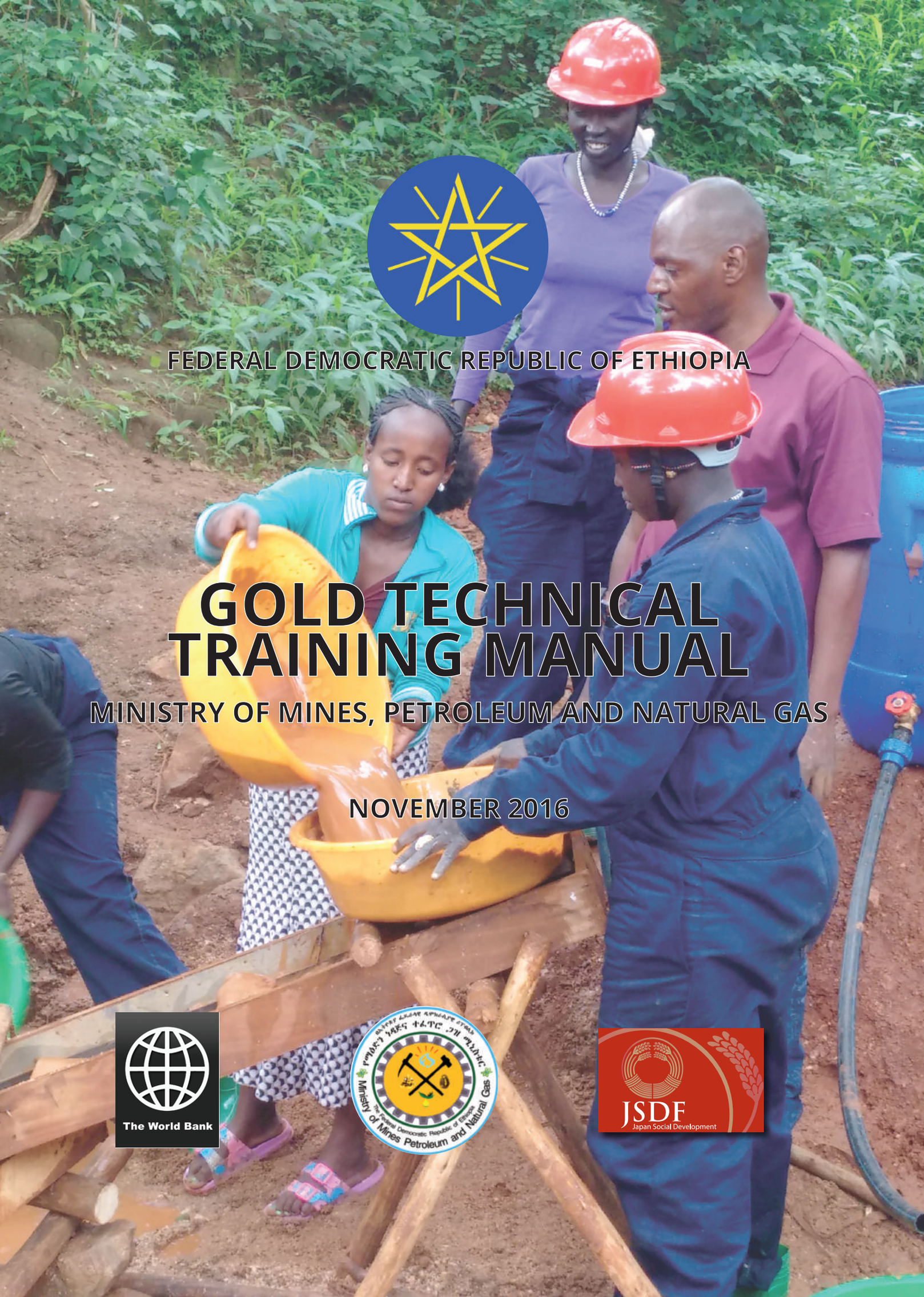

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

GOLD TECHNICAL TRAINING MANUAL

MINISTRY OF MINES, PETROLEUM AND NATURAL GAS

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The World Bank

Ministry of Mines, Petroleum and Natural Gas
The Federal Democratic Republic of Ethiopia

JSDF
Japan Social Development

FOREWORD

Estelle Levin Limited (ELL) and Sudca Development Consultants (Sudca) developed this training manual for the JSDF Project and the Government of Ethiopia's Ministry of Mines, Petroleum, and Natural Gas (MOMPNG). It was financed by the World Bank administered JSDF grant for support to improve the economic, social, and environmental sustainability of artisanal miners, with a particular emphasis on empowerment of women.

The JSDF Project is coordinated by the Women and Youth Directorate of the MoMPNG.

ELL Training Expert, Dr. Jennifer Hinton, authored the report, with contributions from: ELL Team Lead, Dr. John Tychsen; Sudca Gender Expert, Yimegnushal Takele; Sudca Environmental Expert, Andualem Taye; and ELL Project Manager, Adam Rolfe

The publication of this manual is the product of an extensive participatory research and practical training process, which ran from April to November 2016. An initial needs assessment visit (April – May) focussed on technical mining practices, environmental management, and the role and position of women within gold mining in Benishangul-Gumuz, Oromia, Tigray and SNNP. This informed the design of draft training materials that were used to deliver a training to cooperatives / Women's Economic Strengthening Groups and relevant government personnel (June). Feedback from the participants and the client was incorporated into the training material and subsequent design of the training manual.

The manual prioritises:

- Adult learning techniques that maximise participation and learning-by-doing; and
- A Knowledge, Skills and Attitudes (K-S-A) approach to build capacity in technical content while empowering participants by increasing their Knowledge and Skills to create gender-responsive trainers with the Attitudes necessary to support future actions.

The manual is intended for use by a variety of audiences to guide and supplement their work, whether directly or indirectly related to Artisanal and Small-scale Mining (ASM). A non-exhaustive list of the potential users is as follows:

- The ASM Department of the MoMPNG
- MoMPNG Directorates working closely with the ASM, Environment & Community Development, Gender, Artisanal Mining Production and Marketing, Public Relations and Communications Directorates
- Regional Mining Bureaus
- Local Woreda and Kabele Officers (Gender, Mining, Environment)
- Artisanal and Small-scale Mining Cooperatives / Women's Economic Strengthening Groups
- Artisanal and Small-scale Communities

CONTENTS

SECTION 1: GUIDELINES FOR TRAINERS

Any woman or man can become an excellent trainer! You don't need to be an expert on a topic to help others learn new skills and ideas and improve their gold mining activities.

Training is not just about giving information in a lecture. Training is about using different techniques and methods to positively change the behaviour and practices of the women and men you are training. To do this, a good trainer will use different techniques and methods to build upon trainees' existing Knowledge, Skills, and Attitudes ("K-S-A"):

- **K = Knowledge.** *This is the facts or information that women and men know.* For example, someone may *know* where salt is located but may not know how to mine it.
- **S = Skills.** *This is the ability to do something.* For example, someone may know *how* to mine salt but may not know enough about how to improve its quality and sell it at a better price.
- **A = Attitudes.** *How women and men act in or feel about a situation.* This also includes the values that people have. For example, someone may have skills and knowledge about salt mining, but doesn't have the initiative to learn how to improve salt quality.

This chapter describes: important characteristics of a good trainer; how a trainer can identify and respond to the different K-S-A needs of trainees; and different methods trainers can use to build K-S-A.

1.1 WHAT MAKES A GOOD TRAINER?

A good trainer will:

- Respect the existing knowledge, skills, and attitudes of people you are training and **build-upon** this by introducing something *new* (an idea, method, or way of working).
- Be encouraging, supportive, and patient. Understand that each person might have different training needs. Some women and men miners will need more time and encouragement than others.
- Help the women and men you are training by finding the solutions themselves.
    - Ask questions about what they know and how they think a problem can be solved.

  - Introduce new ideas and methods using your coaching and mentoring skills.
  - Talk about what they learned and how it can improve people's lives.
  - Talk about possible unintended impacts of the new method and how you can manage this.
- Remember that women and men may face different challenges speaking up or participating. A good trainer will adapt by taking steps to ensure *all* trainees benefit from training. Remember that different people have different K-S-A and you may need to adapt your methods for women, men and other groups (and may even need to train them separately).
- Keep a positive attitude! It takes time to change behaviours of trainees and a lot of practice to become a good trainer.

1.2 IDENTIFYING THE TRAINING NEEDS OF MINERS

To identify the training needs of women and men miners, you will need to:

- Decide what women and men miners *should* know and be able to do, and the attitude needed to increase their incomes, mine more safely, protect their health and the environment, and support the development of their families.
- Understand what women and men *already* know, can do and how they act or feel. Is this different for women's and men's groups? Will you need to adapt your training approach for each?

Using each section of this manual, **make and complete a table like the one below** to decide what to focus on when you are training women and men miners:

	Knowledge			Skills			Attitudes		
Topic	What miners need to KNOW about	What MEN miners already KNOW about	What WOMEN miners already KNOW about	What miners need to be able to DO	What MEN miners can already DO	What WOMEN miners already DO	What kind of attitude miners need to have	What MEN miners already know	What WOMEN miners already know
Legal Rights:									
Prospecting:									
Extraction:									
Crushing, Grinding, Sieving:									

Gold Recovery:									
Safety:									
Environment:									

Table 1: Men and Women KSA Analysis

For each topic, decide what *new* knowledge, skills, and attitudes your trainees need. Use this training guide to help you find the information you need to help train others.

For each topic, decide what *new* knowledge, skills, and attitudes your trainees *need*. Use this training guide to help you find the information you need to help train others. Review the differences between the men and women you will train, as well as any intra-gender particularities. How can you address these differences?

To address training needs, particularly of women trainees, you should also consider the following issues:

- Where will the training be done? Is it easy and inexpensive for trainees to access the location? How will it affect the trainees' day-to-day lives?
- When will the training be done? How long or how often will you do it? Could this create a household conflict or inconvenience for trainees? How will you address this?
- What are the costs of the training for the trainee? Think about all costs (lost income, transport, accommodation). Will they be able to afford to participate? How will you address this?

1.3 TRAINING METHODS

Use a combination of methods depending on whether you want to build Knowledge (**K**), Skills (**S**), or Attitudes (**A**).

KIND OF LEARNING	TRAINING METHODS
KNOWLEDGE [Facts, Information]	• Lectures and presentations • Readings • Songs, Films, TV, and Radio • Brainstorming, group, or one-on-one discussions
SKILLS [How to do something]	• Demonstrations • Instructions followed by hands-on practice.
ATTITUDES [Values, what people think about things, how they react to things]	• Posters and visual aids • Discussion • Role plays and simulations

Table 2: Types of learning and methods for training

You don't need to organise a training workshop to be a 'trainer'. Sometimes, the best training is done at the mine site. The most important field techniques you can use are as

coaches or *mentors* of women and men miners. Because women and men may have different training needs, it may be useful to coach or mentor them separately.

To be an effective **coach** of artisanal miners:

1. *Focus on one method, skill, or way of working that you learned about during the training:* Think about what you learned during this training. Pick one topic that you think other miners would benefit from learning about. Remember that women and men miners might have different needs!
2. *Work with 1-3 miners at a time to teach them about the activity.*
    - Talk to the miners about why it would be useful to learn this new task or skill.
    - Demonstrate and instruct the miners on the task or skill – do it together.
    - Talk about what worked well, what did not and how they could improve next time.
3. *Once the miners are comfortable using the new skill or methods,* then introduce it to *other* miners OR focus on teaching miners about a *different* method or topic.
4. *Re-visit the miners you trained later* to make sure that they are using the method in a proper way (or perhaps have improved on the method by adapting it).

To be an effective **mentor** of artisanal miners:

1. *Give advice to women and men miners on a regular basis.* Talk to individual miners about what they think they need to know to improve their mining activities. Remember that women and men miners might have different needs!
2. *If you know about the topic* then give the miners advice on the issue on a regular basis. Work with them to find solutions together.

If you don't know about the topic then ask for advice from those that do: for example mining officers at the Woreda Regional Mining Bureau (RMB) or Ministry of Mines. They may need to do some research to help you advise fellow miners.

SECTION 2: GENDER EQUITY, RIGHTS & RESPONSIBILITIES IN ARTISANAL AND SMALL SCALE MINING

The purpose of the present training manual is to improve the position of women miners in the mining production cycle and to enhance their benefits from mining activity.

The focus of the following sections is the improvement of **technical skills** and the **introduction of modern, efficient, environmentally friendly and gender sensitive technologies**. However, for this to contribute to impactful, meaningful, and sustainable change for women, it is integral that trainees are trained in the importance of gender equity as well as their rights, roles, and responsibilities.

