

This Artisanal and Small-Scale Mining (ASM) Handbook has been written and published in order to help improve the performance of the ASM sector in Zambia.

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 Zambia for the benefit of the country and its citizens.

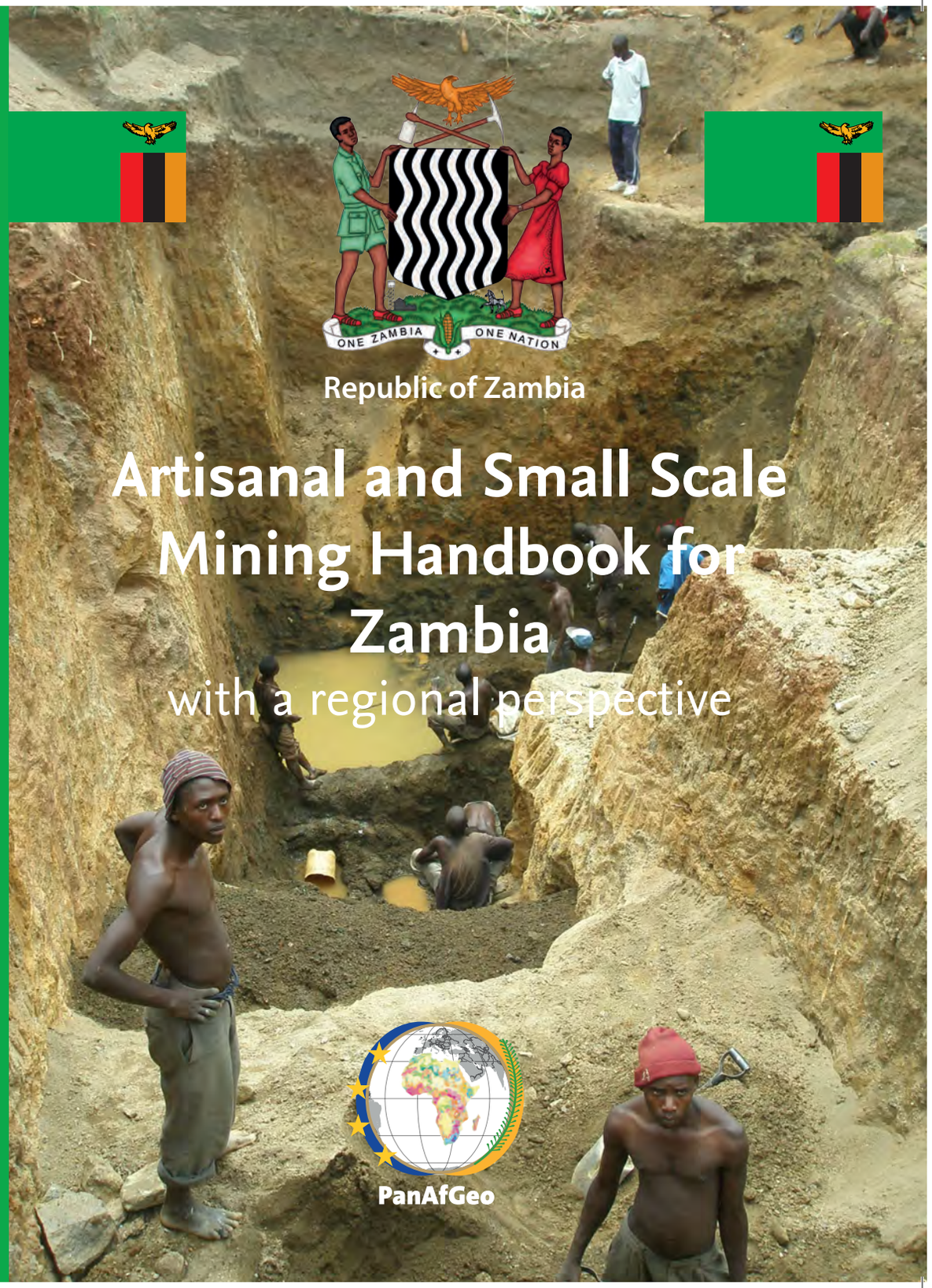
This ASM Handbook covers areas, such as:

- 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

Co-funded by the European Union and by the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF).

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Artisanal and Small Scale Mining (ASM) Handbook for Zambia with a regional perspective



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THE REPUBLIC OF Zambia

Ministry of lands and Natural Resources

Artisanal and Small-Scale Mining Handbook for Zambia

Edited by the
Geological Survey of Denmark and Greenland
April 2018

GEUS

PanAfGeo
Geoscientific Knowledge & Skills in African Geological Surveys

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The Pan-African Support to the EuroGeoSurveys-Organisation of African Geological Surveys Partnership, abbreviated to PanAfGeo, is a project, which supports training of geoscientific staff from African Geological Surveys through the development of an innovative training program. This specific training program, conducted by world-class geoscientific experts from Africa and Europe, includes the acquisition and development of important professional skills that complement geoscientific staff members' technical qualifications.

The PanAfGeo project allows trainees to acquire a state-of-the-art geoscientific tool kit, to learn new and relevant research methods on geology, and to take part in field trips covering eight geoscientific domains.

This Artisanal and Small-Scale Mining (ASM) Handbook for Zambia is the result of a training session held in Zambia in March 2018 through the sub-program on ASM under the overall PanAfGeo project.

The ASM sub-program is co-funded by the European Commission's Directorate-General of Development and International Cooperation (DG-DEVCO), the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) and the Geological Survey of Denmark and Greenland (GEUS).

The ASM subprogram in Zambia is implemented in cooperation with the ACP-EU Development Minerals Programme, which is an initiative of the African, Caribbean and Pacific Group of States (ACP), coordinated by the ACP Secretariat, financed by the European Commission (EC) and the United Nations Development Programme (UNDP), and implemented by UNDP. In Zambia, the ACP-EU Development Minerals Programme is implemented with the support of the Ministry of Mines and Minerals Development.

GEUS, acting as the editor of this ASM Handbook for Zambia, is solely responsible for all results and conclusions presented, which do not necessarily reflect the positions of DG-DEVCO and IGF. However, each individual author is responsible for the scientific content of his/her chapter.

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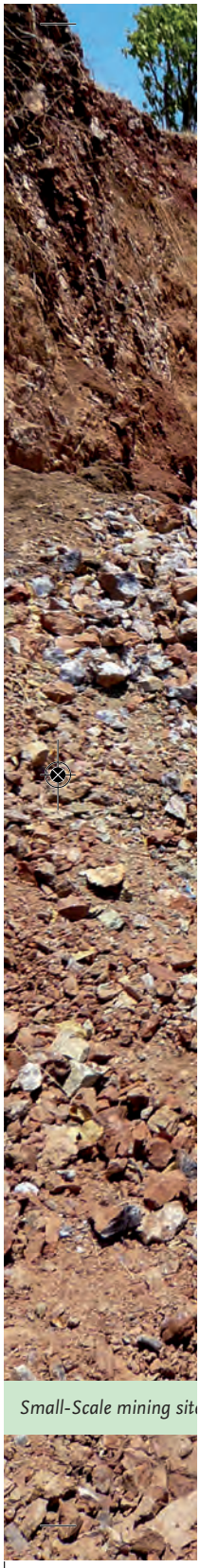
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ABBREVIATIONS

ACP	African, Caribbean and Pacific
AIDS	Acquired Immune Deficiency Syndrome
AMV	African Mining Vision
ART	Antiretroviral Therapy
ASM	Artisanal and Small-Scale Mining
AZWIM	Association of Zambian Women in Mining
CGS	Council of Geoscience
CSO	Civil Society Organisation
CSR	Corporate Social Responsibility
DG-DEVCO	Directorate-General of Development and International Cooperation
EC	European Commission
ECZ	Environmental Council of Zambia
EEC	Environmental Clearance Certificate
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPF	Environmental Protection Fund
EU	European Union
GDP	Gross Domestic Product
GEUS	Geological Survey of Denmark and Greenland
GSD	Geological Survey Department
HIV	Human Immunodeficiency Virus
IGF	Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development
ILO	International Labour Organisation
MC	Mining Claims
MCD	Mining Cadastre Department
MDD	Mines Development Department
MMA	Mines and Mineralisation Act
MPRDA	Mineral and Petroleum Resources Development Act
MSD	Mines Safety Department
NEMA	National Environmental Management Act
NEPL	Non-Exclusive Prospecting License
NGO	Non-Governmental Organisation
PanAfGeo	Pan-African Support to the EuroGeoSurveys-Organisation of African Geological Surveys Partnership
SDG	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SG	Specific Gravity
SSM	Small-Scaling Mining
SSMD	Small-Scale Mining Division
TB	Tuberculosis
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WP3	Work Package 3
ZEMA	Zambia Environmental Management Agency



Source: John Tychsen, GEUS.

Small-Scale mining sit

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Small-Scale mining site north of Lundazi

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Source: Kasper Steen Nørgaard

Victoria Falls at the border between Zambia and Zimbabwe

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FOREWORDS

Ministry of Mines and Minerals Development of Zambia

By Hon. Richard Musukwa, MP, Minister of Mines and Minerals Development



Source: EU Embassy of Zambia

Source: Kasper Steen Nørgaard

Zambia is endowed with a variety of mineral resources, which are exploited at both large- and small-scale operations. Artisanal and Small-Scale Mining (ASM) is mostly conducted by Zambians with immense potential to contribute to both job creation and economic development of the country. For this reason, the Government of the Republic of Zambia has since the early 2000s incorporated national development plans and programmes to develop the country's ASM sector. However, to date this potential has not been realised primarily due to the inability of ASM operations to operate as proper business entities. Furthermore, lack of access to geological and mining information has also inhibited the development of the ASM sector. To date, available geoscientific information has primarily benefited large-scale mining operations.

The 7th National Development Plan for 2017 to 2021 has prioritised the promotion of ASM as one of the strategies for job creation and economic diversification. Programmes to implement this strategy include: enhancing access to geological information by ASM workers; strengthening occupational health, safety and the environment of ASM operations; and skills development of ASM workers.

This ASM Handbook for Zambia, which constitutes the outcome of a training workshop on ASM held in Lusaka, Zambia on 19 to 22 March 2018, under the auspices of the PanAfGeo Project's Work Package No. 3 (WP3), serves as a guide and source of information on best practices to both regulators and workers of the ASM sector. The main objective of this training workshop was to upgrade the knowledge of geoscientific staff from Southern African Geological Surveys, the Ministry of Mines and Minerals Development, and other regulatory agencies of Zambia through the adoption of innovative techniques, relevant professional skills and tools, to improve the management of the ASM sector and thus realise its much talked about potential to contribute to both job creation and economic development.

