Public Health Act
Labour rights	Constitution of Zimbabwe Labour Act, Chapter 28:01 Labour (National Employment Code of Conduct) Regulations, SI 15/06 Labour Relations (HIV and AIDS) Regulations, 1998 National Social Security Authority Act, Chapter 17:04 National Social Security Authority (Accident Prevention and Workers' Compensation) Scheme, SI 68/90

Issue	Legislation
Markets	Gold Trade Act Trade Measures Act, Chapter 14:23
Mining rights	Forest Act Mines and Minerals Act Regional, Town, and Country Planning Act Rural District Councils Act Urban Councils Act Water Act, Chapter 20:24
Permits and licences	Base Minerals Export Control Act Forest Act Gold Trade Act Hazardous Substances, Pesticides, and Toxic Substances Regulations, SI 12/07 Mines and Minerals Act Regional, Town, and Country Planning Act Water Act, Chapter 20:24 Wildlife Act
Women's rights	Constitution of Zimbabwe Labour Act, Chapter 28:01

National legislation

Base Minerals Export Control Act

Chapter 21:06 regulates the export of base minerals from Zimbabwe. Section 4 provides for the conditions of permits to export base minerals.

Children's Act

Chapter 5:06 Section 7 criminalises the ill-treatment, neglect, abandonment, or exposure and procurement of a child to be assaulted, ill-treated, or neglected. The Act further criminalises the abandonment and exposure in a manner likely to cause the child unnecessary suffering or injury or detrimentally affects their health, morals, or any part or function of their mind or body.

Constitution of Zimbabwe

The Constitution is the supreme law of the land and includes numerous provisions that are relevant to ASM. For example, in Chapter 4, which covers fundamental human rights and freedoms:

Section 56 addresses **equality and non-discrimination**. These provisions apply to how individuals should be treated in all sectors, including ASM. The Constitution states that:

> Women and men have the right to equal treatment, including the right to equal opportunities in political, economic, cultural and social spheres.
>
> Every person has the right not to be treated in an unfairly discriminatory manner on such grounds as their nationality, race, colour, tribe, place of birth, ethnic or social origin, language, class, religious belief, political affiliation, opinion, custom, culture, sex, gender, marital status, age, pregnancy, disability or economic or social status, or whether they were born in or out of wedlock.

Section 65 covers **labour rights**. These also apply to all sectors, including ASM. The Constitution affirms that all people have the right to fair and safe labour practices; to just, equitable and satisfactory conditions of work; and to be paid a fair and reasonable wage. It also states that women and men have a right to equal remuneration for similar work. Except for members of the security service, employees also have the right to form, join and participate in the activities of trade unions and employee organisations and to participate in collective bargaining and collective job action. This means that it is legal to strike, sit in, withdraw labour, and take other similar concerted action; however, the exercise of this right can be restricted in order to maintain essential services. This section also includes a provision on maternity leave, defining women's right to fully paid maternity leave for a period of at least three months.

Section 81 outlines the **rights of children** (defined as every boy and girl under the age of 18 years), which are particularly relevant to the mining sector in relation to child labour. The Constitution states that every child has the right to be protected from economic and sexual exploitation, from child labour, and from maltreatment, neglect, or any form of abuse.

Environmental Health Practitioners (Professional Conduct) Regulations, SI 142/98

Environmental health practitioners (e.g., environmental health technicians or officers) conduct inspections of mines and other institutions to ensure that they are maintaining standards of hygiene are maintained and complying with public health regulations. They also undertake water quality monitoring. Miners should therefore be aware of what the law says about the conduct of these service providers.

For example, Section 4 states that environmental health practitioners are required to act with professional competence, diligence, and honesty, and refrain from allowing their professional judgment to be influenced or compromised by any political, commercial, or economic interests, or by any other improper pressure. They must respond promptly and efficiently to the needs and requests of the community they serve, and the course of action they recommend must be the most appropriate in dealing with the prevailing environment health problem. Section 10 states that environmental health practitioners are not allowed to perform any environmental health procedure or other professional act for which they are inadequately trained or insufficiently experienced, except in an emergency.

There are also rules about issues such as:

- **Information sharing:** Section 6 prohibits them from sharing any information, either verbally or in writing, about people they deal with during their work if that information is given to them in confidence. If another law requires them to reveal the information, they must follow that law but cannot share the information beyond fulfilling their legal requirements.
- **Advertising**: Section 7 allows an environmental health practitioner engaged in private practice (either self-employed or employed by another person) to advertise his or her name, address, telephone number, qualifications, available hours, and services offered. However, any advertising must be 'dignified' and 'restrained', and environmental health practitioners are not allowed to use their names or photographs in the context of their profession for any commercial advertisement.
- **Partnership**: Under Section 8, environmental health practitioners engaged in private practice are not allowed to practise their profession

in partnership or assist or act on matters pertaining to environmental health in collusion with an unregistered person.

- **Obstruction and compliance:** Section 9 states that environmental health practitioners or any employees acting on their behalf are not allowed to prevent, hinder, or obstruct the local Rural District Council from carrying out its duties. They also must comply with any summons, notice order, or direction issued by the council, the executive committee or the disciplinary committee in terms of the regulations.

Environmental Management Act, Chapter 20:27

This Act provides a framework for control of environmental issues, preventing pollution and environmental degradation, securing ecologically sustainable management, and the use of natural resources. Mining is a prescribed activity according to Sections 2 and 97, which means that mining activities require an environmental impact assessment (EIA) to be conducted by environmental consultants. The Act also lays out the required fees for EIAs. Miners must prepare an EIA report to be approved by the Environmental Management Agency (EMA). The EIA report is used to identify and evaluate the environmental impacts of mining operations when carrying out bi-annual environmental audits. Quarterly environmental audits must be submitted to EMA in accordance with section 106. Environmental rehabilitation, also called an environmental management plan, is also legal requirement of the Act.

Explosives Act

This Act further regulates and controls the possession, purchase, acquisition, delivery, manufacture, storage, use, conveyance and handling of explosives. Explosives should only be supplied by a manufacturer who holds a license, and should only be supplied to an individual or organisation with an explosives permit. This individual or organisation must properly transport, store, and use explosives. For example, ex[plosives should be stored a magazine that has been certified as suitable by an inspector from Ministry of Mines and Mining Development.

Explosives Regulations, SI 72/89

These regulations cover the use, storage, possession, sale, transport, and manufacture of explosives. These regulations prohibit any person from storing or carrying (or allowing another person to store or carry) explosives without a blasting license. They also stipulate that explosives should only be carried from a storage place to a working place in their unopened box of origin, in stout canvas sacks or in other containers approved by an inspector. If the boxes are open, they must be carried under the direct supervision of a holder of a blasting licence.