By developing a better understanding of the present position of women in mining, as well as legal provisions and government responsibilities to protect and promote the role of women, this section will complement the skills learned in later sections and provide trainees with a basis for realising the benefits of the training programme when applying their new skills.

The introduction of new technologies and skills to operate them will only provide trainees with the *potential* to improve their livelihoods and the benefits of mining; an understanding of gender equity and their rights and responsibilities will permit the trainees to apply these skills in a way that *maximises their potential*.

2.1 GENDER AND DEVELOPMENT

Introduction

Women constitute 26% of the mining households in Ethiopia (ASM Baseline Survey, Sudca, 2013). When we look at the gender distribution by mineral type, women hardly participate in salt extraction and dimension stone production. They likewise have a very limited role in gemstone mining. Thus, the only area where women engage as recognised miners is gold mining, which also varies from region to region. For example, in Benshangul-Gumuz Region, females [including girls] are very actively engaged and make up 51%; while in Tigray, they represent 39% of the mining workforce. However, even in these regions, where women constitute a considerable size of the mining workforce, the gender disparities between men and women as well as boys and girls are considerable.

Does gender equity matter?

Gender equity is not just a question of being fair to women and girls or narrowing the economic and social gaps between male and females. It is a matter of national and community development. For instance, The Global Hunger Index indicates that countries with the highest levels of gender inequality show the highest levels of hunger. Thus, con-

fronting gender inequality stands out among the key elements of reducing hunger and, hence, of reducing poverty (USAID, 2011).

Domains for analysing gender inequality

ASPIRATIONS:

Children constitute a significant, although diminishing, proportion (5-10% depending on the region) of the ASM labour force in Ethiopia (EITI, 2016). Children, especially girls, are prone to high levels of non-enrolment, absenteeism, and school dropout. This has a profound impact on the aspirations of children of the present generation and the development of their communities, in much the same way as it did for previous generations.

Figure 1: Children in mining communities, particularly girls, are vulnerable to school dropout, absenteeism, or recieving no education at all. Photo from Asgede Tsimbila woreda. Tigray Region (Photo: J. Hinton)

GENDER DIVISION OF LABOR:

Women report spending two thirds of their time in mining and the rest on crop production, domestic chores and discharging their child care responsibilities. Nevertheless, despite these additional burdens, women spend as almost as much time as men mining.

All of the above factors result in a disproportionate work burden for women and girls, impacting their development and aspirations. In turn this can also determine their social status. Often the problems detailed above are confounded in female headed households.

Figure 2: Photo from Menge Woreda. Benshangul Gumuz Region (Photo: J. Hinton)

ACCESS TO AND CONTROL OVER ASSETS AND RESOURCES:

Ownership of the majority of household assets such as family land holdings, houses, livestock, income, etc. in mining communities is primarily the reserve of men. In the case of access to mining areas, in places where miners are organized (e.g. in Tigray), mining areas are collectively owned by cooperatives while in other areas (e.g. in Benshangul Gumuz) mining areas are open-for-use by all community members.

PARTICIPATION AND DECISION MAKING:

Women are reported as having the most decision making power over income *they* have generated. Where they are not involved in income generating activities, whether from social or cultural exclusion, there is a risk that gains (including those resulting from increased productivity leading to higher income in ASM households) could be misused. This could actually worsen the existing situation of women and girls if they are obligated to take on additional work burdens but restricted from accessing the improved income. This risk could be heightened if, for instance, machinery were to be co-opted by men. Conversely, assessment demonstrates that ASM women who actively participate tend to have a stronger voice in community/collective issues, relative to their inputs at the household (HH) level.

INSTITUTIONAL CAPACITY AND COLLABORATION AMONG PARTNERS:

Some major factors slowing down the gender mainstreaming process in artisanal mining include: limited staff capacity in government to integrate gender; weak collaboration and interconnectedness across gender offices; and persistence of unorganised and highly individualised mining operations.

OTHER SOCIAL PROBLEMS:

Many women around the mining areas are engaged in low paying and/or risky livelihood activities such as food vending, catering, sale of goods, and/or sex work. The resultant marginalisation can increase women and children's exposure to child abuse, human trafficking, HIV, gender-based violence, and/or harmful traditional practices. Lack of knowledge about safety rules and on the need to use safety equipment, accompanied with exposure to toxic and poisonous chemicals is also an issue. The domestic division of labour means the workloads of women are reportedly increased by deforestation and its associated impacts on availability of water and firewood.

2.2 LEGAL RIGHTS AND RESPONSIBILITIES OF WOMEN AND MEN MINERS

The development of you, your family, and your community depends on whether the rights of women, men, boys and girls are **respected, protected,** and **fulfilled!** To do this, women and men miners have to fulfil *responsibilities* while the government needs to discharge its *obligations.*

What are the rights of women and men miners?

According to the Constitution and the Mining Proclamations of Ethiopia:

- **Eligibility for License:** No person is required to possess financial resources, technical, and professional competence in order to acquire an artisanal mining license. (Art.2, The Mining Proclamation, MOM 2010)
- **All nationals** can apply through their Regional Mining Bureau for an artisanal license (Proclamation No. 816/2013).

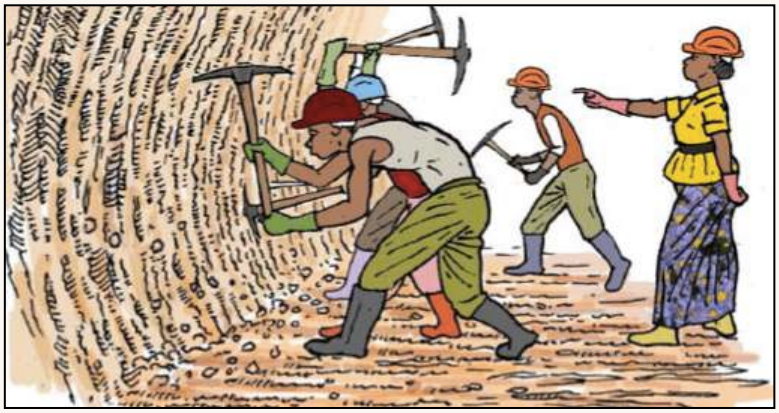


Figure 3: Both women and men have the right to work in different areas of the mine (Source: Hinton et al, 2009)

- An artisanal license is **valid for a period specified in the license (not exceeding two years)** and is non-renewable (Proclamation No. 816/2013).
- The **maximum area** to be covered by a single license shall be 5,000m^2 for artisanal mining operations.
- One can't be a holder of two licenses at a time. (Art. 10, Council of Ministers, 1994)
- **The right to be organised**: ASM workers have the right to form associations or cooperatives to improve their conditions of work and economic well-being.
- Women workers have the right to equal pay for equal work. (The Constitution Art. 42)
- **Small-scale and special small-scale mining licenses** are granted for an initial period of up to 10 years and can be renewed for 5 years (Proclamation No. 816/2013). Please consult with your Regional Mining Bureau for further information.

- **Environmental impact:** Artisanal miners are not required to submit an environmental impact assessment or to allocate funds to cover the costs of rehabilitation of environmental impact. (Art. 60, Council of Ministers, 1994)

Legal rights concerning equal opportunities, equal pay for equal work and non-discrimination

- Women shall, in the enjoyment of rights and protections provided for by the Constitution, have equal rights with men. Women have equal rights with men in marriage. (The Constitution Art. 35)
- Women have the right to acquire, administer, control, use, and transfer property. In particular, they have equal rights with men with respect to use, transfer, administration and control of land. They shall also enjoy equal treatment in the inheritance of property. (The Constitution Art. 35)
- Every Ethiopian has the right to engage freely in economic activity and to pursue a livelihood of his choice anywhere within the national territory. (The Constitution Art. 41)

Legal rights concerning safe working conditions

- To prevent harm arising from pregnancy and childbirth and in order to safeguard their health, women have the right of access to family planning education, information, and capacity. (The Constitution Art. 35)
- Workers have the right to enjoy a healthy and safe working environment.

Legal rights concerning access to justice

- Everyone has the right to bring a justiciable matter to, and to obtain a decision or judgment by, a court of law or any other competent body with judicial power. (The Constitution Art. 37)

The responsibilities of women and men miners

- **Royalty:** The amount of royalty payable by the holders of artisanal and small-scale mining licenses shall be at the rate fixed by the laws of the states. (Art. 63, Council of Ministers, 1994)
- **Order of Processing of Applications:** An application submitted for a large scale mining license shall take precedence over applications for small-scale and artisanal mining licensees, and an application for small-scale mining

license shall take precedence over an application for artisanal mining license; (Art. 13, Council of Ministers, 1994)

- **Revoking a License**: The Licensing Authority may, after giving 90 days prior written notice, revoke an artisanal mining license, but preferential treatment or compensation shall be given to the licensee. (Art. 32, Council of Ministers, 1994)
- **Termination of a License**: Mining rights shall terminate if a license expires without being renewed or licensees acted unlawfully. (Art. 77, Council of Ministers, 1994)

Legal rights of children

- Every child has the right to life; to nationality; to know and be cared for by his or her parents or legal guardians; not to be subject to exploitative practices, neither to be required nor permitted to perform work which may be hazardous or harmful to his or her education, health or well-being; to be free of corporal punishment or cruel and inhumane treatment in schools and other institutions responsible for the care of children. (The Constitution Art. 36)

Figure 4: Children's Rights

- In all actions concerning children undertaken, the primary consideration shall be the best interest of the child. Children born out of wedlock shall have the same rights as children born in wedlock. The State shall accord special protection to orphans. (The Constitution Art. 36)
- Under special circumstances, children of age 14 and above can engage in safe paid works, but subject to limitations in working hours, not to work during weekends, and not to work overtime.
- Alternative education should be provided for young girls and boys engaged in the mining activities;
- Parents/guardians are responsible for ensuring that both girls and boys enjoy their right to rest, play, and attend school.

2.3 OBLIGATIONS OF THE GOVERNMENT

The Government of Ethiopia has a legal obligation to **respect, protect,** and **fulfil** the rights of its citizens. A few examples of important obligations of government include to:

- Fairly and without discrimination - on the basis of gender, class, or ethnicity - ensure that mandates (including those mandates of Regional Mining Bureau and Woreda offices related to technical assistance and advice to artisanal miners) are fulfilled;
- The State shall enforce the right of women to eliminate the influences of harmful customs. Laws, customs, and practices that oppress or cause bodily or mental harm to women are prohibited (The Constitution Art. 35);
- Provide training on legal right of women artisanal and small-scale miners to apply human rights and gender equality principles (avoid physical harassments and psychological torture);
- Create awareness to protect against the sexual exploitation of women and girls by workers, traders and those who are engaged in other jobs around mining areas;
- Prevent harassment and discrimination;
- Strengthen the legal trading system in collaboration with responsible bodies such as police and trade bureaus to support women artisanal miners;
- Set-up mechanisms to protect the economic interests of girls who work for relatives, friends of the family, or guardians;
- Make sure women, women's organisations and associations are active participants in decision making, for example in consultations and meetings;
- Identify and address local and associational sources of conflict in artisanal and small-scale mining communities and promote conflict resolution, since women are often the prime victims of conflicts that arise. In addition, it must ensure active participation of women in resolving conflicts;
- Develop regular and gender sensitive assessment and monitoring techniques to overcome the hurdles to positive change and to support the development of women in artisanal mining;
- Ensure that the rights of other land users are protected; and
- **Provide Assistance -** The government may provide incentives and assistance to artisanal mining carried out by cooperatives. (Art. 75, Council of Ministers, 1994)

2.4 WHAT TO DO WHEN RIGHTS ARE NOT RESPECTED, PROTECTED, AND FULFILLED?

- **Appeal Procedures:** Any person who is aggrieved by any administrative decision of the Licensing Authority pursuant to Proclamation 816/2013 may apply to the officials of the Licensing Authority hierarchically [Woreda - Regional - Federal] (Art. 79, Council of Ministers, 1994).
- After one has exhausted the administrative remedies with the Licensing Authority, they may apply to the competent court for the review of an administrative decision contemplated in sub-article (1).
- In the case of any criminal act (such as sexual or physical violence or denial of payments), the victim may take their case to the local police or the relevant government administrative body for justice.

SECTION 3: SYSTEMS OF GOLD PRODUCTION

Economic, environmental, and occupational safety and health issues are different at each step of gold production. To understand the training needs of miners at your site, determine which type of gold (in soil and/or sediments, or gold in rock) is produced and answer these questions:

- What jobs do your trainees do at each step? How are they currently doing these jobs?
- Do men and women do different jobs? Are they using different tools and methods?
- *At each step,* what do women and men need to know about and be able to do in order to: make more money, work more safely, and protect the environment?