This ASM Handbook is published at a time when the Government has prioritised the development of the ASM sector in order to achieve economic diversification and enhance job creation.

This ASM Handbook is a source of useful geological and mining information, such as: the critical role of the Geological Survey Department in the development of the ASM sector; the obligations of the Zambia Environmental Management Agency in relation to the de-

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velopment of the ASM sector; basic exploration, mining and mineral processing methods; value addition in the Development Minerals; occupational health, safety and environmental issues of ASM operations; business planning for ASM operations; and strengthening community voices in mineral resource governance in Zambia.

This ASM Handbook comprises contributions from experts from Southern African and European Geological Surveys, the University of Zambia, the Ministry of Mines and Minerals Development of Zambia, the Zambia Environmental Management Agency and the Zambia Development Agency.

I am confident that this ASM Handbook has come at a right time and I believe it will serve as a valuable guide and resource book to all stakeholders of the ASM sector, including ASM workers. I therefore urge all stakeholders to make use of this ASM Handbook and make sure that it remains a living document with regular updates on the sector. The Ministry of Mines and Minerals Development will ensure that the ASM Handbook is relevant at all times by keeping it updated on new technologies and processes applicable to the sector. It is my hope that this ASM Handbook will serve as a very useful tool to the ASM sector in Zambia.



Hon. Richard Musukwa, MP
Minister of Mines and Minerals Development

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FOREWORD

By H.E Ambassador Albert Muchanga



Source: Commissioner for trade and industry.

In the recent past, Africans have taken important steps towards galvanizing the continent's transformation and sustainable development. The new dynamism is laying a strong foundation for our prosperity and with it, skills development that is critically required to achieve the vision and objectives of the African Union Agenda 2063: the Africa We Want. Skills and capacity building are strategic elements of empowerment to fish. This is what the PanAfGeo projects is all about"PanAfGeo" which is a partnership project between EuroGeoSurveys and the Organization of African Geological Surveys (EGS and OAGS). It is working hand in hand with the National Geological Surveys for the training of geoscientific staff from African Geological Surveys. It is being implemented within the AU-EU Joint Partnership. It aims to increase African-owned geological knowledge and skills for sustainable mineral resource development, infrastructure development as well as natural disaster prevention and mitigation.

In 2009, the African Union Heads of State and/or Government endorsed the Africa Mining Vision (AMV) as a blue print for ensuring that mineral resources (gas, liquid and solid) play their transformative role in the social and economic transformation of African economies to foster inclusive growth and sustainable development. The AMV is one of the key instruments for achieving commodity based industrialization and job creation, which is of critical importance to our youth. Ultimately, the AMV will generate wealth for all African nations and their nationals.

The PanAfGeo project will strengthen the geological sector in Africa through capacity building of national geological surveys to deliver on their mandate; increasing the activities of national geological surveys in regional mapping and exploration; strengthening the level of geological knowledge and skills in national geological surveys and strengthening OAGS' potential to meet the needs of the African continent.

In this regard, I would like to thank the EGS and OAGS and more specifically Mr. John Tychsen, of the Geological Survey of Denmark and Greenland (GEUS) who is the Leader of Work Package Three (WP3) Training on Artisanal and Small Scale Miners (ASM), assisted by Co-Leaders: Mr. Daniel Boamah of Ghana Geological Survey Authority (GGSA) and Mr. Jules Cesar Yaganza of Central African Republic Geological Survey for the job well done.

The African Union Commission is committed to the integration of the ASM into Regional and Global Value Chains and it is hoped that such training will go a long way to assist Member States such as Zambia in achieving this strategic objective.

H.E Ambassador Albert Muchanga
Commissioner Department of Trade and Industry
African Union Commission

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EU Delegation to Zambia

By H.E. Alessandro Mariani, Ambassador of the European Union to the Republic of Zambia and COMESA



Source: EU Embassy of Zambia

Extractive resources, including oil, gas and minerals, influence the socio-economic conditions of countries that represent half of the world's population. Approx. 4 billion people live today in countries where economic trajectories have been shaped to a large extent by their natural resource endowments.

The artisanal and small-scale mining (ASM) sector is estimated to employ, collectively, a minimum of 13 million people, and provide a livelihood for a minimum of 100 million people across the developing world. ASM is considered the most important rural non-farm activity in Africa. In view of its economic importance, the ASM sector is the subject to increasing attention by governments and civil society.

Strengthening capacities, knowledge and skills of those institutions that have a mandate to regulate and provide services to ASM operators is therefore key to harness opportunities to create decent jobs and improve efficiency of operations while preventing negative impacts on the environment, health and safety.

The EU co-funded "PanAfGeo"is a project, which supports the training of geoscientific staff from African Geological Surveys through the development of an innovative training programme. It has been conceived to enable the transfer of know-how directly from the leading institutions (geological surveys) of EU Member States to peer institutions in Africa. We believe that this can be an effective approach for implementing our partnership with Africa and we see this as an example that we would like to replicate in other areas.

The EU is furthermore committed to supporting country-led strategies to transform mineral resources into assets for change, and translate natural wealth into economic and human development. Through a new EU Regulation on Conflict Minerals in May 2017, the EU has also adopted an integrated approach to stop the profits from trading minerals being used to fuel conflicts and to promote due diligence in responsible sourcing. Furthermore, EU legislation – the Accounting and Transparency Directive – requires EU oil, gas, mining and timber companies to make their payments to partner governments public.

Beyond increasing domestic revenues, the reporting of payments to governments by the extractive industries will provide more information thereby enabling local authorities, communities and civil society organisations to hold their governments accountable for the use of these revenues, and for ensuring adequate consideration of the environmental and social costs.

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Apart from regulatory and mining production monitoring support, the EU is supporting small-scale miners through the ACP-EU Development Minerals Programme. The three-year programme, amounting to EUR 13.1 million, aims at developing capacity and sharing best practices within the sector. The programme operates at both the regional policy level and national level, with 40 African, Caribbean and Pacific (ACP) states participating. Zambia is one of the six countries, which are receiving in-depth support under this programme (other countries include Uganda, Guinea, Cameroon, Jamaica and Fiji). The Development Minerals Programme also pays particular attention to the needs of women in the sector, who face additional legal and practical barriers as entrepreneurs.

This Handbook on ASM in Zambia is the result of the work of the Organisation of African Geological Surveys and the EuroGeoSurveys. The Delegation of the European Union to the Republic of Zambia and COMESA is grateful to these organisations for their work on this EU co-funded project and the Handbook, which we trust will become a useful reference for geoscientific staff in Zambia and beyond.

Alessandro Mariani
Ambassador of the European Union to the Republic of Zambia and COMESA

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Training of representatives from ZEMA on environmental issues related to ASM.

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Source: John Tychsen, GEUS.

ACP-EU Development Minerals Programme Implemented by UNDP Zambia

By Mandisa Mashologu, UNDP Zambia Country Director



Source: EU Embassy of Zambia

The United Nations Development Programme (UNDP), in partnership with the Government of Zambia, is implementing the African, Caribbean and Pacific (ACP) and European Union (EU) Development Minerals Programme, which is an initiative of the ACP Group of States, coordinated by the ACP Secretariat, and financed by the European Commission (EC) and UNDP. The programme is part of UNDP's larger investment in the extractives sector to support countries to work towards the United Nations' (UN) Sustainable Development Goals (SDGs).

This programme was conceived because of the high economic growth and urbanisation being witnessed in many parts of the world, which in turn increases demand for housing, construction and consumption goods through transparent, equitable and optimal exploitation of mineral resources to underpin broad-based sustainable growth and socioeconomic development. The objective of this programme is to foster the sustainable and inclusive development of the small-scale mineral resources industry in ACP countries as well as to promote the use and management of Development Minerals.

UNDP Zambia is therefore pleased to collaborate with the Ministry of Mines and Minerals Development, the EU, and the Pan-African Support to the EuroGeoSurveys-Organisation of African Geological Surveys (PanAfGeo) to develop the ASM Handbook for Zambia. The Handbook is envisaged to assist in enhancing and sharing the knowledge of Government regulators, ASM initiatives and other stakeholders to promote good governance, develop institutional and human capacity, optimise knowledge and use of minerals, stimulate economic diversification, harness the potential for ASM, and foster transparency and accountability.

It is well known that if the ASM sector in Zambia is well regulated, the addition of a small-scale, entrepreneurial mining industry can be instrumental in boosting rural industrialisation and job creation through its multiplier effects. The benefits of this sector include the relatively low capital requirements, the ability to work better to exploit small deposits of minerals, the possibility to have widely distributed job opportunities, the low demand for tailor-made infrastructure to serve the industry, and the low after- effects to people and infrastructure upon closure of a mine. Therefore, this is a relevant programme to support in order to bring those that have traditionally been left behind, including jobless youth people and vulnerable women, into the formal employment sector.

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Recognising this, the UNDP, working with the Government of Zambia, is promoting an informed approach to exploitation of the country's abundant mineral resources. These measures are in part reflected in the technical and business training programmes implemented in the country. Between 2016 and 2017, 1,702 persons, mostly small-scale miners, have been engaged in capacity building programmes in the areas of geology, mining, environment, community relations as well as business development skills across the country. This scale is indicative of UNDP and Government efforts towards a sustainable development of the mining industry in Zambia, but we all recognise that more can be done to contribute to employment creation and diversification of the economy.

It is worth noting that the ACP-EU Development Minerals Programme is being implemented at a time when the Government has launched the 7th National Development Plan and therefore provides a unique practical platform for the country to diversify from over dependence on copper to Development Minerals, such as semi-precious stones, which include garnet, tourmaline and amethyst; industrial minerals, such as gypsum and salt; and construction materials, such as sand and gravel; as well as dimension stones, such as marble and granite. To this effect, we as UNDP Zambia note that the sector has the potential to drive economic growth and diversification.

Development Minerals contribute significantly to the achievement of the SDGs due to their close links with the local economy, and the potential to generate local jobs as they are minerals and materials that are mined, processed, manufactured and consumed domestically in industries, such as construction, manufacturing, and agriculture. In Zambia, the sector has a significant impact on poverty reduction through the small and medium enterprises in the sector that can further be supported through business development services and access to markets. It is anticipated that the Zambian ASM entrepreneurs will utilise this ASM Handbook to make well-informed decisions and further assist both policy makers and entrepreneurs to rationalise resources for business development and avoid wasteful exploitation of resources.



Mandisa Mashologu
UNDP Zambia Country Director

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Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development

By Matthew Bliss, IGF Deputy Director, Programs



Source: IGF

Zambia continues to demonstrate to the world the importance of managing the ASM sector in a manner benefitting miners, host communities, and citizens of the host country. Its recent efforts to manage tensions surrounding small- and large-scale miners is consistent with the country's commitment to the IGF's Mining Policy Framework (MPF), which sets out concrete objectives and processes for good governance in the mining sector. Its ASM approach supports Zambia's commitment to the MPF-related goals, specifically, managing mining to achieve its sustainable development and poverty reduction goals.