Factories and Works Act

This Act covers the registration and control of factories, the regulation of conditions of work in factories, supervision of the use of machinery, precautions against accident to persons employed in structural work, and related matters. This Act, as well as the National Social Security Authority (NSSA) Act and the Labour Act, also has provisions around handling workplace accidents in Sections 13 to 15. This includes rules related to:

- **Accident registers:** An accident register must be kept at every workplace, machinery or factory with a record of the particulars of any accidents (e.g., description of accident, where it took place, the names and number of injured or killed workers, nature and magnitude of their injuries, the name of the occupier/building and business address). The accident register must be kept for at least three years after the accident and inspected by an Inspector within those three years.
- **Accident reporting:** As per the NSSA Act, if an accident occurs in a factory or structural work premises or results from machinery and there is death or injury of a worker, it must be reported as soon as possible to an Inspector. The Inspector should be notified in writing of the name of the injured worker(s) and the nature and magnitude of the accident. A medical practitioner should also make a report as soon as possible if he or she suspects that any individual involved in the accident is suffering from poisoning from lead, phosphorous, arsenic, mercury, or anthrax.
- **Inspector's inquiries:** An Inspector can commission an inquiry into accidents or occurrences where a person has been killed or injured as a result of the accident or the Inspector believes that the accident might have led to the death or injury of a worker. During the inquiry, witnesses may be called upon to testify. Evidence must be in writing and accompany the Inspector's report to the Minister. The Inspector also must send copies of both the report and evidence of the Attorney-General's Office if death or injury of a worker was a result of breaking the law.
- **Notifying the employer:** If a workplace accident results in disability or death of a worker, the employer must be notified in writing by the worker, or in the case of the death of a worker, his dependents. This notice is also regarded as a claim for compensation.

The authorities involved in workplace accidents include the Inspector and Chief Inspector of Factories, registered medical practitioners; the National Social Security Authority; the Minister of Public Service, Labour, and Social Welfare; and the Attorney General's Office.

Forest Act

This Act covers the administration, control and management of State forests; the protection of private forests, trees and forest produce; the conservation

of timber resources; trade in forest produce; and regulation and control of burning of vegetation. Part V (Sections 43 to 53) deals with mining timber rights. It establishes the Mining Timber Permit Board and controls the cutting and taking of timber for mining purposes. Section 45 states that no miner may cut down trees without a permit from the Mining Timber Permit Board, and Sections 49 and 50 outline application procedures and consideration of applications for mining timber rights by the Board, respectively.

Gold Trade Act

The possession of gold is controlled by the Gold Trade Act (Chapter 21:03). Part II (Sections 3 to 12) outlines some of the key requirements and prohibitions related to gold possession and trade. For example:

- Section 3 states that it is illegal to deal in or possess gold, either as a principal or as an agent for someone else, without having a licence or permit; being a holder or tributor; or having an authority, grant, or permit issued under the MMA that authorises working an alluvial gold deposit. An employee or agent of someone who meets these conditions who has been authorised by that person can deal in or possess gold that is legally in the possession of his or her employer.
- Section 4 permits dealing and possession of gold between a miner and person authorised to deal in gold. It is illegal for a miner to deal with someone who is not authorised (i.e., does not meet the conditions under Section 3).
- Section 5 stipulates that a miner or tributor can only possess gold won by him or her (or his or her employee) from a location upon which he or she has mining rights.
- Section 8 requires all holders of licences to keep a register of all gold that is deposited with them or that they received, dispatch, or dispose.
- Section 12 prohibits smelting or changing the form of any manufactured article containing gold without permission from the Minister.

Part III (Sections 13 to 22) goes into greater detail on licences and permits. It begins by outlining the different licences that are issued to gold dealers. These include:

- Gold dealing licences
- Gold recovery works licences
- Gold assaying licences

Section 19 provides the legal basis for fees associated with these licences, while Sections 21 and 22 explain the conditions under which a permit may be cancelled or revoked, respectively.

The Gold Trade Act is enforced by the Criminal Investigation and Border Control Department under the Zimbabwe Republic Police (ZRP). This unit is regulated by the Mines and Minerals (Minerals Unit) Regulations SI 82 of 2008. In conjunction with the Mines Inspector, it carries out random inspections on mines and milling centres to check compliance with the Act.

Harmful Liquids Act

This Act stipulates the requirements (and penalties for contravention) for the manufacture, supply, possession, and storage of harmful liquids.

Hazardous Substances, Pesticides, and Toxic Substances Regulations, SI 12/07

These regulations state the rules for manufacturing, using, importing, selling, storing, or transporting hazardous substances, such as mercury and cyanide. This includes, for example, the types of containers that may be used, how they must be labelled, the use of protective clothing and availability of first aid when handling them, other safety precautions that must be taken, and licences that are required.

The regulations contain three schedules:

- The first schedule lists the fees associated with hazardous substance licences. This has been updated through SI 5/11 with effect from the January 2011.
- The second schedule includes the application for a hazardous substance licence.
- The third schedule identifies the substances to which the regulations apply.

Hazardous Substance and Articles (Waste Management) Regulations, SI 37/00

These regulations contain key definitions and rules for waste management of hazardous substances. Waste is defined as any material, whether solid, liquid, or gaseous, which is:

- To be discarded, discharged, or emitted in any form or means of control, treatment, reduction, or compositional change.
- No longer to be used for its original purpose and likely to be stored or accumulated with the eventual intention of treating, disposing of, discharging, or emitting it.
- Sent off-site for refuse, recycling, regeneration, isolation, or treatment/ disposal or from which material generated from such a process will be

extracted (other than biodegradable material or solid, semi-solid, liquid manure resulting from operations on farming or forest enterprises that are brought to an approved use in such an environment).

A landfill is defined as a site that is built/used for the long-term dumping of waste. Problematic substances/articles refer to construction wastes, scrap metal, and derelict vehicles which are not hazardous but damage the environment.

Hazardous waste is defined as any waste that directly or indirectly represents a threat to human health or to the air because it may cause one or more of the following:

- Accumulation of non-biological elements such as pollutants in the food chains
- Persistence of non-biodegradable components in the air
- Acute/chronic toxicity
- Cancer, mutations, tumours, or birth defects
- Chemical instability, reactions, or corrosion
- Explosion/fire
- Infections, pathogens, parasites, or their vectors
- Toxicity or damage to the ecosystem/natural resources

The regulations also prohibit sewage from being be stored in a setting which is either open to the air or from which aqueous leachate could emanate.