3.1 GOLD IN RIVERS, SOILS AND SEDIMENTS

Main steps in gold production include: (i) digging; (ii) transporting ore; (iii) transporting water; (iv) recovering gold by panning *or* by sluicing and then panning; and (v) selling gold.

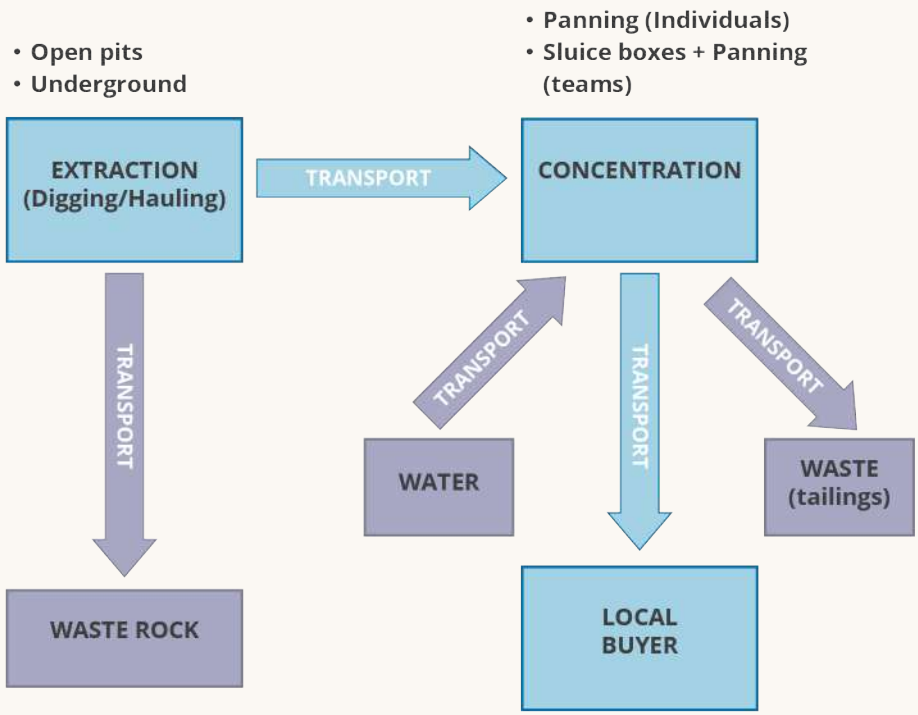


Figure 5: Main steps in production of alluvial or colluvial gold

3.2 GOLD IN ROCK

The main steps in gold production include: (i) digging/rock breaking; (ii) transporting ore and waste rock; (iii) crushing, grinding and sieving ore; (iv) transporting water; (v) recovering gold by panning *or* by sluicing and then panning; and (vi) selling gold.

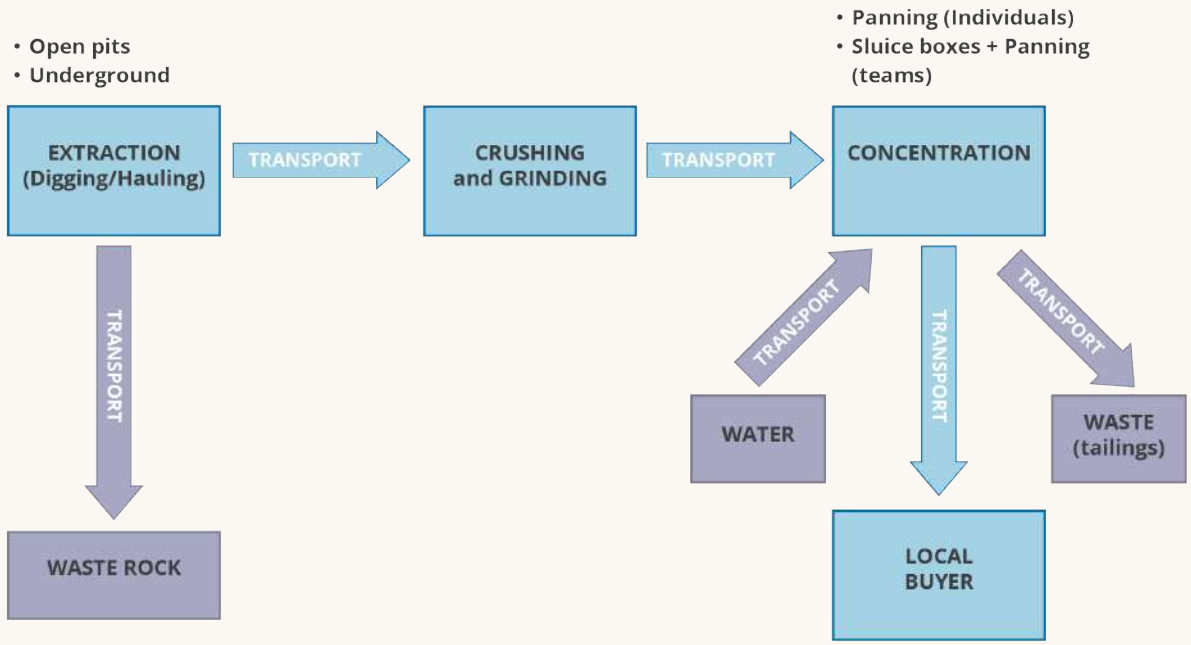


Figure 6: Main steps in production of hard rock gold

SECTION 4: PROSPECTING AND TESTING FOR GOLD

4.1 Gold in Ethiopia

Gold occurrences are widespread in Ethiopia. Exploitation of placer gold reportedly dates back at least 3,500 years. Over the subsequent millennia, gold has been extracted nearly continuously to this day, although not always in large quantities. (Geological Survey of Ethiopia).

Ethiopia has a complex geological history represented in three major geological terrains. The most important terrain for gold exploration and exploitation is the Proterozoic basement, constituting about 18% of the country. It hosts nearly all known gold occurrences.

The gold deposits you are mining appear at or near the Earth's surface. Some of them, however, were formed deep in the Earth's crust. The description below aims at giving you an overview of the geological processes and the environment in which the gold was formed. This knowledge can help in the discovery of additional gold deposits.

Three main kinds of rock

Some rocks are remnants of volcanic eruptions, such as lava and volcanic ash. These are called **igneous** rocks. Examples of igneous rocks are those formed by the extensive lava flows in the Simien Mountains and the numerous recent volcanic rocks created in Rift Valley.

A second kind of rock is **sedimentary** rock, these are made from sediments such as clay, sand and gravel, all deposited on the Earth's surface. Over time, these layers of sediments build up and harden into rock.

The final kind of rock is what we call **metamorphic** rocks. Metamorphic rocks form deep in the crust of the Earth where material is heated to temperatures between 300 and 1100°C and pressed with extremely high pressure.

How the gold deposits were formed

How did the sedimentary and volcanic rocks end up deep in the crust of the Earth? This can happen when more and more sediments and material from volcanic eruptions are piled on top of each other thereby pressing the underlying rocks deeper and deeper down in the Earth's crust. Another way is the formation of mountains, where the Earth's surface is compressed and rock units are thrust on top of each other.

The rock pile gradually sinks into the crust where high pressure and temperature prevail. Layers of sand will be consolidated and metamorphosed into sandstones and

quartzites; and clay into shales and schists. Well-developed foliation and folds due to rock deformation are characteristics of metamorphic rocks.

The metamorphic rocks, also called basement rocks, are exemplified in Ethiopia by the ca. 600 million year old Precambrian or Basement rocks seen in the western part of the country. These rocks contain most of Ethiopia's metallic deposits such as gold, base metals and platinum group elements (PGE). Weathering of extensive gold deposits has given rise to quite extensive placer gold deposits such as Adola in southern Ethiopia and Tigray in northern Ethiopia.

Hydrothermal deposits

Hydrothermal deposits are mostly directly or indirectly related to magmatism. At high temperatures deep in the Earth's crust, the rocks start to melt and eventually form magmas, which are large bodies of molten rocks called igneous rocks. These magmas are gradually squeezed further up in the crust, where they start to cool and crystallise as coarse-grained bodies. Many elements such as gold, tantalum, and beryllium cannot be accommodated in the minerals that crystallise in the magma, but are concentrated at the top of the magma chambers. When pressure builds up, the rocks above start to crack and fluids from the top of the magma chamber flow up into the cracks. These hot fluids are called hydrothermal fluids.

The cracks are gradually filled with quartz and with elements, which could not be accommodated in the magma such as gold, tantalum niobium-forming tantalum (columbite or coltan), and beryllium in aquamarine found in quartz veins and pegmatites. These types of deposits are collectively called magmatic-hydrothermal deposits and are found closely associated to the igneous rocks, commonly granite.

Magmatic deposits

There are different types of magmatic deposits:

- Dykes intruded into cracks in the basement rocks; and
- Large bodies of irregular shapes intruded deep in the crust.

During crystallisation of magmas, economic minerals such as chromite, magnetite, nickel and platinum will appear as bands or pods in the magmatic rocks. The magmas may crystallise as dykes or large irregularly shaped bodies generally medium- to fine-grained. These deposits can be recognised by checking for magnetite and for massive and semi-massive sulphide occurrences, because they host nickel and platinum. These types of mineral deposits, called magmatic deposits, are the targets for small-scale miners.

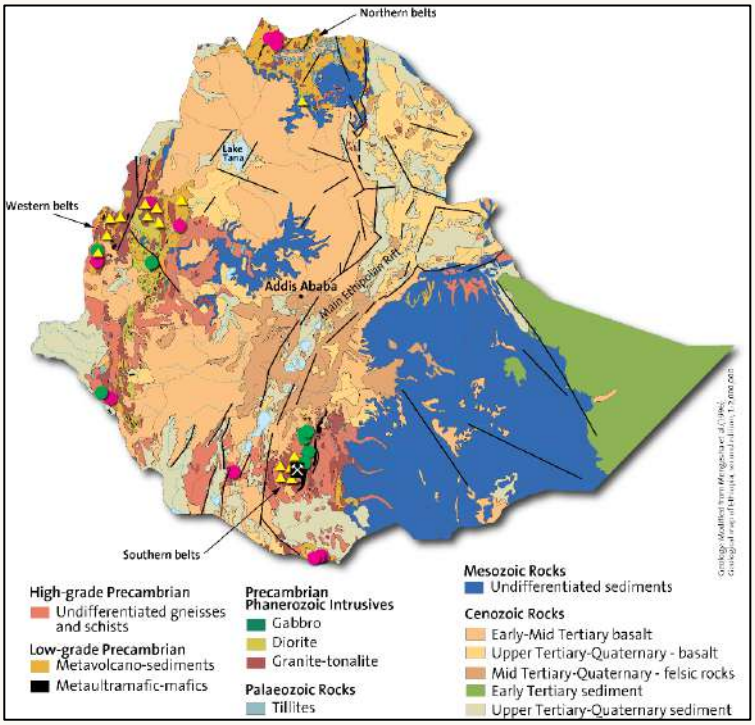


Figure 7: Geological map of Ethiopia with yellow triangles showing gold occurrences in greenstone belts, red dots showing gold occurrences in Cu-Au type mineralization's and green dots showing placer gold occurrences. Mine symbol at Lega Dembi.

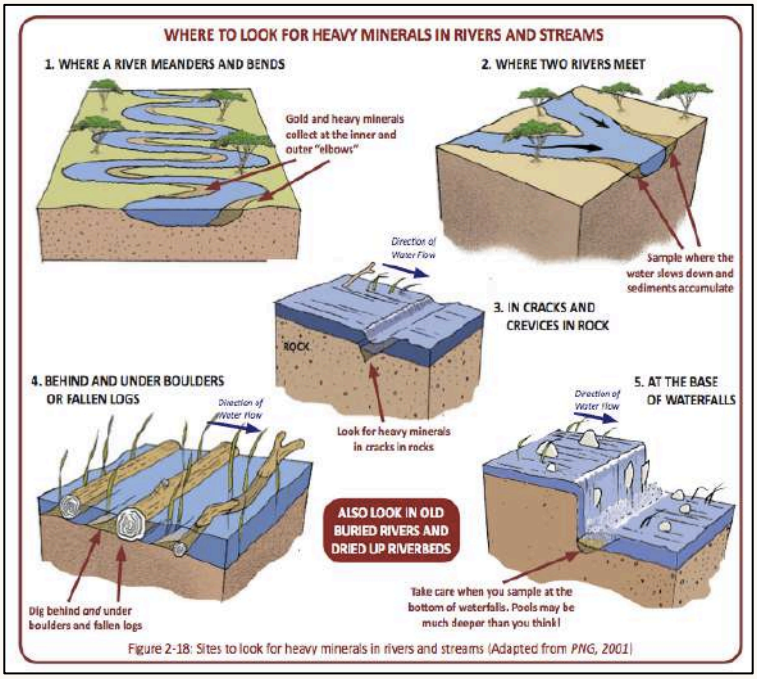


Figure 8: Where to Look for Gold in Rivers (Source: Hinton et al, 2009)

4.2 GOLD IN RIVERS

Gold can be found in rivers and streams. An understanding of the chemical properties of gold can help you identify new deposits. For example, because **gold is heavy** it accumulates in areas where other heavy minerals (like black sands) are found, as well as behind logs and large stones and rocks.