The IGF is a member-driven international partnership established voluntarily by its Member governments under the UN. It was proposed in 2002 at the UN Summit on the Environment in Johannesburg by South Africa and Canada. In 2005, 25 governments met for its inaugural General Session in Geneva, hosted by the United Nations Conference on Trade and Development (UNCTAD). There are currently 64 member countries of the IGF, including Zambia.

ASM is a top priority for IGF member governments, as demonstrated by the theme being voted by members as the inaugural guidance document. In October 2016, IGF released its Guidance for Governments: Managing Artisanal and Small-Scale Mining designed to guide member countries to develop and implement an ASM strategy and related governance. Zambia was one the IGF members to pilot the implementation of the guidance at a regional workshop held in 2017, which provided 13 other IGF member governments with the opportunity to learn from Zambia's hard-earned ASM experience. Due to the success of this pilot, regional workshops have been requested for Francophone and Spanish members, in Cameroon and Dominican Republic, respectively during 2018.

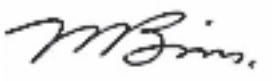
What are our hopes for the ASM sector in Zambia moving forward? Based on our own work and that of others, we look forward to learning with Zambia about: formal dialogue with ASM actors, perhaps via an ASM unit within a relevant ministry; research and support on the effectiveness of cooperatives; and improved transparency, accountability, and dialogue among mining groups and associations.

IGF member governments are grateful for the opportunity to collaborate with and benefit from the PanAfGeo WP3 on ASM. The PanAfGeo WP3, supported by EuroGeoSurveys and the Organisation of African Geological Surveys, coordinated by the French Geological Survey (BGRM), and funded by the EC, the Geological Survey of Denmark and Greenland

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(GEUS), and the Zambia Geological Survey Authority (GGSA), and co-funded by IGF, is being delivered by GEUS in partnership with Zambia and the ACP-EU Development Minerals Program, an initiative of the ACP Group of States, European Union and UNDP.". The depth of coverage of this ASM Handbook is backed up by in-country training with experts from Zambia and neighbouring countries' geological surveys. This ASM Handbook was co-developed by the workshop trainees.

Here is a practical Handbook, based on ASM experience in Zambia and neighbouring countries - use it as such, ask questions or provide comments to its authors. The collective governance of ASM is evolving, and we are pleased to partner on the delivery of this handbook to help improve the ASM sector's contribution to sustainable development and poverty reduction for the women, men, boys, and girls of host countries.



Matthew Bliss
IGF Deputy Director, Programs

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By John Tychsen, International Director and ASM Handbook Editor, GEUS

The Editor is indebted to so many people and organisations, who have contributed, in one way or the other, to the successful production of this ASM Handbook. They are:



Source: GEUS.

Hon. Richard Musukwa, Minister of Mines and Minerals Development; H.E Alessandro Mariani, Ambassador of the European Union; H.E. Janet Rogan, United Nations Resident Coordinator to Zambia; and Deputy Director Matthew Bliss, IGF, who all recognised the importance of the ASM sector in their foreword to this Handbook.

Permanent Secretary Paul Chanda, Director Chipilauka Mukofu, Director Bernadette Mwakacheya for being supportive in the planning and implementation of the PanAfGeo Project.

The large group of Zambian experts and academics, who acted as facilitators, co-trainers and authors for both the training workshop and this ASM Handbook. Their excellent presentations provided valuable local input to the discussions during the group work.

The technical staff of the Ministry of Mines and Minerals Development, Zambia Environmental Management Agency, Zambia Development Agency, Universities and representatives from the ASM community, who actively participated and provided relevant input to the discussions during the training workshop in Lusaka, Zambia.

The participants from the national geological surveys of South Africa, Namibia, Zimbabwe, Botswana, Swaziland and Malawi, who provided valuable regional input to the discussions on the ASM sector in Zambia as well as the future role of a national geological survey in the support to the ASM sector.

The Text Editor, Ms. Julie Sophie Hübertz, the Project Assistant, Mrs. Ulla Holm, and the Local Consultant, Mrs. Gertrude Mundia, for their enthusiastic engagement and hard work in preparing this ASM Handbook and organising the training workshop.

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INTRODUCTION

By Jean-Claude Guillaneau, Programme Coordinator, PanAfGeo Project and Georesources Manager, BRGM, the French Geological Survey



Source: PanAfGeo.

PanAfGeo is a project, which supports the training of geoscientific staff from 54 African Geological Surveys through several training programmes developed and carried out by 12 European Geological Surveys.

This 3-year (2017-2019) Pan-African cooperation programme provides about 45 training sessions for some 1,200 geologists coming from 54 African countries. The PanAfGeo project has a budget of 10.3 million euros and is co-funded by the EU, through DG DEVCO, and a consortium of 12 European Geological Surveys, led by BRGM, the French Geological Survey. The PanAfGeo project allows trainees to acquire a state-of-the-art tool kit, methods and/or the possibility to take part in field trips within eight geoscientific domains: Geoscientific Mapping, Mineral Resources Assessment, ASM, Environmental Management of Mines, Geohazards, Geoheritage, Geoinformation Management, and Communication and Promotion.

The PanAfGeo project's WP3, "Training on ASM", is planned to be carried out through five "in-country workshops" with regional participation. The WP3-lead is Dr. John Tychsen, Geological Survey of Denmark and Greenland (GEUS), the African co-lead of WP3 is Dr Daniel Boamah, Director of Ghana Geological Survey Authority (GGSA) and the deputy co-lead is Mr. Jules César Yaganza Director of the Geological Survey Department in the Central African Republic.

The main aim of the workshops is to train staff from the geological survey authorities, the regulatory agencies and the universities involved in the ASM sector to strengthen their capacity to better assist the country's ASM operators. Particular emphasis is on how the knowledge and skills resources of the geological survey authorities can be mobilised more actively in the service of ASM operators to ensure more profitable, efficient, environment friendly, safe and sustainable mining operations in the countries concerned.

In addition to the training provided, another major outcome of the workshops is a country-specific ASM Handbook, which is intended to serve as a reference book for the future involvement of the geological survey authority's staff in the country's ASM sector and related government agencies.

The first WP3 training workshop on ASM, held in Accra, Ghana, was hosted by Dr Daniel Boamah, Director of GGSA. The ASM Handbook for Ghana, developed in connection with this workshop, was much appreciated by H.E. John-Peter Amewu, Minister of Lands and Natural Resources, Ghana.

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The second WP3 training workshop on ASM, held in Lusaka, Zambia, was hosted by Mr. Chipilauka Mukofu, Director, Geological Survey Department (GSD) of the Ministry of Mines and Minerals Development, Zambia. We were pleased to have trainees from the national geological surveys in Namibia, South Africa, Swaziland, South Africa, Botswana, Malawi and Zimbabwe. The Hon. Richard Musukwa, Minister of Mines and Minerals Development, Zambia praised this ASM Handbook for Zambia during the official opening of the workshop and stated that the Ministry looks forward to distributing the ASM Handbook to a large number of stakeholders in Zambia.

In Zambia, we were pleased to work in cooperation with the EU-funded and UNDP-implemented ACP-EU Development Minerals Programme, which also hosted training sessions in Zambia.

The next ASM training workshop is planned for Malawi in November 2018 in close collaboration with the Geological Survey Department of Malawi and the Geological Mapping and Mineral Assessment Project (GEMMAP).

For more information on the PanAfgeo project visit http://panafgeo.eurogeosurveys.org/ and/or follow it on Twitter, @PanAfGeo.

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THE ROLE OF THE GEOLOGICAL SURVEY DEPARTMENT

By Chipilauka Mukofu, Director, Zambia Geological Survey Department

Introduction

In Zambia, the Geological Survey Department (GSD) is one of the four technical departments of the Ministry of Mines and Minerals Development. The other three departments are:

- The Mines Development Department (MDD);
- The Mining Cadastre Department (MCD); and
- The Mines Safety Department (MSD).

The GSD is headed by a Director, who is assisted by two Chief Geologists and the Chief Hydrocarbon Officer to perform the technical functions of the Department.

In order for the GSD to undertake its functions effectively and efficiently, the Department consists of five sections, as follows:

1. Regional Mapping;
2. Economic Geology;
3. Laboratories;
4. Hydrocarbon; and
5. Administration.

Functions and Responsibilities of the Sections

Regional Mapping

The Regional Mapping Section, headed by a Chief Geologist, is responsible for the geological mapping of the country. The geologists conduct geological mapping mainly during the dry months of the year, i.e. from May to end of October. During the rainy season, when fieldwork cannot be undertaken, the geologists utilise their time to compile geological maps and to complete the accompanying geological reports based on the fieldwork conducted during the dry season.

Because of the geological mapping function, falling under the jurisdiction of the GSD, the GSD acts as the main repository for all geological data and information on Zambia. This data and information is very critical to mineral exploration companies that want to invest in the country's mining sector. In this regard, the GSD acts as the chief advisor to the Government and members of the public on all geological matters of the country.

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Despite having been involved in modern mining for close to 100 years now, only about 60% of the country has been geologically mapped. The remaining 40% is largely in the western and northwestern parts of the country where geological mapping is compounded by the presence of thick Kalahari sands.

Economic Geology

In addition to regional mapping, the GSD is also responsible for carrying out exploration activities on behalf of the Government. This is achieved under the scope of the Economic Geology Section. This Section mainly carries out preliminary exploration, which comprises compiling and packaging exploration data and information for sale to members of the public, who wish to invest in the country's mining sector. The mineral exploration conducted by the Economic Geology Section is demand driven, i.e. exploring for minerals that are most sought after by investors.

Mineral exploration by the Economic Geology Section is accomplished in two ways:

- Conventional exploration and
- Geophysical exploration.

The Geophysics Unit of the Economic Geology Section carries out geophysical exploration. Geophysical exploration involves both ground geophysics and aerial geophysical techniques to identify mineral exploration anomalies.

Another function of the Economic Geology Section is the seismic activity monitoring of the country. The department for seismic activity monitoring, under the Geophysics Unit of the Economic Geology Section, operates a network of seismic stations located in the provincial centres of the country. One of the seismic stations, located about 35km northwest of Lusaka, is an international monitoring station, which is linked to regional stations (e.g. in Tanzania and the Republic of South Africa) and the United States Geological Survey (USGS).

Seismic data monitoring helps the Government safeguard important public infrastructure, such as hydroelectric power stations, by employing earthquake disaster mitigation engineering measures at the construction stage. The seismic data is also very useful to members of the public, such as construction companies and citizens, for them to be informed on matters relating to earthquake-prone areas.