Waste management includes the prevention and reduction of hazardous wastes and the collection, storage, treatment, recycling, transport, and other disposal of hazardous wastes, including the after-care of disposal sites. Every generator of hazardous waste is required to prepare a waste management plan annually (before 31 December). This plan must consist of an inventory specifying the quantity of hazardous waste produced and the components of such hazardous waste. It must set specific goals for:

- Adopting clean production methods
- Reducing the quantities and pollution discharge of hazardous wastes
- Recycling waste wherever practicable in a safe form and manner
- Safe disposal of waste that can neither be prevented nor recycled
- Adopting environmentally-sound practices for the management of hazardous wastes

Every local authority must also prepare a waste management plan annually.

In preparing this plan, the local authority may request in writing that the generators of hazardous waste within its jurisdiction submit to it their own waste management plans.

Health and Sanitation Regulations

These regulations provide for sanitary conditions and drainage, disposal of refuse, provision of latrines, medical examination, care and treatment of employees.

Labour Act, Chapter 28:01

This Act contains general provisions supporting fair labour practices. It is the principal legislation for incorporating international agreements on labour rights, and its preamble gives effect to the ILO Conventions. The purpose of the Act (as stated in Section 2A) is to advance social justice and democracy in the workplace by giving effect to the fundamental rights of employees provided for under Part II; provide a legal framework within which employees and employers can bargain collectively for the improvement of conditions of employment; promote fair labour standards; promote the participation by employees in decisions affecting their interests in the work place; and secure the just, effective and expeditious resolution of disputes and unfair labour practices.

Some of the key provisions include:

- **Union membership:** Workers have a right to form and join a Trade Union and Workers' Committees in terms of Section 4.
- **Forced labour:** Section 4A (1) prohibits forced labour. Forced labour does not include any labour required as a sentence or order of a court, or labour required of a person while he or she is lawfully detained.
- **Non-discrimination:** Section 5 protects employees or prospective employees against discrimination on grounds of race, tribe, place of origin, political opinion, colour, creed, gender, pregnancy, HIV and AIDS status, or disability. This applies to advertisement and recruitment for employment; creation, classification or abolition of jobs or posts; determination or allocation of wages, salaries, pensions, accommodation, leave or other benefits; or the selection of candidates for jobs or posts, training, advancement, apprenticeships, transfer, promotion or retrenchment; or the provision of facilities related to employment. This section also requires employers to pay equal remuneration to male and female employees for work of equal value.
- **Fair labour standards:** Section 6 protects the employees' right to fair labour standards. It prohibits employers from paying wages that are lower than fair labour standards, requiring employees to work more than the maximum hours permitted by law, failing to provide adequate

conditions of employment, or requiring employees too work in conditions that do not meet minimum health and safety requirements. It also states that employers are not allowed to hinder, obstruct, prevent, or penalise employers for seeking access to any legally advance or protect their rights or interests as an employee.

- **Employment of young persons:** As amended by the Labour Amendment Act, Section 11 sets the minimum age for work and apprenticeship at 16 years in most cases, but 18 years for work any work which is 'likely to jeopardise that person's health, safety, or morals'. A contract for work or apprenticeship with a young person who is 16 or 17 years of age requires the assistance of the apprentice's guardian, otherwise the contract is invalid.

The Act further outlines the penalties for not following these provisions. For example, discriminating against an employee or prospective employee carries a penalty of a fine (not exceeding level eight), imprisonment for up to two years, or both a fine and imprisonment. Likewise, failure to protect employees' rights to fair labour standards is punishable by a fine (not exceeding level seven), imprisonment for up to two years, or both a fine and imprisonment.

The Act also outlines the requirements and steps of key labour-related processes, such as maternity leave applications as described below. Note that some provisions of the Labour Act are further elaborated in related regulations, such as the:

- Labour (National Employment Code of Conduct) Regulations, SI 15/06
- Labour Relations (HIV and AIDS) Regulations, 1998
- Labour Relations (Retrenchment) Regulations, SI 404/90 as amended by SI 252/92

Maternity leave applications

Section 18 of the Labour Act explains the procedure for a female employee to apply for maternity leave. She must submit a certified maternity leave application form 45 days before her expected delivery day. A registered medical practitioner or State Registered Nurse has to certify the expected delivery day.

If she forfeits leave/vacation days accumulated in the last six months before taking maternity leave, she is entitled to 75% of her normal pay in addition to receiving her normal benefits paid by the employer. If she is not entitled to any leave or vacation days or if she does not forfeit her leave/vacation days, she is paid 60% of her normal pay and benefits.

In the event that a female employee who has benefited from the above fails to return to work (for any reason other than death or dismissal by the employer),

she must repay the employer for all wages and benefits related to the leave.

The Act stipulates several restrictions, limitations, and rights related to maternity leave. For example:

- A female employee cannot take maternity leave more than once in a 24-month period.
- In total, an employee cannot take more than three years of cumulative maternity leave with any one employee.
- Maternity leave can be 90 days, inclusive of the 45 days before and after the birth of the child. If the child is born after 45 days (as documented in the birth certificate), the maternity leave is extended (though unpaid) by the number of days between the expiry of the 45 days and the date of birth.
- If a nursing mother needs time to recover as a result of childbirth-related complications (and there is a medical certificate to that effect), the maternity leave is extended without pay to include that time.
- Maternity leave must be taken at least 14 days before the expected day of delivery.
- Normal benefits and entitlements, including rights to promotion, advancement, or pension period service, cannot be affected by the employee having exercised her right to maternity leave.
- A nursing mother should be granted at least one hour or two half-hour periods during each working day (during normal working hours) for the purposes of nursing her baby. She may also combine this segment with other normal break times in order to lengthen her nursing period, provided this does not interfere with the efficiency of the company. A nursing mother is entitled to these nursing periods for six months.

If any of these regulations are contravened, it constitutes an unfair labour practice.

Labour (National Employment Code of Conduct) Regulations, SI 15/06

Employment codes of conduct

Alongside Section 101 of the Labour Act, these regulations cover employment codes of conduct, which should include the following.

- Disciplinary rules and specific definitions of misconduct.
- Procedures to be followed if the code is breached.
- Penalties for any breach of the employment code (e.g., oral or written

warnings, fines, reductions in pay for a specified period, suspension with or without pay or on reduced pay, demotion and dismissal from employment).