How to test for gold in rivers:

1. From the pictures above, look for a site in the river where gold should occur.
2. Using a spade, dig a sample from the area made up from 4-5 different spots.
3. Put the sample into a basin. Remove any large stones.
4. Pan the sample:
    - If you see many specs of gold, then this is a good place to mine!
    - If you don't see any gold, or only a few specs of very small gold, try testing another location. You may want to go farther upstream (in the direction where water is coming from).

You can also use this method to help you find the rock source of the gold carried along in the river.

- If you see a few specs of gold in your first pan, move upstream (in the direction where water is coming from).
- If gold gets bigger or you find more specs, keep moving upstream!
- As you continue to get more gold moving upstream, start looking in the hills for quartz veins and other interesting rocks and testing them using the method discussed in Section 4.3, below.

4.3 GOLD IN ROCKS AND SOILS

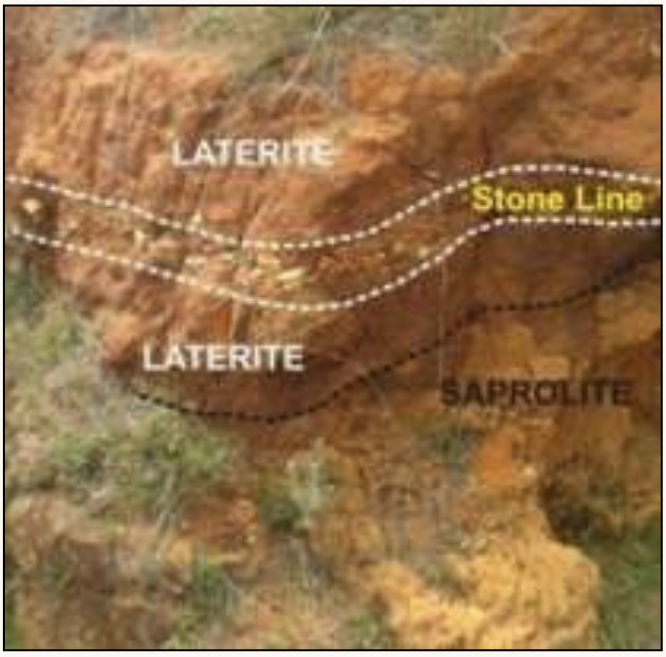
Gold can be found in soils, rocks, and weathered rocks. Look for the following areas to decide the best place to test for gold:

- *Look at the rocks and soils in pits where other miners are finding gold.* Is gold found in pieces of quartz (clear, grey, or whitish coloured rock that looks like glass)? Or is it found in nuggets in soils? Try to find the indicators for gold in your area.
- *Look at the location of other pits where miners are getting gold.* Gold often occurs with quartz in veins. Try to follow these veins in a direction of where you think the gold might go.
- *Visually inspect pieces of weathered quartz found on the ground.* Look for (i) shiny minerals that look like metal or bright orange or bright red powder looking minerals, especially in the cracks of the rock. If there are enough pieces of quartz (about 5kg), it can be crushed into powder with a mortar and pestle and then panned to test for gold.

Figure 9: Learn the indicators of gold in rocks in your area.
Left: Gold sometimes occurs with bright orange, red, or black oxide minerals, and it often appears in white quartz.
Right: Gold sometimes occurs with other metallic minerals that are often silvery orangish

How to test for gold in the ground:

1. Using a spade, dig a pit about 1-2m deep and about 1m wide.
2. Look at the walls of your hole. Do you see any pieces of quartz? Inspect it to see if any indicator minerals are present. This could include:
    - Specs of shiny minerals that look like metal.
    - Bright orange or red coloured minerals, especially in the cracks of the rock.
    - If you are lucky, even visible gold.
3. Take about 5kg of the quartz and crush it into powder using a mortar and pestle. Pan the sample and inspect it for gold.
4. Look at the walls of your pit again. Does the quartz occur in a specific layer? Dig up a bigger sample of the quartz (about 1 basin-full) and some of the soils around it, taking samples from each wall in the interesting layer. Crush it into powder and pan it.
5. Inspect it again for gold.
    - If gold is *not* found, then you can take another sample of soils from a different layer, pan it and inspect it again. If you do not find gold, then backfill your pit and move to a different location.
    - If gold *is* found, then this is a good place to dig! Try following the layers (quartz and surrounding soils) that contain gold.



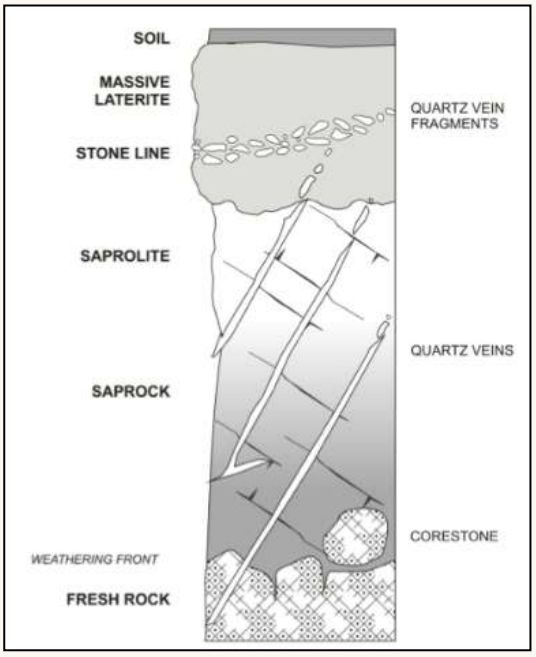


Figure 10: Different Layers in Weathered Soils. (Source: Voormeij, 2013). If gold is found in the stone line, then also look for it at depth.

SECTION 5: EXTRACTION (Digging)

The extraction stage means all the activities and tasks you need to do around digging the rock or soil. There are two types of extraction: (i) surface mining (alluvial or open pit); and (ii) underground.

Whether the extraction features surface or underground mining creates different environmental and safety issues that must be addressed. The most common issues are shown in Table 1.

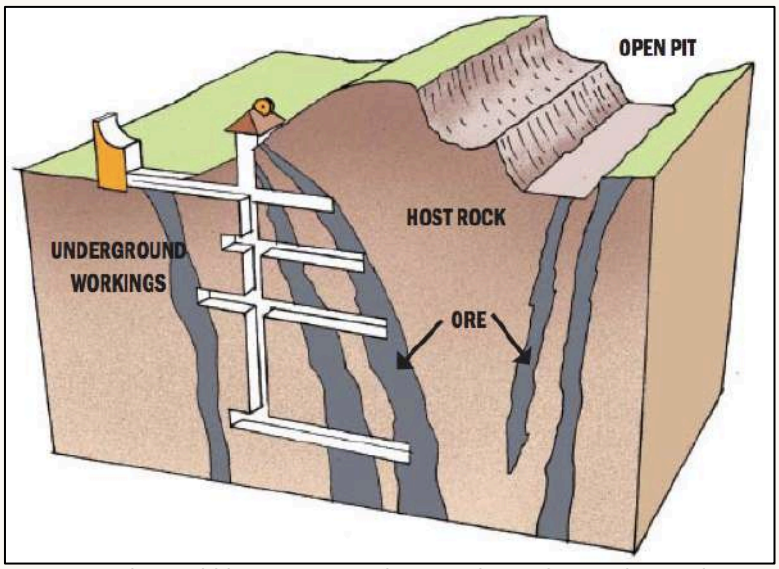


Figure 11: When gold-bearing ore is closer to the surface and spread across an area, then open-pit mining is usually the best method. If ore goes deeper, then underground mining in shafts and tunnels is often necessary.

Issue	Surface Mining	Underground Mining	Action Needed
Poor Management of Waste Rock	• Large amounts of waste rock/soil are produced. • If placed near open pit edges, it can cause collapse of pit walls. • Run-off from waste rock piles can damage soils and rivers.	• Produces less waste rock than surface mining. • If placed near shaft openings, it can cause collapse of shafts or fall into shafts injuring people. • Run-off from waste rock piles can damage soils and rivers.	• Identify the best location for waste rock (far enough away that it won't cause pit or tunnel collapses, but also where it won't run into rivers when it rains) • Transport waste rock to this area as you are digging. • Once a pile gets quite big, cover it with soils (overburden) and plant grasses or trees on it.
Collapse of pits or tunnels	• Steep pit walls can collapse into pits, burying miners and/or causing injury or death. • Collapse can also prevent access to ore and halt mining	• Shafts or tunnels can collapse, burying or trapping miners and/or causing injury or death. • Collapse can also prevent access to ore and halt mining	• *Surface:* Make sure pit walls are not too steep. Use benches when pits are deep. Manage waste rock properly. • *Underground:* Use timbers to stabilise weak rock in tunnels and shafts. Collar and cover the opening. • Consider using open pit methods for shallow (5-6m deep tunnels) in soft soils.

Issue	Surface Mining	Underground Mining	Action Needed
Flooding	• The pit fills with water: • Creating a drowning hazard; • Increasing risk of pit wall collapse; and • Preventing access to ore.	• The tunnels fill with water: • Creating a drowning hazard; • Increasing risk of tunnel collapse; and • Preventing access to ore.	• Purchase a water pump (re-use water for processing). • Dig diversion trenches around pits or shafts to channel rainwater away. • Collar and cover shaft openings to prevent rainwater entry. • Keep people away from flooded areas until measures are in place to remove the water.
Poor Ventilation and Suffocation	• Not applicable.	• Poor airflow underground can cause injury or death of workers.	• Use an air compressor and hoses to force air underground. • Connect two tunnels underground to increase airflow. • Always work in teams. Ensure others know where and when you are working. • Stop work in unsafe tunnels until measures to improve ventilation are in place.

Table 3: Common Environmental and Safety Issues in Extraction

The next sections describe some of simple ways that you can use to deal with these issues.

5.1 SURFACE MINING

Open pit mining involves digging a pit (a big hole), usually in soft, weathered rock or soils. The most serious risk during surface mining is collapse of open pit walls. *This danger has killed thousands of artisanal miners around the world.*

To prevent and manage these risks, you should:

1. Regularly inspect the soils and rock in and around the pit;
2. Reduce the pit wall angle and make benches in deeper pits;
3. Never undercut soft or fractured/cracked rock;
4. Place waste rock at least 10m from the edge of the pit;

5. Remove loose rocks and soil to prevent accidents before they happen;
6. Regularly inspect the soils and rock around the pit;
7. Regularly walk around the edges of your pit to look for any of these indicators of a very high risk of pit wall collapse:
    a. Are any cracks developing? In particular, are cracks developing roughly parallel to the pit edge?
    b. Are soils collapsing (falling into the pit) in small pockets?
    c. Are certain areas of the soils very wet?
    d. Is the rock highly fractured or broken?
    e. Are soils "heaving up" at the bottom of the pit? If so, your pit wall will collapse soon.

Figure 12: An example of bad surface mining practices

This steep pit wall was undercut and collapsed, killing one miner.

Miners tried to make crude benches to help access the ore, but they are too narrow and steep. This portion of the wall also collapsed into the pit.

Figure 13: A crack forming roughly parallel to a pit wall indicates that a pit wall failure may occur soon. (Source: Hinton et al, 2009)

When you see these conditions, *you must take immediate action to prevent pit wall collapse.* Use the methods below to prevent, manage, and minimise the risk of pit wall collapse.

#1. Make benches or "steps" in the pit wall

You should make benches in your pit wall as you go deeper into the earth. Your pit will be wider, but this will help prevent pit wall collapses in the future. Benches are also useful as they can facilitate hauling ore from the pit bottom more quickly.