Hydrocarbon

Via the Hydrocarbon Unit, the GSD is responsible for monitoring petroleum exploration activities in the country. The Hydrocarbon Unit, headed by the Chief Hydrocarbon Officer, is responsible for enforcing the Petroleum (Exploration and Production) Act of 2008 to ensure that all exploration companies are compliant.

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Laboratory

The Laboratory Section of the GSD operates three laboratory units:

1. The Chemistry Laboratory;
2. The Gemology Laboratory; and
3. The Metallurgy Laboratory.

Source: John Tychsen, GEUS.

The major function of both the Chemistry and Gemology Units is to certify and evaluate mineral products before they are exported out of the country. This is a statutory mandate and only the GSD, through these two laboratories, can issue officially recognisable documents, i.e. Mineral Analysis Certificate and Valuation Certificate, for export purposes.

The Metallurgy Unit's main function is to develop mineral beneficiation and refining techniques, which can be easily adopted by small-scale miners. The unit also plays a major role in evaluating mineral processing licenses applications. Furthermore, the officers of the Unit are indispensable during periodic auditing of the mines, which was recently instituted by the Ministry of Mines and Minerals Development.

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Exploration drilling at a potential mining site north of Lundazi

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THE OBLIGATIONS OF ZAMBIA ENVIRONMENTAL MANAGEMENT AGENCY

By John Msimuko, Director General, ZEMA

The Zambia Environmental Management Agency (ZEMA) was established by an Act of Parliament named the Environmental Management Act No 12 of 2011. This Act repealed and replaced the Environmental Protection and Pollution Control Act of 1990 and renamed the Environmental Council of Zambia (ECZ) as ZEMA. In broad terms, the mandate of ZEMA is to implement and enforce the provisions of the Environmental Management Act. The Act provides for integrated environmental management and conservation of the environment, sustainable management and use of natural resources. It also provides for the prevention and control of pollution and environmental degradation.

As provided for by the Environmental Management Act, ZEMA is obligated to:

- Advise the Minister on the formulation of policies on all aspects of the environment and, in particular, make recommendations for the sustainable management of the environment;
- Co-ordinate the implementation of activities of all ministries, appropriate authorities and conservancy authorities in matters relating to the environment;
- Develop and enforce measures aimed at preventing and controlling pollution;
- Develop, in liaison with the relevant appropriate authority, standards and guidelines relating to the protection of air, water, land and other natural resources and the prevention and control of pollution, the discharge of waste and the control of toxic substances;
- Advise any private or public body on any aspect of nature conservation;
- Initiate, conduct and promote research, surveys, studies, training and investigations in environmental management;
- Research or sponsor research on the effects of climate change on human beings and the environment;
- Ensure the integration of environmental concerns in overall national planning through co-ordination with appropriate authorities;
- Undertake general educational programmes for the purpose of creating public awareness on the environment;
- Review Environmental Impact Assessment (EIA) reports and Strategic Environmental Assessment (SEA) reports;
- Monitor trends of natural resources, their use and impact on the environment and make necessary recommendations to the appropriate authority;
- Collaborate with Government agencies, appropriate authorities and other bodies and institutions to control pollution and protect the environment;
- Request information on projects proposed, planned or in progress and advise stake holders on projects, programmes, plans and policies for which environmental assessments are necessary;

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- Collaborate with such local and international agencies as the Agency considers necessary for the purposes of this Act;
- Publicise information on any aspect of the environment and facilitate public access to information on the environment; and
- Carry out any other activities relating to environmental management and the prevention and control of pollution, which are necessary or conducive to the better performance of its functions under the Act.

Primary Functions and Obligations of ZEMA Related to the ASM Sector

Under the Environmental Management Act No 12 of 2011, some of ZEMA's main functions and obligations related to the ASM sector comprise:

Reviewing and Approving Environmental Impact Assessments

An EIA refers to a systematic investigation of conditions of the overall environment of a proposed development or project followed by an assessment of the impacts that the project will have on the environment in its totality i.e. physical, biological, and socio-economic aspects. It is usually done before new projects are launched. In order to ensure that environmental concerns arising out of developmental activities are incorporated into the planning process and as a way of preventing, minimising, mitigating or compensating for adverse environmental impacts, the Government introduced the EIA process by promulgating the EIA regulations, Statutory Instrument No. 28 of 1997. ZEMA's role in the EIA process is that of regulation, coordination and approval of projects. All projects with a potential to create pollution or environmental damage are required to undertake an EIA. Companies are required to obtain prior approval from ZEMA before undertaking potentially polluting activities. The EIA process was designed in such a way as to be consultative and participatory. To this end, the process creates an effective coordination and communication avenue amongst planners, project proponents, Government, private sector, NGOs, community and other interested and affected parties.

Issuing and Controlling Licenses

ZEMA, as an environmental regulator, has an obligation to ensure that potential polluters have in place systems and procedures to avoid or minimise pollution. Pollution prevention and control are regulated through issuance of licenses and permits provided for by the Environmental Management (Licensing) Regulations No. 112 of 2013.

Setting Mandatory Standards and Regulations

ZEMA sets mandatory standards for various categories of potential polluters. These are provided for under Part IV of the Environmental Management Act, which covers issues of environmental protection and pollution control and caters for 8 divisions, namely: Division 1 (Pollution Control); Division 2 (Water Regulation); Division 3 (Air); Division 4 (Waste Man-

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agement); Division 5 (Pesticides and Toxic Substances); Division 6 (Noise); Division 7 (Ionizing Radiation); and Division 8 (Natural Resources Management).

Source: John Tychsen, GEUS.

Monitoring Compliance

Industry and other regulated facilities are under an obligation to provide specified information about their activities and releases into the environment through submission of semi-annual returns. ZEMA's obligation is to analyse these returns to check on level of compliance and provide guidance, including penalties for non-compliance, to guidelines and standards.

Undertaking Inspections

In order to ensure compliance with mandatory standards or regulations and to limit the potential for occurrences, regulators, such as ZEMA, undertake various inspections of plants and facilities of regulated companies.

Reviewing and Approving Plans for Environmental Management and Closure

As part of the overall project cycle, it is a requirement that the EIA process shall plan for the full project cycle. To this end both an Environmental Management Plan and a Post Closure Plan are required for review and approval by ZEMA to ensure that the project does not leave behind a negative environmental legacy.

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Small hut at a ASM mining site between Chipata and Lundazi

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BASIC EXPLORATION METHODS

By Kondwani Zimba, Zambia Geological Survey Department

Exploration is defined as an activity that takes place as part of a strategy to locate and define a particular economically mineable mineral deposit. The prime objective of mineral exploration is to find and acquire a maximum number of such economic mineral deposits at a minimum cost and within shortest timeframe. Historically, exploration of the Earth was confined to the near surface and this was largely a matter of following downward those discoveries made at the surface. In recent years, techniques, which can help with the exploration of the Earth's sub-surface, have been developed and are being used worldwide.

Mineral Identification

Minerals can be identified by a number of characteristics of which the following represent the first steps in the identification of the mineral:

- Colour
- Streak
- Lustre
- Transparency
- Hardness
- Cleavage and Fracture
- Specific Gravity
- Magnetism

Colour

Colour is best described by using primary or simple colours, with descriptors and subsidiary colours added as necessary, e.g. dull reddish-brown, pale greenish-blue. Colour variants, e.g. khaki, mauve, turquoise etc., should be avoided as these are subjective and definitions may vary from person to person.

Although distinctive for some minerals, colour is often not a reliable mineral property as it can show considerable variation within a mineral. Minute amounts of impurities can change the colour of a mineral dramatically, especially that of usually colourless or white minerals. For example, quartz, which is normally colourless, can be violet (amethyst), pink (rose quartz), yellow (false topaz), smoky brown-black (cairngorm), etc.

Streak

The "streak test" is a method used to determine the colour of a mineral in powdered form. The colour of a mineral's powder is often a very important property for identifying the mineral.

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The streak test is done by scraping a specimen of the mineral across a piece of unglazed porcelain known as a "streak plate." This can produce a small amount of powdered mineral on the surface of the plate. The powder colour of that mineral is known as its "streak." The streak test should be done on clean, unweathered, or freshly broken specimens of the mineral. This is done to reduce the possibility that a contaminant, weathered coating, or tarnish will influence the results of the test.

The streak test is valuable because many minerals occur in a variety of apparent colours - but all specimens of that mineral share a similar streak colour. For example: specimens of hematite can be black, red, brown, or silver in colour and occur in a wide variety of habits; however, all specimens of hematite produce a streak with a reddish colour. This is a valuable test for hematite. It can be used to differentiate hematite from a large number of other opaque minerals with a high specific gravity and similar colour and habit.

Lustre

Lustre refers to the quality and intensity of light reflected from the surface of a mineral, such as:

- Metallic – strong reflection, shines like metal, may be very shiny (like a chrome car part) or less shiny (like the surface of a broken piece of iron);
- Vitreous - glassy, bright (shines like glass);
- Resinous - a resin-like shine (resembling amber for example);
- Greasy - a dull sheen, has the appearance of being coated with an oily substance;
- Pearly - a whitish iridescence (resembling pearl for example);
- Silky - a sheen like that of a fibrous material, e.g. silk;
- Adamantine - a brilliant lustre such as that of diamond; or
- Earthy – like the surface of unglazed pottery.

Transparency

Transparency refers to the degree to which light can pass through a mineral, such as:

- Opaque - no light can pass through the mineral;
- Translucent - light can pass through the mineral but is diffused so that images cannot be seen clearly; or
- Transparent - light can pass through the mineral and images can be seen clearly.

Hardness

Hardness is a measure of the ease with which a smooth surface of a mineral can be scratched, or of its resistance to abrasion.
Mohs' scale of hardness is one of the best practical methods of estimating a mineral's hardness, from hardest (10) to softest (1), ref. Figure 1.

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Mineral	Mohs hardness	Absolute hardness	Chemical formula
Diamond	10	1600	C
Corundum	9	400	Al_2O_3
Topaz	8	200	$Al_2SiO_4(OH^-,F^-)_2$
Quartz	7	100	SiO_2
Orthoclase Feldspar	6	72	$KAlSi_3O_8$
Apatite	5	48	$Ca_5(PO_4)_3(OH^-,Cl^-,F)$
Fluorite	4	21	CaF_2
Calcite	3	9	$CaCO_3$
Gypsum	2	3	$CaSO_4 \cdot 2H_2O$
Talc	1	1	$Mg_3Si_4O_{10}(OH)_2$

Figure 1. Mohs Scale of Hardness.