- Who (person, committee, or authority) is responsible for implementing and enforcing the rules, procedures, and penalties.
- Requirements for notifying any person who is suspected of breaking the code that proceedings will be started, in writing and at least 30 days prior to the proceedings.
- Statement of the rights of a person suspected of breaking the code to be heard by the appropriate person, committee or authority before any decision in his or her case is made.
- Provisions for a written record or summary to be made of any proceedings or decisions in such cases to be made at the time they occur.

Codes of conduct can be registered by an employment council or works council through an application to the Registrar. This code of conduct then binds the related industry or workplace. Even if an employment council has applied to register a code of conduct, a works council can still apply; however, it must first refer the employment code to the employment council for its approval. If both register codes of conduct, the one registered on behalf of the employment council prevails and is binding, unless the employment council gives approval. To amend an existing code of conduct, either the works council or employment council that registered the code can apply to the Registrar to have it amended.

If there are no proceedings within the 30-day notice period, the employer concerned may refer the matter to a Labour Relations Officer for determination, provided that the proceedings/matter are not related to a breach of a code of conduct.

Any person who is not satisfied with the determination related to a breach of a Code or the conduct of any appeal against this determination or conduct to the Tribunal.

The Tribunal may confirm the decision or proceedings which have been appealed against, or

Send it back to the person, Committee or authority responsible for implementing and enforcing rules procedures and penalties of the Code or vary the decision or proceedings which have been appealed against.

Workplace disciplinary hearings

Alongside Section 17 of the Labour Act and the Labour Relations (General Conditions of Employment) (Termination of Employment) Regulations, these

regulations outline the disciplinary hearing process. The process includes:

1. Establishing jurisdiction.
2. Investigating the alleged misconduct, offence, or breach of the code of conduct.
3. Appointing a person, committee, or authority as the Disciplinary Officer, Committee, or Authority, respectively.
4. Charging the alleged offender.
5. Notifying the alleged offender of his or her right to be heard during the hearing. The alleged offender can issue a statement in relation to the alleged offence or he/she can elect not to give a statement. The alleged offender may bring in witnesses.
6. Preparing for and conducting a hearing. The final determination should be made within 14 days from the commencement of the hearing.
7. Making a determination, such as imposing penalties or fines, giving verbal or written warnings, reducing wages for a specified period, demoting or suspending the offender with or without pay, and dismissing the offender from work. When an employee is dismissed, the Disciplinary Officer or Committee must notify the employee of the reasons for dismissal and when the contract of employment terminates.
8. Handling appeal procedures.
9. Keeping a written record of the summary of proceedings and determination for at least 12 months.

Warnings: The chairman or representative of the Workers' Committee must witness both verbal and written warnings being given to an alleged offender. A verbal warning is valid for 90 days, a written warning is valid for 180 days, and a last written warning is valid for one year (365 days).

Suspension without pay: An employer can suspend an employee without pay and other benefits if the employer has reasonable grounds to believe that the employee is guilty of any of the following offences:

- Any commission, omission, or conduct that is in breach of the terms and conditions of the employment contract
- Intentional refusal to obey employer's lawful instructions
- Wanton destruction of employer's property
- Theft or fraud
- Inability to perform his or her duties due to intoxication
- Absence without justified leave for a period of five or more days

- Persistent failure to perform his or her duties
- Inability to perform his or her work efficiently and effectively
- Express or implied fraudulent misrepresentation of his or her skills

An employer who suspends an employee should apply immediately to a Labour Relations Officer for an order or determination on terminating the employment contract. If the Labour Relations Officer is satisfied with the grounds for the employee's suspension, he or she makes a determination (e.g., fines, demotion) or terminates the employment contract. If the Labour Relations Officer is not satisfied with the grounds for the employee's suspension, he or she can reinstate the alleged offender, and may order a repayment of wages or salaries back-dated from the time of suspension. The employee may also be compensated for loss of benefits incurred during the suspension.

Alternative penalties: Alternative penalties may include:

- Demotion and/or reduced salary and wages if the appropriate penalty in respect of an act of misconduct is dismissal.
- Suspension without pay or reduced pay for maximum of five working days if the appropriate penalty is a last written warning or dismissal.
- Reduction in pay (up to a maximum of 5%) for maximum of three months if the appropriate penalty is dismissal.

Appeals: An employee can appeal to the Disciplinary Committee against the decision of the Disciplinary Officer within three working days of having been notified of the decision. The Disciplinary Committee must consider the appeal within four working days of receiving it. An employee then has a right to appeal the Disciplinary Committee's decision in writing to the Works Council[62] within five working days of being notified of the decision. It must be considered within 10 working days of having been received. Finally, if the employee wants to appeal the decision of the Works Council or Committee, this must be done in writing to the Council's General Committee within five working days. Subject to any law which allows an aggrieved party to appeal to the Labour Tribunal, the General Committee's decision is final.

Labour Relations (HIV and AIDS) Regulations, 1998

These regulations cover:

- **Education of employees on HIV and AIDS:** Every employer is obligated to provide education and information about HIV transmission and prevention, as well as safe sex and risk reduction measures in relation

[62] The Workers Council consists of a maximum of four members. If it exceeds four, which is approved by the Council to consider appeals. Where there is no Works Council or composition of the Council is the same as that of the Disciplinary Committee, an appeal can be made directly to the Council's General Committee.

to sexually transmitted infections. Education and information must be provided by persons who have proven sound knowledge and expertise in matters relating to HIV and AIDS who are able to communicate information with consistency and accuracy. Employers must also offer counselling facilities for HIV and AIDS patients.

- **Medical testing and confidentiality:** Employers are not allowed to directly or indirectly require any person to undergo any form of HIV testing as a precondition to an offer of employment, nor can they directly or indirectly any employee to undergo HIV testing. Employers also cannot require any employee to disclose his or her HIV status, and cannot disclose any information relating to the HIV status of any employee acquired by that person in the course of his or her duties, except with the written consent of the employee to whom the information relates or if the information is required to be disclosed in terms of any other law.
- **Job status and training:** Employers are prohibited from terminating the employment of any employee on the grounds of that employee's HIV status alone, and from discriminating on the grounds of his HIV status alone when determining promotions, transfers, any training or other employee development programme, or job status.
- **Employee benefits:** The HIV status of an employee shall not affect his or her eligibility for any occupational or other benefit schemes provided for employees. If the eligibility of a person for any occupational or other benefit scheme is conditional upon an HIV test, the conditions attaching to HIV and AIDS shall be the same as those applicable to comparable life-threatening illnesses. Where any HIV testing is necessary, the employer must ensure that the employee undergoes appropriate pre- and post-HIV test counselling. No inferences concerning the HIV status of the employee may be drawn from such exercise by the employee of the option not to undergo the testing. Any employee suffering from HIV or AIDS is subject to the same conditions relating to sick leave as those applicable to any other employee.
- **Protection:** In cases where a person who is employed in an occupation or is required to provide services where there may be a risk of transmitting or acquiring HIV, the employer shall provide appropriate training together with clear and accurate information and guidelines on minimising the hazards of the spread of HIV and related communicable diseases to employees and members of the public. Additionally, personal protective devices should be issued free of charge in these cases, and the employer must review for safety and efficacy the use of any equipment, devices, and procedures, including first aid procedures.