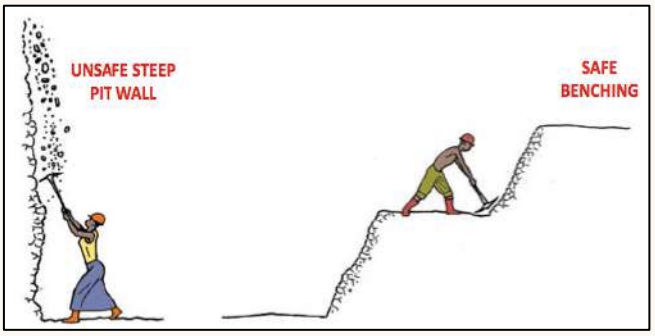


Figure 14: Benches will help prevent pit wall collapses so you can continue working.
(Cited in: Hinton et al, 2009; Adapted from Walle and Jennings, 2001)

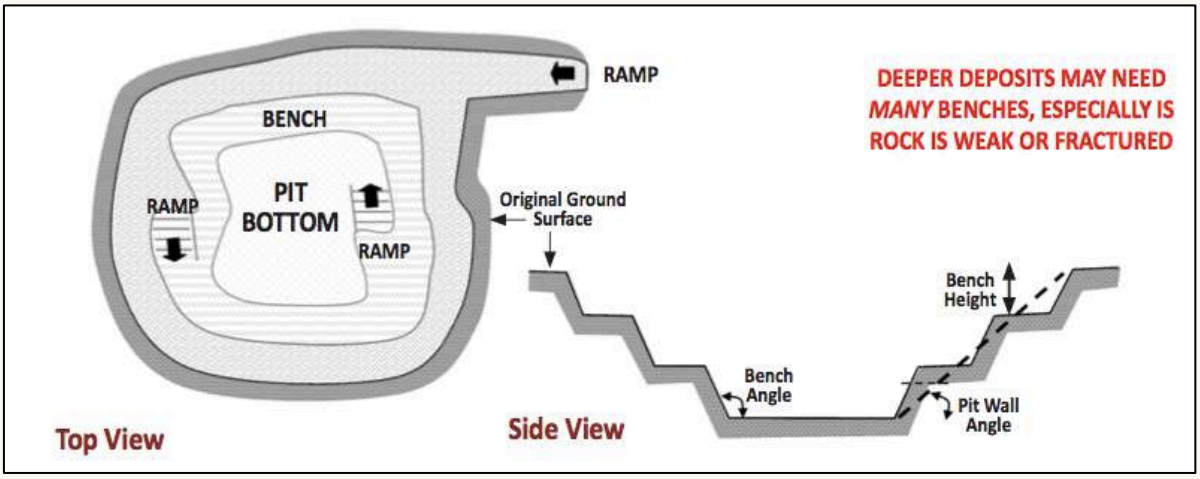


Figure 15: The Deeper you dig, the more benches you need! (Hinton et al, 2009)

Benches should continue *all the way* around your pit. They are not simply steps dug in the wall.

Figure 16: These benches continue along the hill slope (Photo J. Hinton)

#2. Never undercut soils or soft or broken rock.

The softer or more broken the rock or soil, the more likely it will collapse. Undercutting rock – especially soft or broken rock – is extremely dangerous and should be avoided. If you *must* undercut rock (for example, if you plan to start mining underground), put in place timbers and supports to help prevent an accident.

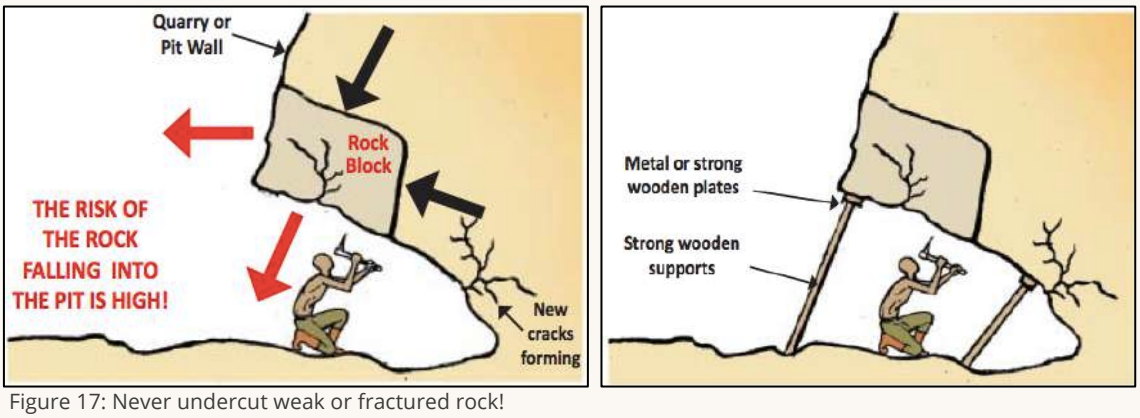


Figure 17: Never undercut weak or fractured rock!
If you must undercut rock, use timbers and strong wooden or metal plates to prevent it from collapsing.
(Cited in: Hinton et al, 2009; Adapted from Walle and Jennings, 2001)

#3. Place waste rock at least 10 metres from the edge of the pit

Waste rock around the edges of a pit can add extra weight that can cause your pit wall to collapse! It can also fall into the pit and injure workers or block your access to the ore.

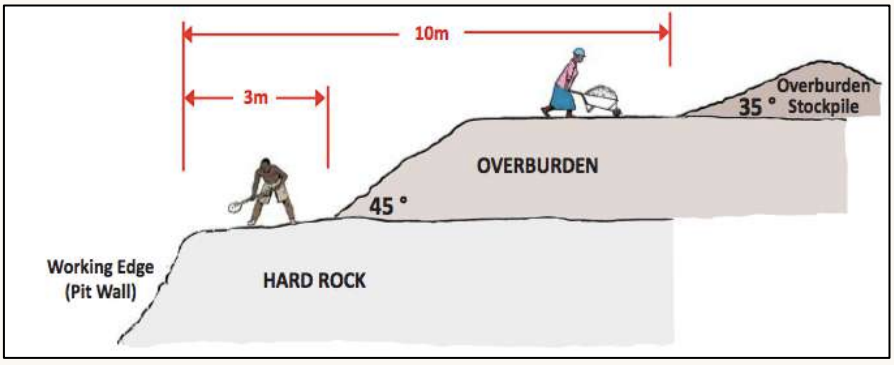


Figure 18: Place waste rock and overburden at least 10metres from the edge of your pit
(Cited in: Hinton et al, 2009; Adapted from Walle and Jennings, 2001)

#4. Remove loose rocks and soils to prevent accidents before they happen

Loose rocks and loose soils can fall into the pit and injure workers. If you find large loose rocks, loose soils, or cracks around the pit edge, tell everyone to get out of the pit. Work with 1-2 miners and use long poles and (for soils) spades to push the rock or soils into the pit. Make sure all of these hazards are removed before workers return into the pit.

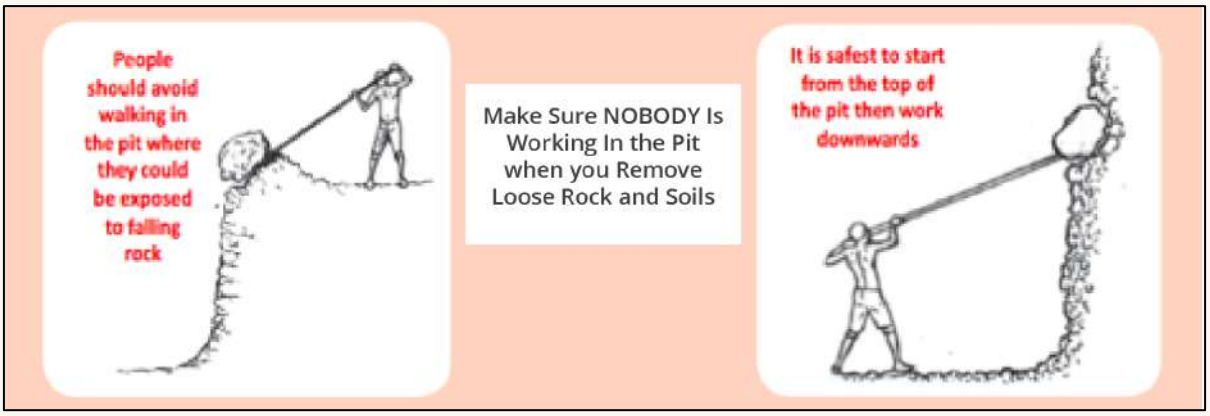


Figure 19: Carefully remove loose rock and soils to prevent them from injuring workers later
(Cited in: Hinton et al, 2009; Adapted from Walle and Jennings, 2001)

5.2 UNDERGROUND MINING

Digging tunnels and shafts underground is even more dangerous than surface mining. Underground mining carries a high risk of death and injury from rock falls, tunnel collapses, and poor ventilation.

To prevent and manage these risks, a responsible miner should:

1. Use timbers or stones to help prevent tunnels and shafts from collapsing;
2. Collar and cover the shaft/tunnel opening to keep it stable and help keep rainwater out;

3. Promote airflow by using an air compressor and/or connecting tunnels underground; and
4. Never place fuel powered ventilator underground! This can cause asphyxiation.

#1. Support Tunnels in Weak Rock and Soils Using Timbers

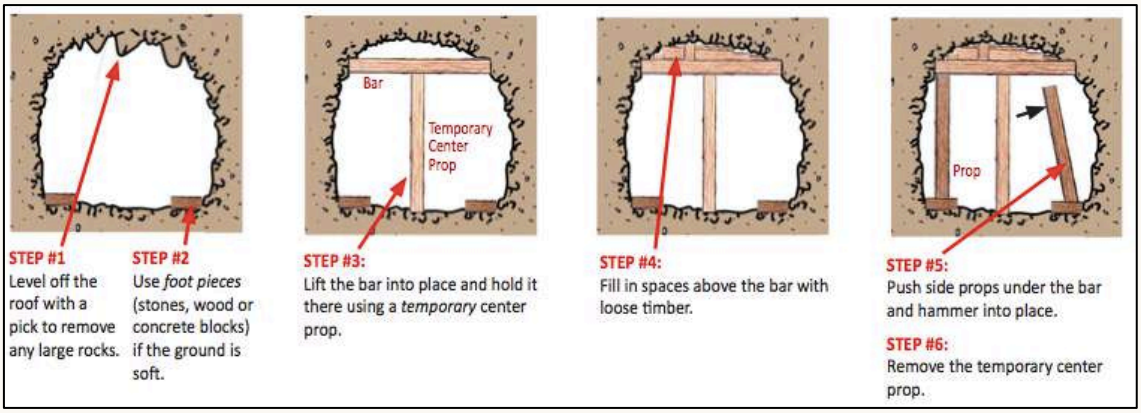


Figure 20: Basic steps in timbering (Source: Hinton et al, 2009)

Timbers are a very important investment for a responsible miner. To prevent tunnels and shafts from collapsing, use timbers *as you encounter* weak or broken rock. Figure 20 shows the basic steps in installing timbers. Adapt this depending on whether you are working on a steep or vertical shaft or a horizontal tunnel Figure 21).

Timbers are used in different ways depending upon the ground conditions (type and nature of rock). This can be different in different parts of the mine. In some places, waste rock or sandbags can also be used to create pillars to help tunnels from collapsing.

#2. Collar and cover your shaft to keep it stable and help keep rainwater out

Collaring involves using timbers, sandbags or sometimes *both* to make the mine entrance stable. Sandbags also help keep rainwater from entering the mine, especially when the mine entrance is covered. This requires a small investment but it will help you mine faster and more safely!