Cleavage and Fracture

Cleavage refers to the tendency of a mineral to break along flat planar surfaces as determined by the structure of its crystal lattice. These two-dimensional surfaces are known as cleavage planes and are caused by the alignment of weaker bonds between atoms in the crystal lattice. Cleavage planes are distinguished from fracture by being smooth and often having reflective surfaces.

Fracture refers to the way a mineral breaks other than along a cleavage plane.

Specific Gravity

Specific Gravity, also known as SG, is a measurement that determines the density of minerals. Two minerals may be the same size, but their weight may be very different. The SG of a mineral determines how heavy it is by its relative weight to water. The SG value is expressed upon how much greater the weight of the mineral is to an equal amount of water. Water has a SG of 1.0. If a mineral has a SG of 2.7, it is 2.7 times heavier than water. Minerals with a SG under 2 are considered light, between 2 and 4.5 average, and greater than 4.5 heavy. Most minerals with a metallic lustre are heavy. The SG may slightly vary within a mineral because of impurities present in the minerals structure.

SG is calculated by the following formula:

$$SG = W_{Air} / (W_{Air} - W_{Water})$$

Magnetism

Several minerals react when placed within a magnetic field. Some minerals are strongly attracted to the magnet, others are weakly attracted, and one mineral is actually repelled.

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There are also several minerals that are attracted to magnetic fields only when heated. Magnetic properties of minerals are defined as follows:

- Ferromagnetism: Describes a strong attraction to magnetic fields.
  This property is exhibited in few minerals, notably Magnetite and Pyrrhotite.
- Paramagnetism: Refers to weak attraction to magnetic fields. The attraction is usually discernible, but it may be so weak that it is undetectable. Most paramagnetic minerals become strongly magnetic when heated. A small number of paramagnetic minerals, such as Platinum, are not essentially paramagnetic, but contain iron impurities, which are responsible for the paramagnetism. However, some specimens lacking iron also exist, and these are not paramagnetic. Some examples of paramagnetic minerals are Hematite and Franklinite.
- Diamagnetism. Only one mineral, Bismuth, is diamagnetic, meaning it is repelled from magnetic fields.
- Magnetism. Only a variety of one mineral acts as a magnet, generating magnetic fields on its own. This mineral is Lodestone, the magnetic variety of Magnetite, which found in only a few deposits throughout the world. Although it is only weakly magnetic, its magnetism is definitely discernible.

Examples of Minerals Available in Zambia

Characteristics of the most common minerals extracted by ASM operators in Zambia are:

Emerald ($Be_3Al_2Si_6O_{18}$)

An emerald is a clear green variety of beryl (a Beryllium-Aluminium Silicate). An emerald possesses a vitreous (glassy) lustre, imperfect cleavage and a concoidal fracture. The distinctive green colour of an emerald, ref. Figure 2 below, is caused by the presence of a small quantity of chromium (Cr^{3+}). An emerald has a BeO content of 11% to 15%. Emeralds crystallise in the Hexagonal crystal system (six-sided elongated prism).



Source: Kondwani Zimba, Zambia Geological Survey Department

Figure 2: Examples of Emeralds

The hardness of emeralds ranges from between 7.5 and 8. The SG of emeralds is between 2.63g/cm³ and 2.91g/cm³.

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Aquamarine ($Be_3Al_2Si_6O_{18}$)

Similar to emeralds, an aquamarine is a member of the beryl group. An aquamarine is blue in colour, but the colour may vary from a deep blue to a much pale shade of blue. The green variety, denoted "apple green", is a watery green without any trace of yellow, due to the presence of iron, ref. Figure 3 below.

The most valuable colour of an aquamarine is a rich sky blue; however, because the stone (an aquamarine) is pleochroic, i.e. doubly refracting, even blue stones have a hint of green colour. Being a beryl, an aquamarine has the same hardness as an emerald, i.e. between 7.5 and 8. The SG of aquamarines is about 2.71 g/cm3. The refractive indices are about 1.570 to 1.590. The lustre is vitreous and not exceptional.



Source: Kondwani Zimba, Zambia Geological Survey Department

Figure 3: Examples of "Apple Green" Aquamarines

Tourmaline (Na (Mg, Fe, Li, Al, Mn)$_3$Al$_6$ (BO_3)$_3$$Si_6O_{18}$)

Tourmaline is a complex silicate of Boron and Aluminium, which commonly occurs as well-developed prismatic crystal, belonging to the Trigonal crystal system. The crystals have triangular cross-sections and are often elongated with vertical striations running parallel to the optic axis, ref. Figure 4 below. The gem varieties are bright and transparent and have hardness of 7.5. The SG is between 3.02 g/cm3 and 3.20 g/cm3. The refractive indices are about 1.620 to 1.640. The fracture is concoidal and lustre is vitreous.

Tourmaline assumes many different colours, such as: brown to brownish; black (Dravite); black (Schorl); deep blue (Indicolite); colourless (Achroite); pink to red (Rubelite); peacock blue (Elbaite); green (Verdelite); emerald green (Tsilaisite); and lilac – mauve (Siberite).

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Source: Konduwani Zimba, Zambia Geological Survey Department

Figure 4: Examples of Tourmalines

Garnet $(Mg, Fe, Mn, Ca)_3(Al, Cr, Fe)_2Si_3O_{12}$

Garnet is a group name applied to about fifteen different and complex silicate species with generally similar characteristics but of different compositions and with elements that are replaceable with each other. The minerals of the garnet family contain silica and other elements, such as aluminium, iron, manganese, magnesium, calcium and chromium. There are at least six end members, which mix in all proportions so that most garnets, in practice, are a mixture of two or more of these.



Source: Konduwani Zimba, Zambia Geological Survey Department

Figure 5: Examples of Garnets

Garnets crystallise in the Isometric (Cubic) crystal system. The hardness varies from 6.5 to 7.5 and is dependent on the chemical composition. The density ranges from 3.50g/cm³ to 4.50g/cm³ and the refractive indices for the various garnets range from about 1.690 to 1.890. Garnets have no cleavage and break into splinters (concoidal fracture). The lustre is usually vitreous.

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The different varieties of garnet include:

- **Pyrope:** The magnesium-rich member of the pyrope-almandine series. Usually bright red, but Pyrope can also be of a less attractive black or dark red colour. Its red colour, sometimes very bright, is due to small quantities of chrome in the crystal structure. Pyrope can also be perfectly transparent, but this feature is less visible in dark specimens. The most valuable types are, of course, the transparent ones with the brightest red colour. A garnet is referred to as pyrope if its SG is between 3.65 g/cm^3 and 3.87 g/cm^3, the refractive index is between 1.720 and 1.760 and the hardness is 7. Pyrope is relatively common, although less than Almandine. Very large stones, up to several hundred carats, have been found; but these are rare and are found in museums and famous collections.

- **Almandine:** This type of granite is generally darker red than pyrope and may appear black, although minimal cases of pinkish red specimens are found. It has a brilliant lustre, but its transparency is frequently marred, even in very clear stones, by excessive depth of colour. The deep, almost violet-red is typical, and has given rise to the expression "Red Garnet". The SG of almandine is between 3.95 g/cm^3 and 4.20 g/cm^3 and the refractive index is between 1.760 and 1.830. Its hardness is between 6.5 and 7.

- **Rhodolite:** This is an intermediate group of garnets in the pyrope-almandine series. It is a deep pink or pinkish-red colour. Rhodolite is a sub-variety of pyrope-almandine characterised by its particular colour. The SG of rhodolite is between 3.74 g/cm^3 and 3.94 g/cm^3 – a very limited range – and the refractive index is between 1.755 and 1.765. The hardness is 7.

- **Spessartite:** A silicate of manganese and aluminium, belonging to the garnet family. It has a typical crystal form of garnets, usually occurring as isolated, well-formed rhombic dodecahedral crystals. The colour is orange-pink, orange-red or brownish yellow. It may be semi-opaque or transparent; however, gem-quality spessartites are a scarcity. Transparent crystals are highly lustrous and are used as gems. Spessartite has a hardness of 6.5 to 7.5. The SG of gem-quality spessartite varies from 4.12 g/cm^3 to 4.20 g/cm^3 and the refractive index is between 1.790 and 1.810. Similar to all other garnets, spessartite has no cleavage.

- **Grossular:** Silicate of calcium and aluminium, belonging to the garnet group. Grossular garnets occur in a very wide range of colours. Grossular also has typical crystal form of garnets, occurring in isolated crystals, which are often complete, in the shape of a rhombic dodecahedron, sometimes combined with a trapezohedron. They vary from opaque to semi-opaque. The typical colour is light (gooseberry) yellowish green, but they can also be strong to bluish green, honey yellow or pinkish yellow or even

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perfectly colourless. When transparent, the crystals have good lustre. Like other garnets, grossulars have no cleavage. The greenish to yellow varieties are used as gems. The hardness is 6.5 to 7.5 or a little more. The SG is somewhat variable, i.e. from 3.58 g/cm^3 to 3.69 g/cm^3. The refractive index is 1.740.

Amethyst (SiO_2)

An amethyst is a purple or mauve coloured quartz, ref. Figure 6 below. The purple colour is due to traces of titanium and manganese. It varies from light to dark purple. The crystals are seldom homogeneous in colour but have alternating light and dark bands parallel to the crystal faces (colour zoning). Amethyst occurs in the Trigonal crystal system. Amethyst has a hardness of 7 and a SG of 2.65 g/cm^3. The refractive index varies between 1.540 and 1.550. The lustre is vitreous and is dichroic, i.e. exhibiting a bluish or reddish purple tinge when viewed from different angles.



Source: Konduani Zimba, Zambia Geological Survey Department

Figure 6: Examples of Amethysts

Citrine (SiO_2)

Citrine is a yellow-brown to ochre-coloured (fine reddish-yellow or golden) transparent quartz, which derives its colour from traces of ferrous oxide, ref. Figure 7 below. The colour varies from pure yellow to dull yellow, honey, or brownish yellow, sometimes even with a russet tint. As with amethyst, the colour is often broken up into patches or bands, although due to its depth of hue, the zoning is less obvious. It has good lustre, similar to amethyst, and is generally very clear and virtually free of inclusions, because the amount of raw material available allows for considerable selectivity. A high-quality citrine is rare; hence, most citrines, which are marketed (often under the name "Golden Topaz"), are amethyst or smoky quartz, which have been heat-treated. Similar to amethyst, citrine has a hardness of 7, the SG is 2.65 g/cm^3 and the refractive index is between 1.540 and 1.550.