All employers are also required to provide every employee with a copy of these regulations, and any person who contravenes any provision of these regulations shall be guilty of an offence and liable to imprisonment of up to six months or both a fine and such imprisonment.

Labour Relations (Retrenchment) Regulations, SI 404/90 as amended by SI 252/92

Short working time

These regulations, as well as Section 17 of the Labour Act, cover processes related to short working time. Before an employer notifies employees of intended retrenchments in terms of Section 3 of SI 404 of 1990, he or she must secure an agreement with employees or with the Workers Committee or Council to examine one of the following measures for a period of up to 12 months:

- Provision of short-time work for the employees
- Introduction of shift work
- Reduction or postponement of employees' wages
- Transfer of employees between departments, plants, enterprises and related companies
- Introduction of job shared and reduced working hours
- Introduction of rotational unpaid leave

This agreement is not affected by any employment regulations, collective bargaining agreement, or contracts. An employee placed on short-time work should be paid per every hour worked (equivalent to his or her weekly or monthly wage), but should not receive less than half of his or her present monthly/weekly wages.

This may require the employer to divide some or all of the employees into shifts. Shift work employees should alternate half days, weeks, or months provided that these employees shall work for more than one month at a time, or for total of six months in any period of 12 months. The pay should be for shift hours, weeks, and months actually worked.

Where an employer reduces or postpones payment of employees, the pay should not be reduced by more than half of the hourly, weekly, or monthly wages/salaries. No more than half of the hourly, weekly, or monthly wage/salary of these employees should be postponed or delayed.

Before an employer implements these special measures, he or she is required to give written notice to the retrenchment committee, stating the reasons for and providing evidence on the importance of these measures as well as how these will avoid retrenchment of employees. Every employee affected measure must also be given seven days' written notice.

If the retrenchment committee is not satisfied with the measures or is not convinced that they will avoid retrenchment, the committee should notify the employer in writing within 30 days. If this occurs, the employer is prohibited from introducing such measures or must suspend their implementation if they have already been introduced. The committee may also ask the employer to provide further reasons and evidence to justify the necessity of implementing the measures in avoiding retrenchment of employees. If the employer fails to provide further reasons or evidence, the committee may, in writing, prohibit the employer from implementing these measures.

If an employee is not working full-time as a result of the implementation of any of the above measures, the time he or she spends idle should be considered as paid leave, because the employee is entitled to paid leave in terms of his or her normal conditions of employment and unpaid compulsory leave if it exceeds the period of paid leave.

Employee retrenchment

These regulations, along with Section 17 of the Labour Act, outline the procedures for retrenching employees. They include:

1. The presence of a Workers Council/Employment Council constitutes an 'Authority' for the for the purposes of the retrenchment procedures. In the absence of an Authority, the employer must notify the Retrenchment Committee[63] of his or her intention to retrench the employee(s).
2. The employer provides the Authority the details of the employee(s) on the retrenchment list and reasons for their proposed retrenchment.
3. The Authority should immediately meet the employer and employees concerned to secure an agreement on whether the employees should be retrenched and if the retrenchment is being implemented in terms and conditions of the regulations. A record of the proceedings between employers and employees or their representatives must be properly kept.
4. If the Authority secures an agreement within one month of receiving notice of an intended retrenchment, the employer should receive written approval (Form LRR1) of retrenchment of the employees according to the agreement. A copy of the approval is also sent to the Retrenchment Committee, and then up to the Minister.
5. If the Authority fails to secure an agreement, it must send a written notice on the matter to the Retrenchment Committee (Form LRR2). This form

[63] Or any person authorised by the Retrenchment Committee or the Minister of Public Service, Labour, and Social Welfare to perform the duties of an Authority.

must be accompanied by copies of all documents that the employer and employees concerned have submitted to the Authority and by copies of the minutes of the Authority's proceedings and deliberations.

Within two weeks, the Minister must either approve or refuse the proposed retrenchment. If the retrenchment is refused, the Minister must notify the Retrenchment Committee, the Authority and the employees concerned of his or her decision in writing (Form LRR3). The Authority, the Retrenchment Council, and the Minister must consider that the retrenchment of employees should be avoided as much as possible without affecting the efficient operation of the business. They should consider the reasons for the proposed retrenchment and its effect on the employees, including their prospects of finding other employment, and the terminal benefits to which they are entitled.

It is the duty of every employer to ensure that his or her employees are kept informed and are consulted in relation to any major changes in production, programmes, organisation, and technology that are likely to result in the retrenchment of any of his employees.

It is an offence for an employer to retrench any employee unless:

- The concerned employee(s) have been given at least one month's written notice of retrenchment.
- The retrenchment has been approved in terms of these regulations.
- The retrenchment is effected in accordance with the terms and conditions of any such approval.

Any intended retrenchment of an employee not carried out in terms of these regulations and procedures is not legal or valid.

Manpower Planning and Development Act, Chapter 28:02

This Act provides the legal basis for the continued existence of the Zimbabwe Manpower Development Fund (ZIMDEF) and for the imposition of levies to finance manpower development. Miners are required to contribute to the ZIMDEF Fund through annual or quarterly levies.

Mines and Minerals Act

The MMA is the principal piece of legislation governing the minerals industry and forms part of the Mining Code. It overrides all other Acts affecting mining and is therefore the country's most powerful Act around mineral resources management. A wide-ranging piece of legislation, it vests ownership of all minerals in the president and contains regulations for prospecting for claims, working them, maintaining health and safety, and abandonment of claims. Several amendments have served to attract foreign direct investment

by enabling participation in large-scale mining. The Mines and Minerals Amendment Bill, first introduced in 2015 but not yet passed into law, would ammend the MMA, which was enacted in 1961.