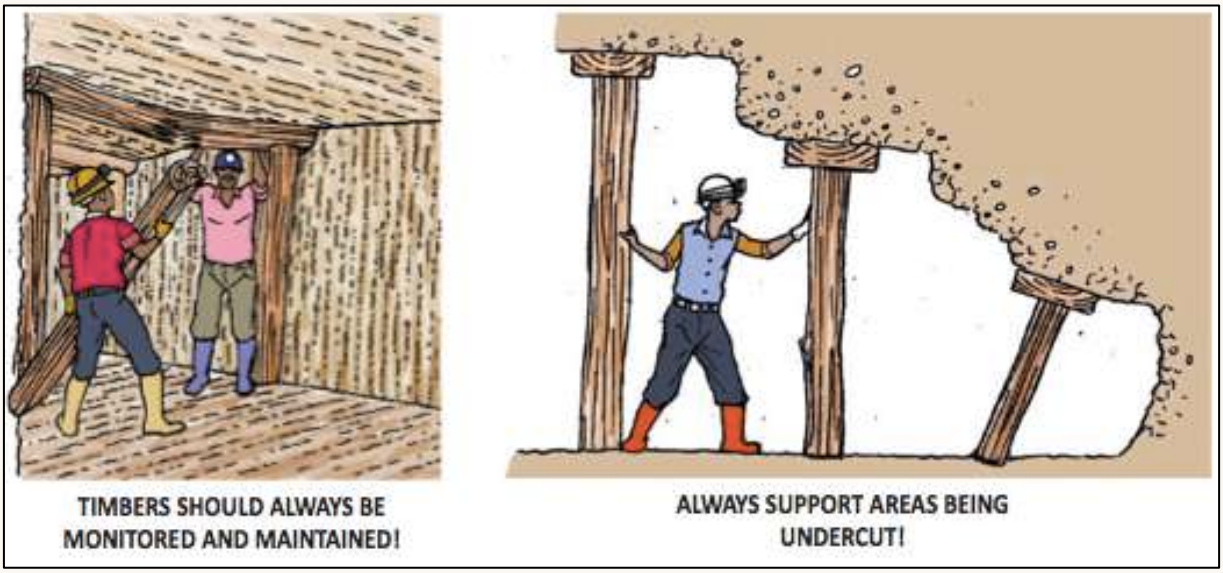


Figure 21: Timbering prevents rock falls and tunnel collapses
(Photos: J. Hinton; Figures cited in Hinton et al, 2009 and adapted from Walle, 2006)

Figure 22: Covering the mine entrance (left) and using timbers to stabilise the shaft opening (right) is important for safety and productivity of the mine (Photos: J. Hinton)

#3. Promote Airflow in Underground Shafts and Tunnels

Poor underground ventilation can stop miners from working or (for those who foolishly take the risk) result in death or other serious health issues.

Connecting two shafts or tunnels underground can help increase the flow of air.

It also provides an alternative exit for miners if a tunnel collapse occurs and can make hauling ore and waste rock from underground even faster.

Sometimes, it is not always possible to connect tunnels (for example, for very deep tunnels). In that case, miners will need to invest in *forcing air* underground.

Although it requires some investment, the easiest way to do this is using an air compressor with hoses. Make sure the hoses are checked regularly for holes and repaired immediately, and the air compressor is in good working condition and has sufficient fuel.

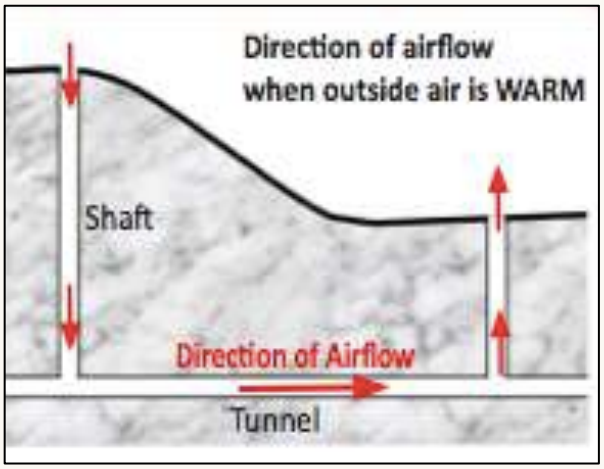


Figure 23: Connect a shaft at a higher elevation with a shaft at a lower elevation to increase airflow
(Source: Hinton et al, 2009)

SECTION 6: CRUSHING, GRINDING, AND SIEVING

Once you've identified gold-containing rock, it needs to be crushed from large rocks to a fine powder. This can take you several steps, utilising several different techniques for crushing, grinding, and sieving. By reducing the physical size of the large rocks, you expose more surface area. Exposing more surface area increases the probability of obtaining gold from the rocks by gravity concentration or other refining methods.

Several methods for crushing, grinding, and sieving rocks are presented below. Two key factors will indicate how many stages you'll need to go through: the size and shape of the gold grains, and the hardness of the rock.

The size and shape of gold grains found in your crushed rock will vary and can include: round, flat, coarse, or tiny grains. Depending on the size and shape, more stages of crushing or grinding can be necessary.

The table below lists rock types by their relative hardness or 'crushability'. As you can see, rocks with higher amounts of quartz – recall gold is often accompanied by quartz – are harder than many other rock types, and thus require considerable effort to crush:

Type of Rock	Hardness
Basalt	Very hard
Granite	
Quartz/quartzite	
Copper ore	
Iron ore	
Sandstone	
Limestone	Soft

6.1 MANUAL CRUSHING, GRINDING, AND SIEVING METHODS:

As an artisanal or small-scale miner you will employ a manual (non-mechanised) method of crushing and grinding the rocks to produce gold ore.

If the rocks are large to begin with, a common method for sizing them down to fit into a stamp mill or ball mill for grinding is crushing. You first place the oversized rocks (larger than 5cm) on a large flat rock. A Hessian or nylon ring can be placed around the oversized rocks to hold them in place while they are hit with a hammer and broken up into 1 cm (or smaller) pieces. You can then use a piece of stone to grind the newly crushed

rocks. Through this process, you will reduce the material to 0.5mm - 1 mm pieces. This coarse material can then be ground using one of the methods described below to produce even finer pieces.

Figure 24: Miner in Mozambique crushing with a sleds hammer (Photo: J. Tychsen)

Figure 25: Miner in Mozambique crushing and grinding with mortar in Mozambique (Photo: J. Tychsen)

Mortar

Crushing and grinding can be achieved in a batch fashion with a pestle and mortar. What you use for a mortar and for a pestle can vary. For example, some miners place pre-sized rocks in a steel bowl with a rounded bottom or in a short length of wide pipe welded onto a steel plate (this is the mortar), and then pound the rocks with a steel rod such as an automobile axle (this is the pestle).

Figure 26: Miners in Ethiopia crushing and grinding with mortar.
The crushed material are sieved. Material not passing the sieves are crushed again (Photo: J. Tychsen)

Manual ball mill (fine grinding)

You can make a small ball mill from a simple steel container such as a gas cylinder or a steam pipe. The cylinder should have a small, sealable door where the rocks and steel balls are put into the container. A hand crank is attached or welded to the container so that it can be turned. The container is often raised off the ground on wooden trestles or forked timbers. As you turn the manual ball mill, the rocks bump against the steel balls, grinding the ore finely. Note that the balls don't have to actually be steal, but can be any number of things as long as they are of harder material than the rocks.

Figure 27: Small manual ball mill used in Mozambique
(Photo: J. Tychsen)

Figure 28: Loading steel balls into a manual ball mill
(Photo: M. Veigo)

Figure 29: Different kinds of "balls" for a manual mill
(Photo: J. Tychsen)

6.2 TYPES OF MECHANISED EQUIPMENT

Different types of mechanised equipment are better for different stages of crushing and are often used in combination with manual techniques. Mechanised crushing typically occurs through the pinching of a rock between two metal plates (jaw, gyratory, or cone) or through the impact of a metal surface on a rock (hammer mill and stamp mills). The following are common types of mechanised crushers used in gold mining:

Jaw crusher

Jaw crushers are common in artisanal gold mines. A small crusher operating in batches of 5 to 10 tons of ore and handling 500 kg/h to reduce it to 6.5 mm is suitable for most artisanal mining operations.

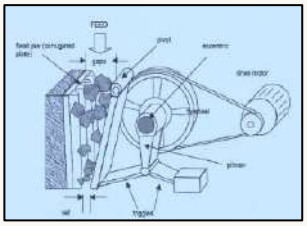


Figure 30: Drawing of a jaw crusher
(Photo: J. Tychsen)

Figure 31: A small-scale miner feeding a small jaw crusher
(Photo: M. Veigo)

Figure 32: Photo of jaw crusher (Photo: MBMM)

Figure 33: Photo of the crusher's jaws (Photo MBMM)

Hammer mill

A hammer mill is commonly used to crush hard rocks. In a hammer mill, pivoted hammers are mounted on a rotating shaft and crushing is achieved as the rocks break on impact with the hammers and the fixed breaker plates mounted in the mill frame. The speed of the hammer mill can be anywhere from 500 – 1800 rotations/min.

Figure 34: Photo of hammer mill (Photo: MBMM)

Figure 35: A pivoted hammers mounted on a rotating shaft (Photo: MBMM)

6.3 GRINDING WITH AN AUTOMATED TUMBLING MILL

Grinding is undertaken after the material has been crushed to achieve a particle size fine enough to liberate the most gold possible. You will typically grind the material with some sort of tumbling mill: a round metal barrel driven either manually or mechanically and filled with a grinding media such as steel balls, rods or hard pebbles. Grinding can be undertaken dry or wet.

Figure 36: Diesel driven octagonal wooden dry ball mill in Mozambique (Photo: J.Tychsen)

SECTION 7: HOW TO GET MORE GOLD BY USING SLUICE BOXES[1]

Sluice boxes are easy to use, cheap to construct locally, and are used by gold miners all over the world. By using a sluice box, you can wash ore *much faster* than by panning alone. Sluice boxes work best when you can dig a lot of ore in a day and there is a lot of water nearby.

7.1 WHAT IS A SLUICE BOX?

A sluice is a wooden or metal box that is lined with carpet, burlap, or mats at the bottom.

- If gold is coarse (e.g. about the size of a matchstick head or bigger), a sluice box will also have "*riffles*" that help to keep the carpet/mats flat and trap more gold.
- Riffles are pieces of wood, bamboo, or metal inserted at 10-20cm spaces between them. Each riffle should be about 2.5 cm high.
- One side of the box (where the ore and water are *fed*) must be higher than the other side. A sluice is usually at an angle of 5°-15°.
- Water and ore are fed into the higher end of the sluice. As the water and ore flow down, **heavier gold** and black sands settle to the bottom and are trapped in the carpet/mats or riffles as light waste minerals (like quartz) are washed away off the end of the sluice.

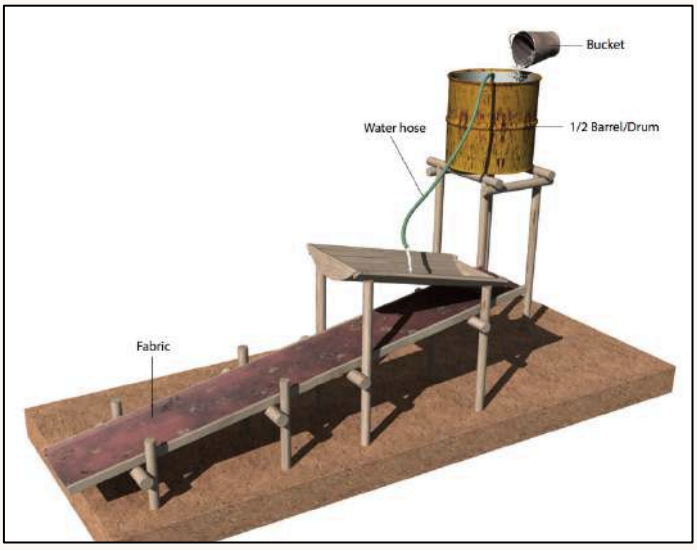


Figure 37: A typical sluice box (Source: P. Appel)

[1] This section extracted and adapted from Hinton et al, 2009, *Small Scale Mining Handbook: A Guidebook for Advancing Artisanal and Small Scale Mining in Uganda*, New Vision publ., 436p.

7.2 TYPES OF SLUICE BOXES

You should use different types of sluices depending on your resources, the gold type, the amount of ore you want to process, and the availability of water at your site. Generally speaking:

- Use a narrow sluice (25-35cm wide) *if* you have very little water or pulverized ore.
- Use a wide sluice *if* you have a lot of material to process (e.g. alluvial or tailings) *and* a lot of water.
- Sluices should always be about 1.8-2 metres long.
- Use higher riffles (1.5-2 cm) for coarse gold and short riffles (0.5-1.5 cm) for fine gold.
- Sluices can be wooden or metal. Wooden sluices are cheaper and easier to make locally, but metal sluices last longer.
- A "ground sluice" is also sometimes used. It is basically a channel cut into the ground, usually within or just next to a river. Because it is difficult to use carpets and adjust the angle, ground sluices usually don't work as well as sluice boxes.

Figure 38: Narrow, long sluice with only mats (no riffles). This is used when there is very little water and ore (pounded powder)
(Photo: M. Veiga)

Figure 39: Wide, long sluices are used when there is a lot of water and a lot of material (e.g. tailings or sediments from a river). A water pump is needed. (Photo: M. Veiga)

Figure 40: Ground Sluice. These are much less efficient than sluice boxes but can be made using a simple shovel (Photo: J. Hinton)

7.3 HOW TO USE A SLUICE BOX

There are three main steps in using a sluice box. The method below is used when a water pump is not available. For most sluice boxes, you'll need 3-4 people working together in a team.