Source: Konduani Zimba, Zambia Geological Survey Department

Figure 7: Examples of Citrines

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Quartz (SiO_2)

Quartz (Silica Dioxide), also known as Rock Crystal, is the most common mineral found in the Earth's Crust. Quartz occurs in veins and pegmatites and in fine to medium or course grained rocks (Sedimentary, Igneous, and Metamorphic). Quartz has a hardness of 7 and the crystals are usually hexagonal and columnar and crystallises in the Trigonal crystal system. Quartz also occurs in a gentle pink variety called rose quartz, ref. Figure 8 below. The SG of quartz is 2.65 g/cm^3 and the refractive index is between 1.544 and 1.553.



Source: Sarti Makili, Zambia Geological Survey Department

Figure 8: Examples of Rose Quartz

Granite

Granite is a common type of felsic rock that is usually granular and phaneriric in texture. It can be predominantly white, pink or grey in colour. Granite is usually massive (lacking internal structures), hard and tough, ref. Figure 9 below.



Source: Konduwani Zimba, Zambia Geological Survey Department

Figure 9: Examples of Granite

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Limestone

Limestone is a sedimentary rock composed of skeletal fragments of marine organisms, ref. Figure 10 below. The major components/materials of limestone are calcite and aragonite minerals. Limestone also often contains variable amounts of silica.



Source: Konduwani Zimba, Zambia Geological Survey Department

Figure 10: Examples of Limestones

Talc ($Mg_3Si_4O_{10}(OH)_2$)

Talc is a clay mineral composed of hydrated magnesium silicate, which occurs as foliated to fibrous masses. Talc has a hardness of 1 and can easily be scratched by fingernails. Its colour ranges from white to grey and has a distinct greasy feel, ref. Figure 11 below.



Source: Konduwani Zimba, Zambia Geological Survey Department

Figure 11: Examples of Talc

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Geology of Zambian Gemstones

Gemstone occurrences in Zambia are not just restricted to the famous copper belt region but are widespread, ref. Figure 12 below. Most of the Zambian gemstones were formed during the pan African orogeny[1], such as:

- Emeralds of the Kafubu area. The emeralds were emplaced in the pegmatites during the Proterozoic Time Period, dating back to approx. 1400 Ma, prior to the deposition of the Katanga super group.
- Aquamarines of the Lundazi area. The aquamarines are post-Katanga, pre-Karoo and probably synchronous with agranite, dating back to 489 Ma.
- Amethysts of the Kalomo area (Mwakambika Hill). The amethysts are post-Karoo and probably Jurassic in age, i.e. approx. 300 Ma. Solwezi amethyst occurs in the Basement Domes.
- The coloured gemstones of the Mkushi-Serenje area. The coloured gemstones, such as Tourmaline, Topaz, Zircon, Spinel, Beryl, Rock Crystal, Chrysoberyl and many other types of gemstones are found in the pegmatites of the Basement Complex.

[1] *An orogeny is an event that leads to a large structural deformation of the Earth's lithosphere (crust and uppermost mantle) due to the interaction between tectonic plates.*

Most of the Zambian gemstones occur in large veins or dykes consisting mainly of pegmatites. Veins are bodies of mineral matter where length greatly exceeds width. Gemstones commonly found in veins include: Fluorite, Quartz, Apatite, Tourmalines, Topaz, Epidote, Beryl and Chalcedony. Pegmatites are extremely course grained igneous or metamorphic rocks. Gemstones commonly found in this type of rock include: Beryl, Tourmalines, Garnets, Quartz, Topaz, Chrysoberyl, Spodumene, Zircon and Amazonite.

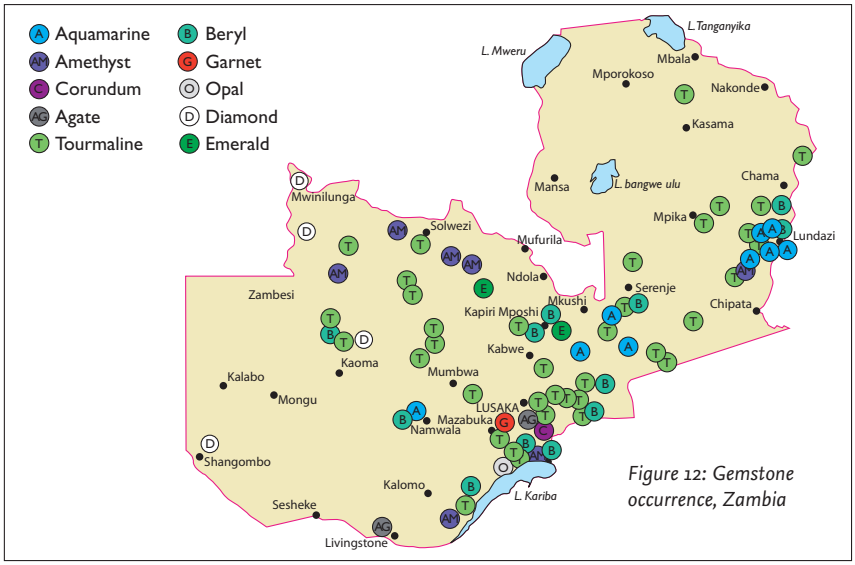


Figure 12: Gemstone occurrence, Zambia

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Basic Exploration Methods

There are various methods by which mineral deposits can be explored and, depending on the results, eventually exploited.

Geological Method

The geological method relies on the identification of rocks and minerals and a detailed understanding of the environment in which they were formed. The geological surveys aim to find out, which types of rock occur at or close to the surface and how these types of rock are related to each other, i.e. their boundaries, ages and structures. Based on known regional environments for mineralisation or models for mineralisation, regional geological surveys can be used to define smaller areas in which more detailed studies can be undertaken.

Exploration, using the geological method, starts with a regional appraisal of large areas, primarily by collating known geological information, reviewing maps, surveys, and reports/records available from the Zambian Geological Survey. Subsequently, a selection of particular regions considered favourable for occurrence of the mineral or minerals being sought are further explored using air photo and/or satellite images.

Once an area of interest is selected, geological field mapping is conducted, which comprises identifying all geological aspects of the area with the purpose of preparing a detailed geological report accompanied by an accurate geological map.

A geological map is defined as a visual record of geological facts, i.e. rock units and associated structures. Such a map will normally show geological formations and their age relationship, various rock types, structures, outcrops, any mineral showings and their distribution.

Geological Survey Methods

A geological survey can be undertaken using a number of different methods depending on the size of a region and the amount of information required.

Geochemical Method

The geochemical method involves the measurement of the chemistry of the rock, soil, and stream sediments to determine abnormal chemical patterns, which may point to areas of mineralisation. When a mineral deposit forms, the concentration of the ore and indicator minerals in the surrounding rocks are usually higher than normal.

When a mineral deposit is exposed to processes, such as weathering and erosion, the mineral elements are dispersed and distributed in the soil, groundwater and stream sediments. Distribution of mineral elements in the natural environment is primarily

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influenced by the mineral elements' fundamental chemical properties, which in turn depend on the mineral element's electronic constitution.

The mobility of a mineral element in the natural environment depends on its:

- Density;
- Readiness to dissolve in water;
- Ability to form compounds with other elements; and
- Acidity (pH) of the environment.

A geochemical survey is conducted in two stages:

1) Reconnaissance survey – an initial assessment of a very large area using a small scale of mapping; and
2) Detailed survey – use of closely spaced samples of an area. The main purpose of a detailed survey is to identify and delineate a geochemical anomaly that will help in locating a deposit of particular interest.

Geochemical exploration survey types include:

- **Stream Sediment Sampling Survey:** The most widely used and effective method in regional geochemical exploration. The survey is based on a chemical analysis of active stream sediments from drainage courses. The underlying premise is that stream sediments are composed of products of erosion and weathering and thus represent the source catchment area of the stream drainage network. The survey involves collecting active sediment samples on the streambed and from streams in an area of active erosion with a good drainage pattern.
- **Soil Sampling Survey:** This method is typically employed in the detailed exploration of a desired mineral belt. Soil samples are collected for geochemical analysis to identify and delineate an area based of enhanced mineral analysis values. The soil samples are collected at a fixed interval along a straight traverse line.
- **Rock Chip Sampling Survey:** This method is used to sample outcropping bedrock by breaking off a small piece for assay using a geological hammer and/or chisel. The survey is effective for reconnaissance surveys and involves sampling of unaltered bedrock with a purpose to demarcate host rock that is considered to support mineralisation.

Other types of geochemical surveys include: hydrogeochemical, biological and geobotanical surveys.

At the end of geochemical survey, the samples are processed and analysed. The assay results are compiled and tabulated. The result is a geochemical map or profile portraying the distribution of the desired element or mineral.

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A geochemical map is the principle means of presenting analysed geochemical data.

Geophysical Method

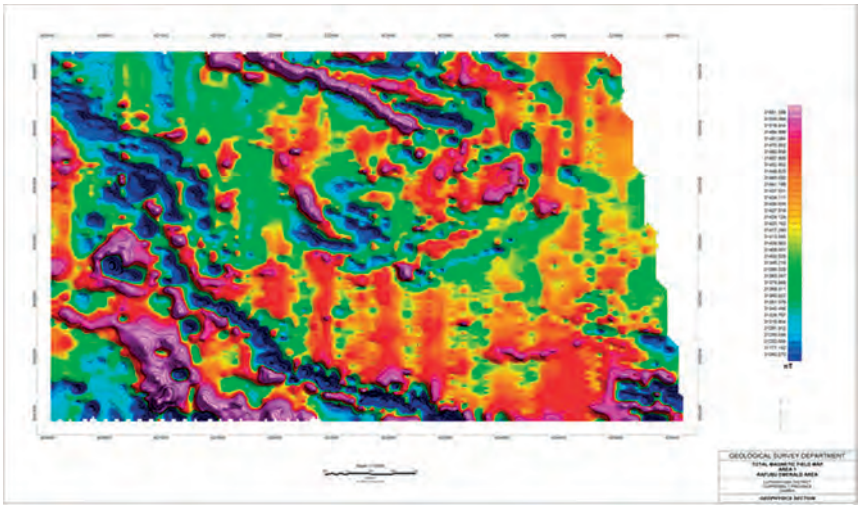
The geophysical method involves the measurement of physical properties of a subsurface rock to interpret and establish geological features, as shown in Figure 13 below. This method is particularly useful in areas that have limited outcrops. This method also allows for rapid regional exploration of areas where ground access may be difficult e.g. bad terrain in the escarpment of eastern Zambia.

Methods	Physical Properties	Types of Fields
Gravity	Density	Earth´s Natural Gravity Field
Magnetic	Magnetic susceptibility	Earth´s Natural Magnetic Field
Resistivity	Electrical Conductivity	Earth´s resistance
Electromagnetic	Electrical Conductivity and inductance	Applied electric og electromagnetic field
Electrical	Electrical Conductivity	Earth´s Natural telluric currents
Seismic	Seismic wave velocity	Artificially created waves

Source: Konduwani Zimba, Zambia Geological Survey Department

Figure 13: Geophysical Methods and Properties

The result of a geophysical survey is a geophysical map portraying the variation of the measured physical properties of the subsurface surveyed and analysed, as shown in Figure 14 below.