Mining (Health and Sanitation) Regulations, 1977

These regulations are administered by Ministry of Health and Child Care and include provisions for adequate hygiene and sanitation facilities in and around mines. However, these facilities are non-existent in ASM and research has shown that no small-scale miner has been penalised for failure to provide them to his or her employees.

Mining (Management and Safety) Regulations, 1990

These regulations control the health and safety in and around mining operations. They cover topics such as management and responsibility in mines, surface protection, protection in working places, ventilation, gases and dust, and examinations in several certificates of competency. They have domesticated some of the ILO Conventions such as Convention No. 45, which prohibits women from working underground. They also require mining companies to provide adequate resources to supply safety clothing and equipment to employees. Research has also shown that small-scale miners do not comply with these regulations.

National AIDS Council of Zimbabwe Act

This Act provides the legal basis for the establishment of the Council, its mandate, and other ancillary matters as required by Guideline 1 of the International Human Rights Guidelines on HIV and AIDS (States should establish an effective national framework for their response to HIV which ensures a coordinated, participatory, transparent and accountable approach, integrating HIV policy and programme responsibilities across all branches of government). Section 32 mandates the establishment of structures known as AIDS Action Committees at all levels down to the village level. There are Provincial, District, Ward, and Village AIDS Action Committees. This provision institutionalises the national response to HIV and AIDS through these local structures. Various stakeholders such as the Ministry of Health, Councillors, Provincial and Rural District Officers, NGOs and civil society participate in these committees

NSSA Act, Chapter 17:04

This Act provides for the establishment of social security schemes to provide benefits to employees. It also provides the legal basis for the National Social Security Authority and the National Social Security Board and outlines their respective functions.

NSSA (Accident Prevention and Workers' Compensation) Scheme, SI 68/90

This statutory instrument regulates the administration and procedures of compensation for workers injured at work and issues to do with the promotion of occupational health and safety. It covers the duties of employers, workers, and other persons in relation to accident prevention, and defines who is considered an employer or a worker, who qualifies for compensation, procedures for obtaining compensation including relevant forms to be completed, and timeframes for submitting them.

Employers are mandated to ensure that occupational health and safety training programmes at the workplace are carried out or that workers be released to attend such training programmes during work times. If workers become aware of any hazards in the workplace, or of any missing or defective equipment or protective device which may endanger themselves or another worker, they must report this to the employer or supervisor or health and safety representative.

Workers are also required to work in compliance with requirements that are prescribed for the protection of health or safety of the worker. This includes:

- Using or wearing the equipment, protective devices, or clothing the employer requires or health or safety reasons.
- Not removing or making ineffective any protective device prescribed or required by the employer without providing an adequate temporary protective device. When the need for removing or making ineffective the protective device has ceased, the protective device shall be replaced immediately.
- Not using or operating any equipment, machine, device, or thing, or otherwise working in a manner that may endanger themselves or any other workers.
- Not taking away from the workplace protective devices or clothing for purposes not linked to the protection of the worker at work.

Pneumoconiosis Act, Chapter 15:08

This Act addresses the control and administration of persons employed in dusty occupations and matters incidental to or concerned with employment in dusty occupations, which includes work in or on a mining location. It prohibits the employment of workers suffering from pneumoconiosis, a category of lung disease that includes silicosis and other conditions caused by dusts that are breathed in and then deposited deep in the lungs, causing damage. A person with pneumoconiosis may not even enter premises where a dusty occupation is carried out without written permission from the Bureau (public office).

Part V of the Act requires the issue of certificates to workers in dusty occupations, and these certificates are mandatory for employment. The Minister

of Health and Child Welfare may prescribe medical examinations that must be undertaken applicants for certificates and standards of fitness with which applicants for certificates must comply. If six months or more have elapsed since a certificate has been issued, further medical examinations may be required. If a medical practitioner believes that a worker who holds a periodical certificate should undergo a prescribed medical examination, the practitioner must certify to that effect to the Bureau. Workers are required to submit to medical examinations if ordered by the Board or the Bureau. Any medical officer or member of the Board or Bureau may enter any place or premises where a dusty occupation is carried out.

The employer must keep a record of and retain the certificate relating to any worker if the worker remains in his or her employ; not doing so constitutes an offence. Anyone who employs a worker in a dusty occupation also needs to keep a register of all employees with the following information for each worker:

- Date of engagement
- Date of discharge
- Nature of the worker's duties
- Wages and allowances paid to the worker
- Date of the last medical examination performed under this Act
- Number and date of expiry of the current certificate

Public Health Act

The Public Health Act establishes requirements related to the prevention and suppression of infectious diseases. To that extent, it mandates notification of a number of infectious or communicable diseases to local authorities, including sexually transmitted infections. While HIV is not a notifiable disease, opportunistic infections such as TB are. TB is the most common opportunistic infection encountered among people with HIV infection in Zimbabwe. Since the advent of the pandemic of HIV infection, TB has remained a serious public health problem.

There are several other things that must be reported to local authorities, including:

- Any case of illness or death suspected to be due to any formidable epidemic disease.
- Any person residing in any hotel, boarding house, or other similar institution known to be suffering from any infectious disease. Failure to give notice attracts criminal liability. The responsible person (owner or manager) is also required to furnish a list of other residents at the request of the medical officer of health.

- Local authorities, in turn, have a number of responsibilities. For example, every local authority may appoint a medical practitioner as the medical officer of health, whose appointment is subject to the approval of the Minister. Local authorities are also required to furnish water, maintain cleanliness and prevent nuisances, and prevent or remedy health dangers to arising from unsuitable dwellings.
- The Act also states that the owner, occupier, or person in charge of any land or premises must ensure that it is clean, safe, and does not cause harm or danger.

Regional, Town, and Country Planning Act

The Act defines mining operations to include quarrying and other surface mineral workings and states that no person can carry out mining on a mining location without a permit issued in terms of the MMA. Part V deals with the control of development to curb the growth of illegal settlements and allow plans of the local authority to be rolled out in phases.

Rural District Councils Act

A mining operation this is situated in a rural area is liable to pay a levy to the Rural District Council. Section 96 (1) (b) stipulates that:

> A council may impose a land development levy upon all persons who, on the fixed date, are or who, at any time during the period of twelve months next following the fixed date, become owners of mining locations situated on rural land within the council area, mining for: Gold, silver, platinum or precious stones and employing more than five workers; or Base minerals as defined in the Mines and Minerals Act [Chapter 21:05] and declaring an output in tonnes in accordance with the provisions of that Act.