Step One: Feed Ore and Water into the Feeder Box

The feeder box is a small wooden box or plastic basin that is located at the higher end of the sluice.

- One person directs the hose from the water tank into the mixing area. If a water pump or tank isn't available, two people can manually feed water into the mixing box to keep adding water *at a constant, steady rate.*
- One person slowly shovels ore into the mixing area.
- One person removes large stones as he/she hand mixes the contents of the box.

The water-ore mixture passes from an opening in the feeder box or basin across a screen to capture small stones that were not removed during hand mixing. The person shovelling the ore may be able to remove these..

Figure 41: Feeding the Sluice Box. (Photo: J. Hinton)

KEY REMINDERS:

- **Make sure that the carpet or mat is firmly secured** to the bottom of the box when the sluice is being used.
- **Know how long you should continue to feed the sluice box with ore and water**
  - For ore that has been crushed/pounded, continue feeding the sluice box for about 1 hour.
  - For ore that is not crushed/pounded, but is dug easily from soils or sediments, continue feeding for 1.5 - 3 hours[2].
- **Always mix the ore and water thoroughly in the feeder basin**. Make sure that larger stones are removed!
- **Add water at a constant rate** throughout operation. The water level should be about 2.5-3 cm high in the sluice box at all times.

[2] For mechanised sluicing using water pumps and where large amounts of ore are available, then operations might continue for many hours (e.g. 5-8 hours).

Step Two: Feed ONLY Water into the Feeder Box

Once a batch of ore has been fed into the sluice box, continue to add ONLY WATER for at least two or three more basin-fulls.

Figure 42: A woman miner continues to put water only in the feeder box

Step Three: Clean Out the Gold Concentrate

To recover your concentrate from the sluice box:

- Block off the open (lower) end of the sluice box with a piece of wood;
- Pick out any larger stones that may have entered the sluice and set them aside;
- Carefully remove any riffles that may be in your slice and rinse them with a bit of water into the panning basin;
- Carefully remove the carpet/mat and place it in a basin or plastic drum. Make sure none of the concentrate falls on the ground;
- Wash the carpet/mat carefully with water by hand or with a hose to remove all the concentrate into the basin;
- Sweep out the bottom of the sluice box to collect any concentrate that might remain; and then
- Pan the concentrate collected from the riffles, carpet, and bottom of the sluice to recover your gold.

7.4 IMPORTANT TIPS FOR TRAINERS

When you are teaching gold miners, remember to:

- **Give hands-on training to the people most affected**. Women are mainly doing panning and hauling water in Ethiopia. Make sure you give them enough time to ensure that they are comfortable using the sluicing methods.
- **Make sure that the carpet or mat is firmly secured** to the bottom of the box as the sluice is being used.
- **Always mix the ore and water thoroughly in the mixing box**. Make sure that a screen is always used and larger stones are removed! If the ore is *not* screened than gold recovery will be very, very poor.
- **Always screen the ore**. For ore that is crushed/pounded into powder, use a fine mesh. For ore that is dug directly from soils and sediments near to and within sediments, use a coarse screen (e.g. 1cm holes) or basin with small (2-3mm) holes punched in the bottom. If the ore is *not* screened than recovery will be very, very poor.
- **Adjust the angle to find the best performance**. The angle of the sluice box depends on the *size* of gold at a site and availability of water.
    - For coarse gold, the angle can be steeper (usually between 10**°**-15**°**).
    - For finer gold, the angle can be shallower (usually between 5**°**-10**°**).
    - Try different angles to see which one gives the best gold recovery!
- **Make sure that tailings are <u>not</u> discharged directly into rivers and streams**. Sluicing should *only* be done in offshore pits to protect the environment and human health! See Section 8: Environmental Management for advice.
- Consider using a Zig-Zag sluice to capture both coarser and finer gold. The first (higher sluice) should use a steep angle (to capture coarser gold). For finer gold, the angle can be shallower.

Figure 43: A Simple Zig-Zag Sluice Box. Adjust the angles of each box. The first box should be steeper (to capture coarser gold) and the second box shallower (for fine gold). Use wire mesh to help keep mats/carpets secure.

SECTION 8: ENVIRONMENTAL MANAGEMENT FOR ASGM

Training objectives of this module are to help build competence on:

- Identification of environmental impacts of artisanal mining;
- Design and implementation of environmental management plans;
- Environmental monitoring;

8.1 DEFINITION OF KEY CONCEPTS

Environment: according to Marie-Louise Larsson, the legal definition of 'environment' must include: a) ecosystems and their constituent parts; b) all natural and physical resources; and c) the social, economic, aesthetic, and cultural conditions which affect the environment or which are affected by changes to the environment. (Marie-Louise Larsson, 2010)

Environmental Impact: The degree of change in an environment resulting from the effect of an activity on the environment, whether desirable or undesirable. Impacts may be the direct consequence of an organisation's activities or may be indirectly caused by them. (EPA, 2000)

8.2 ENVIRONMENTAL IMPACTS OF ASM

Mining and mining waste can affect the environment in a number of ways: physical properties, chemical and mineralogical composition or reaction, its volume and area covered, as well as the waste disposal methods employed. Some common impacts include:

- Disturbance of surface matter resulting in increased erosion risk;
- Contamination of site, ground water and environs caused by:
    - Release of toxic elements used in mining, and
    - Release of toxic by-products of mining;
- Air pollution from gaseous emissions;
- Loss of flora and fauna; and
- Increased risk of accidents.

Mining affects the environment through various processes from exploration to digging and beneficiation stages. Here we concentrate on impacts that emanate from the *direct* effect of the mining process, through activities such as:

- **Prospecting** e.g. prospecting holes dug to find quartz veins containing gold;
- **Transport** e.g. cutting down of flora along transportation routes; and
- **Processing** e.g. washing of ore.

The diagram below demonstrates some of the impacts that artisanal mining can have on the environment from the point of discovery of the mineral of interest to the point of sale (BRGM, 2001).

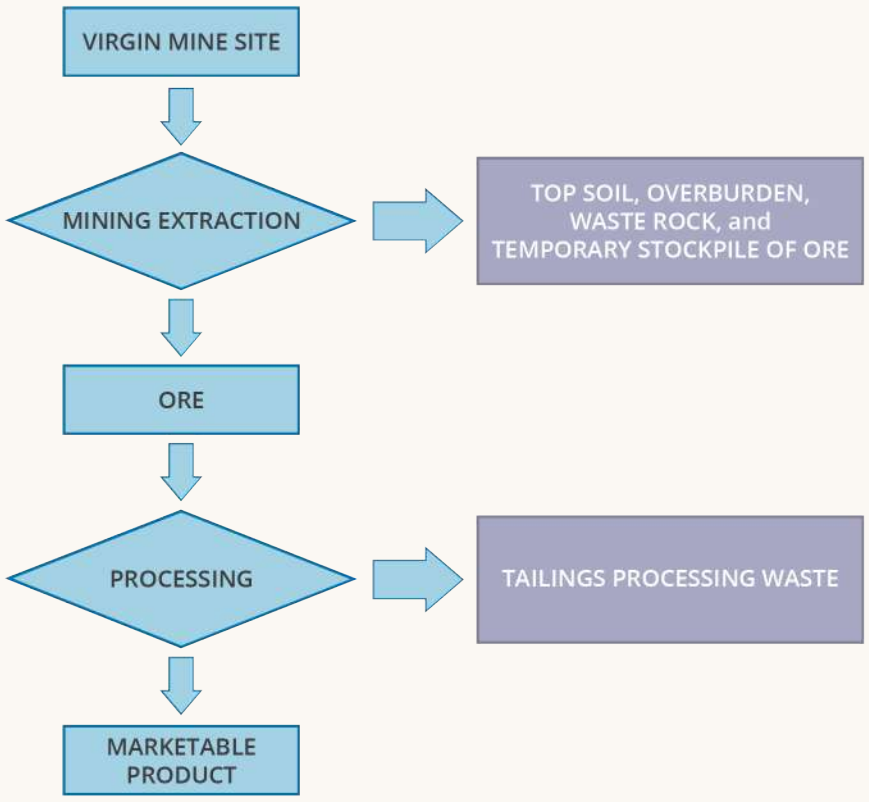


Figure 44: Mining waste types

The impacts that are commonly found in ASM are discussed below. The Environmental Management Plans that follow can inform how you deal with these impacts and issues:

8.2.1 Deforestation and Forest Degradation

When gold deposits are found in forests, they are frequently cut to give way for the digging of pits, for construction of residential or working premises, for fuel for cooking and in some cases for processing the ore and the manufacturing of hand tools.

Unfortunately, replanting is rarely planned to make up for the trees that were cut down. The result is devegetation or deforestation.

Figure 45: Devegetation and soil disturbance due to ASM (Photo: T. Andualem)

8.2.2 Mining Waste

The mining cycle is likely to produce waste at two phases: in the initial phase, while removing the over-burden, and during the processing phase, in the form of tailings. Apart from displacing land that could be used by other economic activities, removed overburden can also increase the turbidity of water in the streams and increase sedimentation, both of which can be detrimental to aquatic life.

Waste produced during the mining and processing operation (tailings) can have a number of adverse environmental impacts due to its physical and chemical properties.

8.2.3 Impacts on Water Resources

The most significant impact a mine can have is its potential effect on water quality and availability of water resources within the project area and / or downstream. Potential impacts on water resources include:

- Acid mine drainage and contaminant leaching;
- Impacts of tailing impoundments, waste rock, heap leach, and dump leach facilities;
- Erosion of soils and mine wastes into surface waters; and
- Knock on impacts of mine dewatering.
- Key questions that must be asked prior to commencing and throughout your mining operations include:

- Will the surface and groundwater supplies remain fit for human consumption based on the mining processes used?
- Will the quality of surface waters in the project area remain adequate to support native aquatic life and terrestrial wildlife? (Environmental Law Alliance Worldwide, 2010).

Figure 46: Tailings dumped in the open. They will be washed leading to acid drainage (Photo: T. Andualem)

8.2.4 Impacts on Air

Potentially poisonous gasses can be released during drying, roasting, and smelting operations of the beneficiation process. This can be harmful to both the environment and health of the local community.

8.2.5 Impacts on Wildlife

Impacts on wildlife can arise in the case of habitat loss or fragmentation due to the deforestation of the area for mining development. Moreover, with the influx of people to the mining site (caused by in-bound migration) predators such as dogs can increase in number, potentially threatening vulnerable species in the area.

8.2.6 Impacts on Soil Quality

Mining can contaminate soils over a large area. Agricultural activities near a mining project may be particularly affected. Mining operations routinely modify the surrounding landscape by exposing previously undisturbed earthen materials. Erosion of exposed

soils, extracted mineral ores, tailings, and fine material in waste rock piles can result in substantial sediment loading to surface waters and drainage ways. In addition, spills and leaks of hazardous materials and the deposition of contaminated windblown dust can lead to soil contamination (Environmental Law Alliance Worldwide, 2010).

Figure 47: The disturbed soil is prone to erosion; note the erosion marks (photo: T.Andualem)

8.3 IMPACTS OF MINING PROJECTS ON SOCIAL VALUES

Mineral development can create wealth, but it can also cause considerable disruption. Mineral activities must ensure that the basic rights of the individual and communities affected are upheld and not infringed upon. These must include the right to control and use land; the right to clean water, a safe environment, and livelihood; the right to be free from intimidation and violence; and the right to be fairly compensated for loss. While social impacts can be diverse and extensive, some critical to consider include:

8.3.1 People

Migration of people is very common wherever there is artisanal and small-scale mining, as the mine is often the single most important economic opportunity in the area for a large number of people. Consequently, a large influx of people can lead to pressures on land, water, and other resources as well as bringing problems of waste disposal.

In many instances, women are precluded (by themselves or another party) from participating in certain aspects – such as the digging of mines – for a range of reasons. The work could be perceived to be too arduous or there may be a fear of sexual abuse or exploitation. As a result, women will seek alternative (often less lucrative) livelihoods in

connection with ASGM. For example, a woman might sell food and beverages to the miners or participate in commercial sex work.

8.3.2 Cultural Resources and Cultural Clashes

Migration immediately following the development of mine sites brings people from different geographies and cultures to one site. Those who are not 'local' may not understand or value what is culturally important or what is culturally acceptable / unacceptable. Meanwhile, 'local' populations may resent the arrival of the not-local person. This situation creates the potential for the migrant population to enter into serious confrontations or violent clashes with the host community

8.3.3 Livelihoods

Mining can contaminate various natural resources including water, soil, and forest, which were easily accessed and utilised by the community prior to the mining's commencement. If the contamination results in scarcity of these resources or damage to grazing and farmland it can become a source of (violent) conflict. In some areas, the indigenous population may be highly dependent on their environment for their very survival: living by activities such as hunting. In these cases, even a relatively mild impact could produce a catastrophic consequence on a community's livelihood.