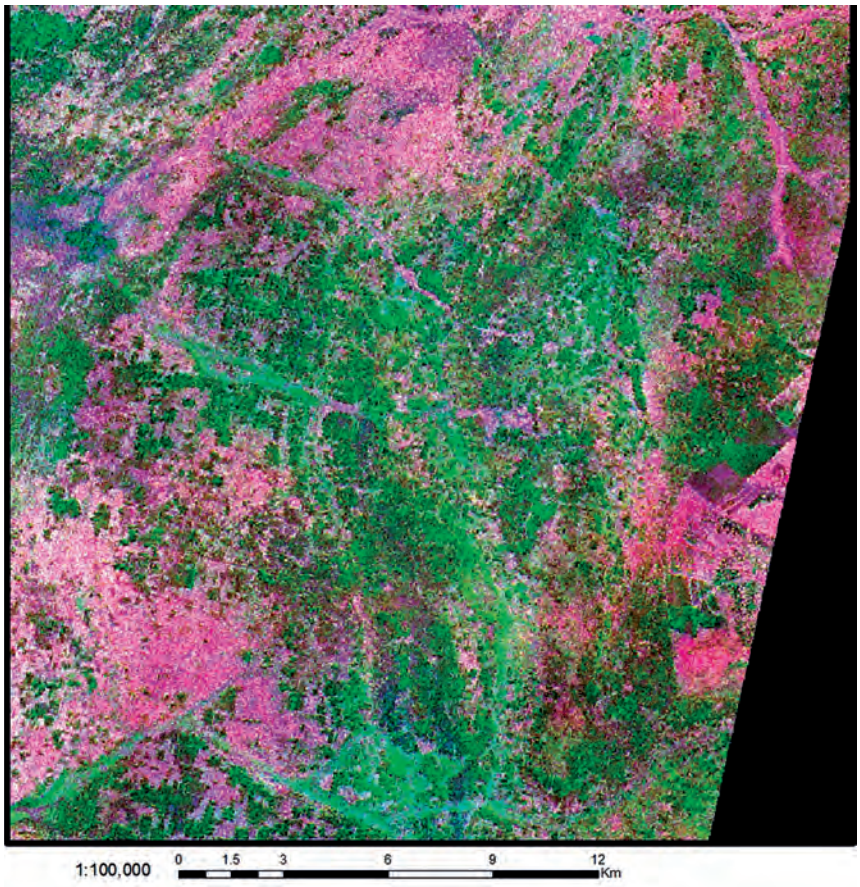
Source: Konduwani Zimba, Zambia Geological Survey Department

Figure 14: Example of Geophysics Magnetics, Area of Northern Zambia

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Remote Sensing Method

The remote sensing method is used to find potential exploration targets by collecting and interpreting information, i.e. geological structures, of an area of interest using satellite images, as shown in Figure 15. This method is particular useful at the reconnaissance stage of an exploration.



Source: Kondwani Zimba, Zambia Geological Survey Department

Figure 15: Example of Remote Sensing Image

Drilling

Drilling is one of the most important, and can be the most expensive, of all mineral exploration stages and procedures. The drilling stage follows on from geological surveys and mapping. Where the results of the initial exploration program are positive, a drilling program is usually carried out to confirm and evaluate the resource.

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OVERVIEW OF ASM IN ZAMBIA

By Choolwe Chadukwa, Senior Mining Engineer, Mines Development Department

General Overview of Artisanal and Small-Scale Mining in Zambia

Zambia has had a long history of mining, spanning over 100 years, with the mining sector continuing to play an important role in the country's economic development. Even though most of the mining activities to date have been undertaken by large-scale mining companies, there are a growing number of artisanal and small-scale miners involved in the exploration of both gold and gemstones as a result of the Government's policy to formalise and empower artisanal and small-scale miners in order to make them more productive so that they can support the development of lapidaries and local auction sales and therefore enhance the capacity of local businesses to participate in the mining sector value chain and to boost export revenue.

In Zambia, ASM dates back to the 1930s when the first mineral deposits were discovered in Ndola Rural. From the early beginnings and until 1984, the area played host to numerous unlicensed mining activities. In 1984, mining activities became subject to licensing as the area was declared a protected area. By 1990, the area had been divided into mining plots of about one square kilometre each. As of December 2017, the Ministry of Mines and Minerals Development has issued about 579 mining licences to the ASM sector. At present, ASM operations have become so extensive that mining excavations and huge waste dumps have become the most common sights in and around mining areas.

ASM activities encompass a wide range of mining practices. In certain areas, mining has been a traditional activity for generations, and may be a seasonal enterprise to supplement agriculture-based livelihoods. In some cases, significant commodity price fluctuations, mining closures or other economic shocks may lead to large numbers of ASM workers moving rapidly into an area, often with associated stresses to the environment and local communities. Sometimes the opening of a large-scale mine operation attracts ASM workers into the area within a short time, given that the presence of a large-scale mine is evidence of the availability of minerals in the area.

A census of Development Minerals in Zambia, conducted by the Ministry of Mines and Minerals Development with the support of the ACP-EU Development Minerals Programme, revealed that of the 109 mining plots/sites visited in the ten provinces of the country, both mechanised and non-mechanised mining operations, approx. 75% held legal licenses. The survey furthermore revealed that the vast majority of the ASM workers were unaware that their ASM activities required a valid license nor did they know how to obtain such a license.

Despite the Government's efforts to support and promote the ASM sector, a majority of ASM workers cannot afford to acquire the necessary equipment to explore and exploit the mines in a cost effective way, but are forced to employ simple tools and methods, such as

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a pick and shovel, to access the mineral resources; hence, the contribution to the country's Gross Domestic Product (GDP) by the ASM sector is almost negligible due to underdevelopment. In most cases, especially where simple tools are used, mining is conducted in an uncoordinated and dangerous way, which poses a hazard to humans and the environment. Some of the negative aspects of unregulated ASM activities include poor health and safety practices, child labour, pollution and contamination of water systems.



Source: John Thycsen, GEUS

Figure 16: Aquamarine prospect in Lundazi. An excavator has dug through the overburden to the hardrock with aquamarine.

Status of Minerals Exploited by the ASM Sector in Zambia

Gemstones

The ASM sector in Zambia is dominated by the mining of gemstones, primarily emeralds, amethysts, aquamarines, beryls and garnets. Other minerals exploited by the sector include topaz, quartz, and opal. Most of these gemstones and precious stones are used for ornamental purposes due to their specific properties.

Gemstones are mainly produced in rural areas, such as: Ndola Rural on the Copper belt (emeralds); Lundazi and Nyimba in Eastern Province (aquamarines, tourmalines and quartz); Siavonga and Mapatizya in the Southern Province (amethysts). Other gemstones mined by the ASM sector in these rural areas include: aquamarine, amethyst and rose

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quartz. In the Nyimba area at Hofmeyer, illegal miners, at an abandoned site that used to belong to the Mindeco Small Mines, mine black and green tourmaline, and pink quartz. In the Muchinga and Northern Provinces, quartz, used by the construction industry, is mined. Similarly, in Solwezi, along the Lunga River, quartz is mined and exported to China, where it is used for jewellery and other ornamental purposes.

At present, Zambia accounts for about 20% of the World's emerald deposits. There is therefore great potential for the gemstone sector to contribute significantly to the national economy and job creation, if the sector is well managed and supervised. At present, more than 400 mining plots in the emerald and amethyst areas have been issued to ASM workers by the Ministry of Mines and Minerals Development, but only three large-scale mining companies, i.e. Kagem (emeralds), Grizzly (emeralds) and Kariba Minerals (amethyst), are active and producing minerals - the rest of the plots, owned by ASM workers are not active due to lack of capital, skills, geological information etc. In 2016, Zambia's annual emerald production was approx. 70,000 kilos of which 90% was attributed to the three large-scale mines, i.e. Kagem, Grizzly and Miku.

At present, there are only three large-scale mines actively operating in the country's gemstone sector. To spur investments in the sector, in 2013, the Ministry of Mines and Minerals Development embarked on a programme aimed at merging 408 small-scale gemstone plots, starting with the Lufwanyama District in the Copper belt Province, in order to create reasonably large mining plots that would be technically and economically viable for mining purposes. The amalgamation of these mining plots was in accordance with the provisions of the country's Mines and Minerals Development Act. By merging these small-scale mining plots, both the license holders and the Government would benefit, as it would help attract investments required to effectively and efficiently explore and exploit the mining areas. Furthermore, license holders of barren ground would also benefit as such areas could be used for waste/dumping sites for such large-scale mining operations.

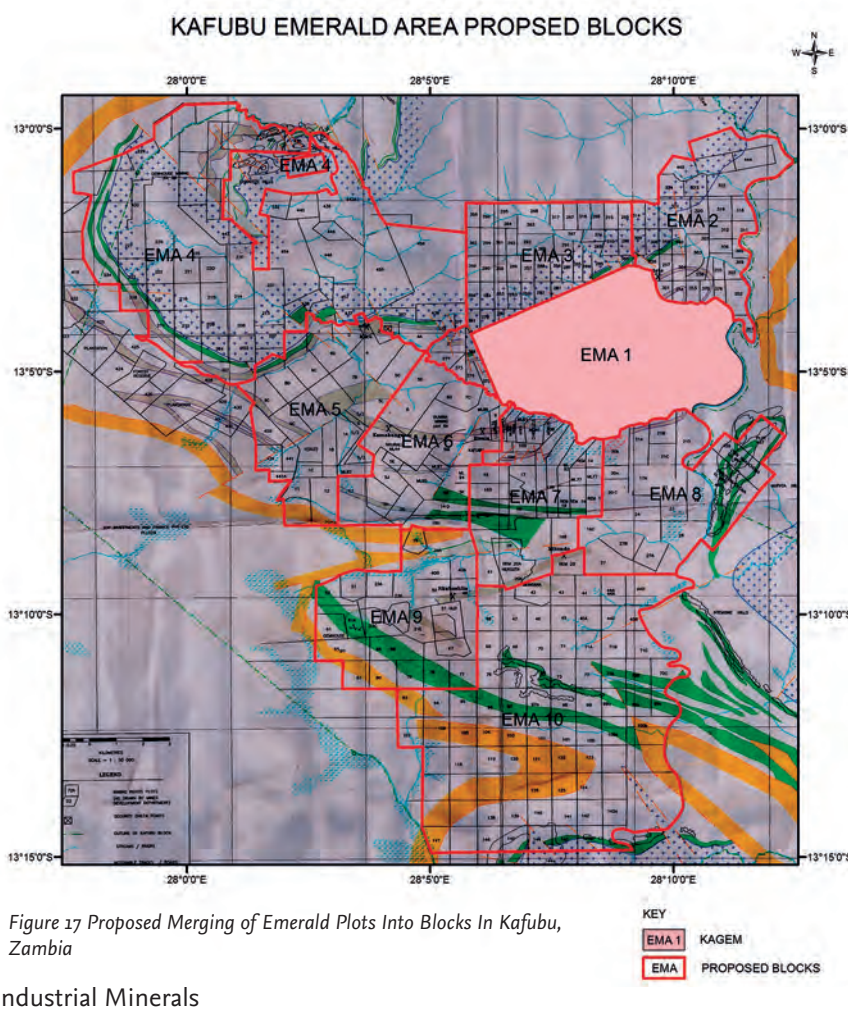
To undertake the merger of the small-scale mining plots, an Inter-Ministerial Task Team was established to manage the programme in the Lufwanyama District, initially, and to recommend investment packages that would be employed to attract the required investments. The programme would subsequently be extended to the amethyst mining plots in Mapatizya in the Southern Province.