Trade Measures Act, Chapter 14:23

Section 4 deals with the authorised units of measurement, such as:

- The metre for measurement of length
- The square metre for measurement of area
- The cubic metre for measurement of volume
- The kilogram for measurement of mass

Urban Councils Act

This Act provides for the establishment of municipalities and towns and their administration by local boards and municipal and town councils. It confers functions and powers and imposes duties on these bodies, including those related to levies paid by miners.

Water Act, Chapter 20:24

This Act covers the use of water for the purposes of mining. Note that miners' and prospectors' rights to water for primary purposes or groundwater are not affected by the Act. According to Section 34, an application for a permit to use water for mining purposes should be directed to the Mining Commissioner of the Mining District. Under Section 46, an application for a permit to conduct operations in public streams should be directed to the water catchment council.

Wildlife Act

Section 119 of the Act requires a permit for prospecting in parks and wildlife estates and states that no person can work on a mine lawfully in a park or wildlife estate without the written permit from the Minister that has been approved by the President of Zimbabwe.

Zimbabwe National Water Authority (Water Levy 2000), SI 2000

Section 3 states that water levies must be paid before the end of each quarter by holders of permits for the use of ground or surface water (issued in terms of the Water Act). The levy benefits the Water Fund. Section 4 explains that the levy should be paid to one of the following, as applicable:

- The catchment council from which the permit holder obtained the permit.
- The sub-catchment council (if established) for the area to which the permit relates.
- An agent or office of the National Water Authority. The Authority must advertise in the newspaper circulating as to the area where such an agent operates.

International instruments

United Nations Convention on the Rights of the Child (CRC)

This is the primary international instrument for safeguarding the rights of children. Article 3 states that in all actions concerning children, whether undertaken by public or private social welfare institutions, courts of law, administrative authorities or legislative bodies, the best interests of the child is paramount. Countries are supposed to ensure that the institutions, services and facilities responsible for the care or protection of children conforms to the standards established by competent authorities, particularly in the areas of safety and health.

Article 32 affirms children's right to be protected from economic exploitation and from performing any work that is likely to be hazardous or to interfere with

the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral or social development. Countries are responsible for taking legislative, administrative, social, and educational measures to ensure this. This includes providing for a minimum age for employment, appropriate regulation of the hours and conditions of employment, and appropriate penalties or other sanctions to ensure effective enforcement.

Other rights that may be violated when child labour is employed in ASM are covered by the following articles:

- Article 19 states the right of children to **protection from all forms of abuse and exploitation**. Countries should ensure that there are measures in to protect children from such abuse and exploitation, including effective procedures for establishing social programmes to support children and their parents/guardians, as well as for other forms of prevention and for identification, reporting, referral, investigation, treatment and follow-up of instances of child maltreatment and, as appropriate, for judicial involvement.
- Article 24 protects children's rights to the enjoyment of the **highest attainable standard of health** and to facilities for the treatment of illness and rehabilitation of health. Countries must also develop preventive health care, guidance for parents, and family planning education and services.
- Article 27 states that every child has the right to a **standard of living** adequate for his or her physical, mental, spiritual, moral and social development.
- Article 28 provides the **right to education** and states that primary education should be compulsory and freely available to all.
- Article 31 affirms children's **right to rest and leisure**, to engage in age-appropriate play and recreational activities, and to participate freely in cultural life and the arts.

African Charter on the Rights and Welfare of the Child

This is the primary regional instrument for safeguarding the rights of children, and it mirrors many of the provisions of the CRC. Article 15 deals directly with child labour, stating that children have the right to be protected from all forms of economic exploitation and from performing any work that is likely to be hazardous or to interfere with the child's physical, mental, spiritual, moral, or social development. It contains an additional section about the promotion and distribution of information on the hazards of child labour to all sections of the community.

Like the CRC, it states that in all actions concerning the child, the paramount consideration shall be the best interests of the child (Article 4), and affirms children's right to education (Article 11), rest and leisure (Article 12), and physical, mental, and spiritual health (Article 14).

ILO Minimum Age Convention (No. 138)

This convention sets 18 years as the minimum age for employment for work that may jeopardise the health, safety, or morals of young persons. It prohibits children under the age of 13 years from engaging in any type of work. Children aged 13 to 15 years are prohibited from any work that is not light work. Light work is defined as:

- Not likely to be harmful to children's health or development.
- Not preventing their attendance at school or their participation in vocational orientation or training programs approved by the competent authority.
- Not preventing them from benefitting from consistently received instruction for their fullest physical and mental development.

ILO Convention on the Worst Forms of Child Labour (No. 182)

This convention prohibits children under the age of 18 years from performing any type of employment or work classified as the Worst Forms of Child Labour. This term is defined as comprising:

- All forms of slavery or practices similar to slavery, such as the sale and trafficking of children, debt bondage, and serfdom and forced or compulsory labour, including forced or compulsory recruitment of children for use in armed conflict.
- The use, procuring, or offering of a child for prostitution, to produce pornography, or for pornographic performances.
- The use, procuring, or offering of a child for illicit activities, in particular for the production and trafficking of drugs.
- Work which, by its nature or the circumstances in which it is carried out, is likely to harm the health, safety, or morals of children.

ILO Worst Forms of Child Labour Recommendation (No. 190)

In addition to Convention 182, the ILO's recommendation on the Worst Forms of Child Labour provides protections for children under the age of 18 years from hazardous work. Hazardous work refers to:

- Work that exposes children to physical, psychological, or sexual abuse.
- Work under ground, under water, at dangerous heights, or in confined spaces.
- Work with dangerous machinery, equipment, and tools, or which involves the manual handling or transport of heavy loads.
- Work in an unhealthy environment, which may, for example, expose children to hazardous substances, agents or processes, or to temperatures, noise levels, or vibrations damaging to their health.
- Work under particularly difficult conditions, such as work for long hours or during the night, or work where the child is unreasonably confined to the premises of the employer.

List of References

Appleton, J. and Williams, T. (1998). *Mitigation of mining-related mercury pollution hazards: Project summary report.* British Geological Survey, Technical Report WC/98/34.

Artisanal Gold Council. (2014). *Health issues in artisanal and small-scale gold mining: Training for health professionals.*

Australasian Joint Ore Reserves Committee (JORC)(2004). *JORC code.*

Coats, J.S. et al. (1998). *An affordable exploration and mining license administration system for developing countries.*

Colina, P. (2006). *Briefing on mining in the Philippines and the effects on occupational health and safety of mine workers.* Presented at the Conference on Coal Mining in Renmin University, Beijing. Retrieved from: http://www.iohsad.org/

Darling, P., & Society for Mining, Metallurgy, and Exploration (U.S.)(2011). *SME mining engineering handbook.* Englewood, Colo.: Society for Mining, Metallurgy, and Exploration.