8.3.4 Health

Health impacts can be caused by the exposure of the community to increased level of hazardous and toxic chemicals or poisoning to crops and livestock. Poor management of the mine site can also lead to increased risk of accident. Migration can also increase the risk of communicable diseases such as water borne, sexually transmitted infections including HIV/AIDS, and respiratory illnesses.

8.3.5 Assets

Mining can result in a loss of access to land, including forest, agricultural land, and water resources. Loss of access may be caused by *direct* or *indirect* impacts of mining, for example:

- Land directly licensed to miners following the discovery of a deposit;
- Pollution of agricultural land and potable water;
- Transport routes carving through the existing land parcels; or
- Deforestation.

8.3.6 Access to Clean Water and Fuel Wood

As mentioned above, mining can lead to deforestation that reduces the forest resources of an area and also the quantity and quality of water people are using for home consumption. This can be a significant source of tension between communities. In traditional communities, since it is mainly women who are responsible for collecting water and fuel/wood, the impacts of the depletion of these resources may do more and immediate harm to women and girls than men. For example, depletion of forest/wood can increase work burdens when a woman must travel farther and wider for access to the same resource.

8.3.7 Physical Injury or Death

Poor environmental and health and safety mine site management can lead to increased risk of injury or death for miners and members of mining communities.

For example, mining pits are often not filled following exploitation. This can lead to an increased risk of accidents, especially during the rainy season when the grasses grow and obscure the mine pit openings. The hazard can be acute for humans, livestock, and wildlife alike!

As described in Section 5 (extraction), digging in pits can present a direct threat of pit collapse to miners, especially when timbering or stairs are not used to support the pits. In addition, aeration is often insufficient in pits, especially where there is only one vertical shaft, which limits the supply of oxygen to the miners creating a risk of asphyxiation.

8.4 ENVIRONMENTAL MANAGEMENT IN ASGM

8.4.1 Environmental Impact Assessment

Please note: *As described in Section 2 of the manual, Artisanal Mining titleholders are not required to produce an environmental impact assessment (EIA). However, as part of the application process for a Small-scale Mining Licence miners are expected to submit an EIA. This section is therefore informative when considering how to transition from artisanal to small-scale mining.*

An EIA is a multidisciplinary, comprehensive, and detailed study of the expected significant interactions between a proposed development (mining in our case) and the environment within which it is to be implemented. It is mostly used when the potential adverse impacts of a project or an activity are believed to be significant. An EIA identifies the major impacts of a mining activity to be done in an area, what measures could be taken to reduce the negative impacts and enhance the positive impacts, who should monitor the impacts, and who should implement the mitigation measures.

An EIA should be undertaken at the planning or early design stage, or when planning to scale-up on-going activities. This permits the integration of environmental mitigation

activities directly into your mining activities. The EIA process is shown in Figure 48 below. Please note that the community's participation throughout the process is crucial. Your EIA should never be finalised without formal stakeholder participation.

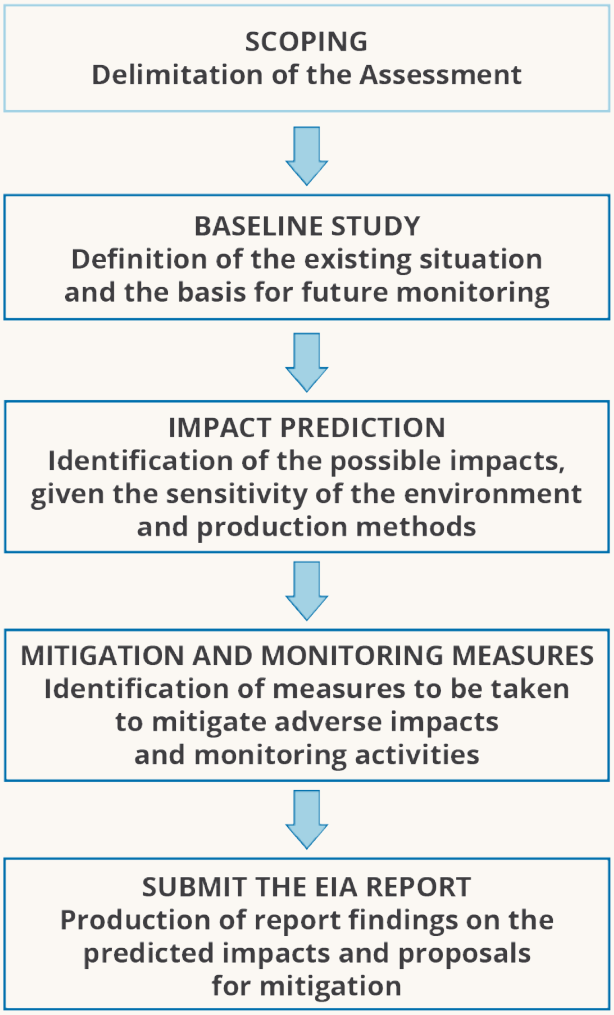


Figure 48: EIA process

8.4.2 Water Management

WATER MANAGEMENT IN UNDERGROUND AND SURFACE MINING

Water that passes through active mine sites is vulnerable to acid drainage, increased turbidity, and an increased load of heavy metals. Since water is not easily contained (and in the case of some alluvial mine sites the mining itself is conducted in active waterways) this can lead to the pollution of waterways and areas well beyond the immediate mine site.

Good water management will significantly reduce negative environmental impacts of mining!

Due attention needs to be given to good water management during mine development, operation, and closure.

Various control techniques can be used to reduce the likelihood of significant water contamination and the various health and community impacts associated with it. The primary objective is to reduce water contact with overburden, ore, and tailings, which can be done through:

- **Establishment of a diversion of surface water** from runoff or rivers entering the mine site. Building diversion ditches or dams can reduce the potential for water contamination from exposed ore and waste rock;
- **Use of covers and lining on waste rock and ore piles;**
- **Containment of water leaving the mining site** in a lined pond or dam to prevent the contamination of ground water through seepage; and
- **Recycling and reuse of water used for processing ore** in order to reduce the volume of water requiring treatment.

You may use one or more of the above strategies depending on the material situation at the mine site and your financial and technical capacity.

WATER RECYCLING AND REUSE

As discussed above, water coming from a mine area is at risk of having been contaminated.

Water is one of your scarcest and most precious resources as an artisanal miner in Ethiopia, especially during the dry season. Water reuse and recycling can help reduce the amount of water needing treatment, ease the burden of water collection, and increase the availability of potable water.

Since it is often women who collect water for processing gold and domestic use, careful management of water resources can help to reduce this labour burden on women.

You can recycle water by allowing processing water to settle in a settling pond for some time so as to reduce its turbidity. You will need to clean these ponds from time to time for effective service. In some parts of the country, such as the Konso area, people stir the water with sticks from certain plants to speed up the settling process. If that is not possible, letting the turbid water settle by itself can also make it suitable for reuse.

8.4.3 Waste Management

Mining waste is principally made up of mining bi-products, of which the over-burden (removed to reach ore in the extraction process) and tailings (bi-product of processing ore) are significant contributors.

Improper disposal of coarse mining waste can cover large areas of land that could otherwise be used for productive purposes. Alternative methods of mining waste disposal include:

- Terrestrial impoundment, such as using tailings / settling ponds;
- Underground backfilling – putting the waste back from where it came;
- Deep water disposal, where large bodies of water (lakes and sea) permit; or
- Recycling – use of waste for alternative purposes e.g. construction.

WASTE ROCK

You can commonly find waste rock at an active or an abandoned mine site. Waste rock is that which is disturbed during the mining process and therefore is prone to erosion. It can be a significant source of pollution for surrounding land and water resources.

How you will manage the inevitable waste rock from your mining operation should be planned early on in the mining cycle. You should take into account the environmental sensitivity of the area, future land use opportunities, and the financial and technical capacity of the miners.

Wherever possible, contact between waste rock and floodwaters should be avoided! Covering the waste rock with topsoil will encourage plants to grow, reduce erosion, and prevent leaching risk associated with waste rock.

Backfilling is one of the best ways to deal with waste rock. Simply dump the waste rock back into the pit you previously mined. This also contributes to mine site restoration!

TAILINGS

Tailings are bi-products of the processing phase of the mining process e.g. soil and rock etc. that are left over once the mineral has been extracted from the ore. Managing the discharge is very important as chemicals and other natural waste products are often found in tailings. For example, sulphide rich waste rocks can oxidise and lead to acid drainage issues.

If left to build up, tailings can have a number of short and long-term environmental impacts, including:

- Contamination of surface and ground waters;
- Dam safety and stability (if water diversion is being used);
- Dust (especially in the dry seasons); and
- Blocking of waterways.

Maintenance and stewardship plans are therefore necessary to manage tailings!

One easy, efficient, and environmentally friendly way of dealing with tailings is to dry it out and use it to backfill pits. This is called dry tailings disposal.

Figure 49: Improperly Managed Mining Waste Leads to Acid Drainage and Related Pollution (photo: T.Andualem)

Most mining in Ethiopia is of placer gold (gold found by a river or stream). Where it is not, water is scarce and the infrastructure required to transport it to the extraction site is costly. Therefore, in the case of hard rock deposits or alluvial deposits found at a distance from the present riverbed, ore is often manually transported to streams, rivers, or ponds for processing. Riverbanks and other natural water sources then become tailings dumping areas, which can have a serious impact on human health as well as livestock (that may drink the water), fish, and other wildlife.

Solutions to mitigate negative impact include:

- Storing wet tailings in lined ponds to protect against the acids and chemicals polluting the ground water and to avoid unnecessary run off; and
- Processing ore away from the natural water stream through the use of water pumps and sluices. Tailings can then be stored in lined ponds or dams.

8.4.4 Reclamation Methods

Mine site reclamation can allow communities to effectively reuse mined areas. Finding a use for land that would otherwise become abandoned can bring value to the mining community and offset negative impacts. Reclamation can be as simple as returning a mine site to its natural (or close to its natural state) so that wildlife can flourish, or transforming it into a site appropriate for industrial or agricultural purposes (where possible).

Mine reclamation planning starts before mine operations begin. If you are considering a mine site that is already active, the sooner that miners think about reclamation the bet-

ter. Starting a reclamation project after the mine has closed will be too late – irremediable damage is likely to already have occurred!

Key considerations for successful mine site reclamation include:

- Reclamation should be planned early, preferably before mining even begins;
- Reclamation can be integrated into mine management plans (e.g. health and safety planning). For example, material dug in one pit can be used to backfill another pit, thereby ensuring both effective safety and environmental management.
- When extracting, top soil should be kept separately from the subsoil, parent material, and waste rocks;
- When backfilling a pit, subsoil should be back-filled first and once it has settled (after several months with some rainy days) topsoil should be added to "top-up" the pit. Topsoil is a nutrient rich and vital soil in which plants can flourish. Where possible, add manure or compost to speed up the reclamation process;
- Once the topsoil is replaced, the area should be planted with indigenous multipurpose (leguminous) trees, shrub, and grass species. If in doubt about this step, you can consult kabele or woreda officers (agricultural) for recommendation on this step of the reclamation process.
- You should now have produced a living ecosystem! Remember that regular habitat management techniques apply and will help the ecosystem to thrive. For example, techniques such as weeding, cultivation, pruning, or thinning should not be neglected as they encourage plants to grow. For best results, leguminous plants should be ploughed in just before they set seeds.

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The publication of this manual is the product of an extensive participatory research and practical pilot training programme. The technical training manual focusses on adult learning techniques that maximise participation and learning-by-doing, empowering participants with the Knowledge, Skills and Attitudes (K-S-A) to build capacity in technical content as well as increasing knowledge and skills to become gender-responsive trainers and have the attitudes needed to support future action by trainees.

The manual is intended for use by a variety of audiences: A non-exhaustive list of the potential users is as follows:

- The Artisanal and Small-Scale Mining Department of the MoMPNG

- MoMPNG Directorates working closely with the ASM, Environment & Community Development, Gender, Artisanal Mining Production and Marketing, Public Relations and Communications Directorates

- Regional Mining Bureaus

- Local Woreda and Kebele Officers (Gender, Mining, Environment)

- Artisanal and Small-scale Mining Cooperatives / Women's Economic Strengthening Groups

- Artisanal and Small-scale Mining Communities