Dreschler, B. (2001).*Small-scale Mining and Sustainable Development within the SADC Region, Country Study commissioned by MMSD.*

Freer, G. (2015). Zimbabwe: *When I say ISALS, you say, internal savings and lending schemes, Progression: Harare.*

Gonçalves, A. (2011). *Analysis of gold extraction processes of artisanal and small-scale gold mining in Portovelo-Zaruma, Ecuador.* Retrieved from: https://open.library.ubc.ca/media/download/pdf/24/1.0308783/4

Hayes, K. & Perks, R. (2012). *Women in the ASM of the Democratic Republic of the Congo*. In Luaja, P. and Rustad, S.A.(Eds), High-value natural resources and peacebuilding. London: Earthscan.

Hinton, J. et al. (2013). *Small-scale mining handbook.* Kampala.

Hollaway, J. (1993). *A Review of Technology for the Successful Development of Small-scale Mining. United Nations Seminar on Guidelines for the Development of Small- and Medium-scale Mining, 11-19 February 1993, Harare, Zimbabwe.*

Hosford, P. (1993). *Innovations in mineral processing technology for small- and medium-scale mining operations. United Nations Seminar on Guidelines for the Development of Small- and Medium-Scale Mining, Harare, Zimbabwe.*

International Labour Organisation website https://www.ilo.org/ipec/facts/WorstFormsofChildLabour/Hazardouschildlabour/lang--en/index.htm

IIED (2003).*Artisanal and Small Scale Mining: Challenges and Opportunities.*

Marsden, J. and House, C. (2006). *The chemistry of gold extraction, 2nd edition.*

Ministry of Mines and Mining Development. (2018). *Procedures of acquiring licenses and permits (MMA, Chapter 21:05).*

Mlambo, L. (2016). *Extractives and sustainable development in Zimbabwe : Minerals, oil and gas sectors in Zimbabwe.* Friedrich Ebert Stiftung: Harare

MMCZ website http://www.mmcz.co.zw/about-us/

Mondlane, S. (2016). *Artisanal and small-scale mining.*

NEC Zimbabwe 2014-2018 national minimum wage

Organization for Economic Cooperation and Development. (2012). *Gender Equality in Education, Employment and Entrepreneurship.* Retrieved from:http://www.oecd.org/employment/50423364.pdf

Pact (2017). *Impact of ASM on poverty in Zimbabwe.*

Pact. (2015). *A Golden Opportunity: A scoping study of ASGM in Zimbabwe.* Washington, D.C.: Pact.

Patil, J. &Damle, P.G. (2017). *Up-gradation of rollers in track of open pit drill rig.* International Journal of Scientific Research Engineering & Technology, 6(5), pp. 500-504.

Reserve Bank of Zimbabwe (2018). *January 2018 Monetary Policy Statement: Enhancing Financial Stability To Promote Business Confidence*

Samukange, T. (2016, January 13). *Small-scale miners' mercury use scars environment.*

Santiago Pozo-Antonio et al, (2014). *Techniques to correct and prevent acid mine drainage: A review.*

Satyanarayana, I. (2012). *Basics of drilling.* Retrieved from: https://www.slideshare.net/isnindian/basics-of-drilling-1

SAZ. (2016). ZWS 1010:2016 *Zimbabwe code of practice for mercury use, storage and disposal in small-scale mining.*

SAZ. (2016). *ZWS 1011:2016 Zimbabwe standard for design, dewatering support of mining shafts in small-scale mining*

SAZ. (2016). *ZWS 1000:2016; Zimbabwe code of practice for cyanide use, storage and disposal in small scale mining –requirements.*

SAZS. (1993). *Zimbabwe standard specification for safety helmets for industrial use and for firemen. Version 1.0.*

Spiegel, S. J. (2012). *Formalisation Policies, Informal Resource Sectors and the De-/Re-Centralization of Power: Geographies of Inequality in Africa and Asia.* Retrieved from http://www.cifor.org/fileadmin/subsites/proformal/PDF/RSpiegel1212.pdf

Task Force on Financial Literacy, Canadians, and Their Money (2010). *Building a brighter financial future.*

Technica Group, Inc. (2015). *Health and safety program: Volume VII.*

Technology Transfer Services. (n.d.). *Conveyor safety and preventive maintenance.* Available at: https://www.myodesie.com/wiki/index/returnEntry/id/3050#Basic%20Conveyor%20Maintenance

Tsoroti, S. (2017). *Disaster looms at deserted Mashava gold mines.* Retrieved from: https://www.newsday.co.zw/2017/08/disaster-looms-deserted-mashava-gold-mines/

U.S. Bureau of Mines, (1996). *Dictionary of Mining, Mineral, & Related Terms. U.S. Department of the Interior.*

UN General Assembly. (1979). *Convention on the elimination of all forms of discrimination against women.*

United Nations Environment Programme. (2011). *A practical guide: Reducing mercury use in artisanal and small-scale gold mining.*

United Nations. (1997). *Glossary of environment statistics. Studies in Methods, Series F, No. 67.* New York.

Vorster, B. & Franklin, D. (2008). *Immediate ground support, after development or stope face exposure, can prevent falls of ground.* Southern African Institute of Mining and Metallurgy Narrow Vein and Reef

Wlodkowski, R. J. (2008). *Enhancing adult motivation to learn: A comprehensive guide for teaching all adults (3rd ed.).* San Francisco: Jossey-Bass, A Wiley Imprint.

World Bank. (2009). *Sector licensing studies: Mining sector.*

World Bank. (2015). *Zimbabwe poverty atlas.*

ZHRC. (2015). *Baseline study on perceptions, attitudes, and understanding of human rights in Zimbabwe.* (Unpublished).

Zimbabwe

Africa

This Artisanal and Small-Scale Mining (ASM) Training Handbook has been written and published in order to improve the performance of the ASM sector in Zimbabwe.

The main purpose of this Handbook is to enable local, regional and national agencies to better guide ASM operators and communities in developing a sustainable ASM sector in Zimbabwe for the benefit of the country and its citizens.

This ASM Handbook covers areas such as:

- Basic Geology
- Guidelines for Acquiring an ASM License
- Organising and Developing an ASM Site
- Minerals Processing
- Health, Safety and Environmental Issues
- Financing of an ASM Business

pact

@pactworld
pactworld.org