The Inter-Ministerial Task Team undertook the following activities to determine which plots to merge and how to attract investments:

- Assessed the status of the small-scale gemstones in selected area/district;
- Established a criterion for merging the mine plots;
- Recommended the optimal size of mine plots to be created;
- Identified the possible legal implications and ways of addressing them;
- Sensitised the small-scale miners and stakeholders on the exercise.
- Generated basic geological data on the merged plots for use to attract investments;
- Designed investment packages for merged plots.

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In the Lufwanyama Emerald Area, the Inter-Ministerial Task Team found that less than 30 licences out of the 408 demarcated mine plots were viable and therefore recommended that these plots be amalgamated by merging the currently small plots into a total of ten (10) medium- to large-scale mining plots that were designated: EMA1, EMA2, EMA3, EMA4, EMA5, EMA6, EMA7, EMA8, EMA9 and EMA10, ref. Figure 17 below.



Source: Geological Survey Department, Zambia

Figure 17 Proposed Merging of Emerald Plots Into Blocks In Kafubu, Zambia

Industrial Minerals

The ASM sector in Zambia also undertakes the exploration and exploitation of industrial minerals, such as Basalt, Granite, Gneiss, Gabbro, Limestone, Dolomitic Marble, Sandstone, Siltstone and Rhyolite, Sand and Gravel, Shale, Tourmaline, Mica Schist, amethyst, Clay and Quartz. A number of ASM workers, including women, are also engaged in stone

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crushing and quarrying, especially in the peri-urban areas due to the demand for crushed stones in the construction industry in cities.

Basalt: Prevalent in the Southern Province. Used as building material and road construction. Usually sourced within easy reach, i.e. rock exposures are gathered and transported to a crushing site for further processing/mining. Quite a few women are involved in the exploitation and processing of basalt, given that simple tools, such as picks, hammers and chisels, can be employed to mine the mineral.

Granite and Rhyolite: Prevalent in the Southern Province (Lusaka and Luapula) and the Eastern Province. Used as construction material. Sold for both domestic and export market. Mined by both legal and illegal ASM workers. A few large-scale mining operations too.

Sand and Gravel: Prevalent in all provinces. Used as construction material. Rock boulders are mined from the surface. Silica sand is mined and used in base metal smelting by large-scale mines.

Clay: Prevalent in the Lundazi and Kalulushi Districts. Used as construction material, i.e. blocks.

Gold

Alluvial gold is also explored and exploited by ASM workers, both legal and illegal, due to high levels of poverty in gold mining areas. The gold is usually recovered from streambeds and stream banks by means of panning. This traditional process of panning gold is slow and inefficient as the recovery rate is low (about 10%) with the minute sizes (about 90%) left in the rubble, ref. Figure 18 below. Furthermore, alluvial gold panning operations require availability of water, e.g. a steady stream or river; hence, alluvial gold panning activities are limited to two seasonal windows, namely from November/December to mid-January and from April to July/August.

ASM workers recover gold using basic equipment, such as a 'James Table', which is improvised by cutting out plastic or metal drums with a series of holes on the base. Gravel, sediments, sand and other material from the river or streambed are poured on the cut drums on the rubber or wool liners placed below the drums. These rubber liners are cautiously placed at a suitable angle to allow only water and lighter sands to flow-through. Heavier gold nuggets are trapped on the rubber or wool liners. Once all the material on the 'James Table' is examined, the liners are washed in basins or wash pans, and the gold is collected. Water is then decanted slowly along with heavy minerals, such as magnetite, from the pans to only retain gold nuggets and gold fines. This improvised processing equipment is unlikely to maximise recoveries, particularly on the finer material and therefore losses can be significant. There is a need for investment in standard panning equipment for the ASM workers to improve recoveries of gold if production levels are to be improved. The provision of standard panning equipment could be one of the incentives to the ASM workers to encourage them to collaborate with the appointed Government Agency to buy the gold.

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Source: Mines Development Department, Zambia

Figure 18: Example of Gold Panning Activities, Rufunsa District, Zambia

Known gold panning areas include: Luano District, Vubwi District, Rufunsa District, Petauke District, and Sasare Area.

In 2016, two scoping missions, undertaken by the Ministry of Mines and Minerals Development, revealed that high-grade gold with a purity of more 90% could be mined from the above-mentioned districts/areas and sold directly to the domestic and international markets without any further processing. Samples collected from the sites visited include: 20.6 Carats in Vubwi (85% purity) and 23.5 Carats in Kampoko area (98%). Other samples collected exhibited highly elevated values in the gold ore, 9g/t in soils of the Rufunsa stream and 26g/t in the Rufunsa quartz veins.

The gold is often smuggled out of the country by illegal dealers, mostly foreign nationals (e.g. Malawians, Mozambicans and Tanzanians), to avoid paying taxes on revenue to the Government thereby denying Zambia and its citizens much needed remuneration for its natural resources. In the Luano Valley alone, the annual production of illegal gold is estimated to 1,200 kilos.

To curb the illegal mining and trading of alluvial gold, the Ministry of Mines and Minerals Development introduced a Gold Panning Certificate, under the 2015 Mines and Minerals Development Act, aimed at formalising mining and trading of gold to ensure payment of taxes to the benefit of the country and its citizens.

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In addition to the introduction of the Gold Panning Certificate, the Ministry of Mines and Minerals Development also initiated the following activities:

- Facilitated the formation of the gold panners associations;
- Licenced the associations/cooperatives;
- Provided technical extension services to the associations on mining, geological, safety, health and environment;
- Linked the associations to possible financial institutions and providers of equipment;
- Created a vehicle for marketing of the gold produced to enhance revenue collection by curtailing illegal trade of gold; and
- Conducted preliminary geological exploration within the illegal gold mining areas to determine the quantity and quality of gold and the primary sources.

Challenges of the ASM Sector in Zambia

The ASM sector in Zambia still faces numerous challenges that have limited its economic contribution to the national economy. To date ASM is largely a poverty alleviation sector in the rural areas of the country. Only a few ASM workers actually pay taxes on the sales of minerals mined - the vast majority of minerals mined by ASM workers in Zambia are mined and used locally, e.g. construction materials, industrial minerals etc., while precious metals and stones are sold to foreign buyers.

The issue of non-compliance with statutory rules and regulations, such as non-payment of annual license fees and area charges, non-submission of mineral production returns, non-submission of annual reports and future programme of mining operations, non-contribution towards the Environmental Protection Fund (EPF), non-adherence to the environmental regulations etc., poses the biggest challenge to the ASM sector, since it affects all stakeholders of the ASM communities.

The use of inadequate mining and mineral processing techniques also results in low productivity and recovery levels of mineral, which in turn result in low revenue and inability to accumulate funds for future investments in mining and processing equipment; hence, a vicious and never ending poverty cycle.

Furthermore, the seasonal nature of certain mining activities, e.g. alluvial gold panning, also poses challenges for ASM workers, as any mining income has to be supplemented with other income generating activities, such as farming.

The ASM sector also lacks appropriate management and technical skills. The labour employed by this mining sub-sector is often unskilled, since raw manpower is usually the main requirement, especially when simple production techniques are used. At present, the ASM sector therefore does not make any significant contribution to the creation of job opportunities for skilled and educated labour, such as geologists, mining engineers, surveyors, etc.

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Mining operations are also often undertaken haphazardly, e.g. overburden is dumped randomly around the pit and proper benching is shunned in an attempt to minimise costs.

When it comes to the participation of women in the ASM sector, socio-cultural and physical barriers, such as the harsh conditions which miners are subjected to and the traditional and cultural beliefs that discourage women from taking the lead in economic activities, prevent women's effective participation in informal mining activities. However, the number of women involved in the ASM sector has increased recently, especially with regard to stone crushing in urban areas and alluvial gold panning in rural areas of the country.

To help alleviate some of the problems of the ASM sector, the Ministry of Mines and Minerals Development established a Revolving Fund to issue loans to ASM workers. However, because ASM workers were unable to pay back loans obtained according to the stated terms and conditions, the Revolving Fund was dissolved. The Ministry of Mines and Minerals Development, with the support of the ACP-EU Development Minerals Programme, is currently implementing a capacity-building programme to provide training and extension services to ASM workers of Development Minerals in Zambia, including the provision of more inclusive finance from the private sector. Another support programme involves the provision of technical extension services specifically tailored for ASM workers for them to learn about environmental issues and general compliances regulations and to employ good mining practices in their operations.

Nonetheless, the ASM sector still lacks financial support in order to invest in suitable equipment and technology for expansion of mining activities.

Legal and Regulatory Framework of the ASM Sector

The Government of Zambia recognised the importance of the ASM sector by establishing the 2013 Mineral Resources Development Policy, which aims to:

- Encourage the use of appropriate, affordable and safe technology by increasing the Government's support to the collation and dissemination of information about appropriate technologies, the provision of extension services and the technology demonstrations;
- Build capacity in Regional Mining Offices to enhance the provision of technical extension services to the ASM sector;
- Collaborate with ASM associations to facilitate the formalisation of illegal mining activities by the ASM sector;
- Disseminate information to raise awareness on occupational health and safety, environmental risks, and provide occupational health and safety guidelines for ASM operations;
- Improve the system of information flow for the mining sector to sensitise and create awareness especially for ASM workers and rural population on the opportunities present and the regulations governing the ASM sector; and

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- Facilitate ASM workers' access to finance for the development of the ASM sector.

The Government's commitment to the development of the ASM sector is further expounded in the current Seventh National Development Plan, launched in 2017, with the aim to enhance the promotion of exploration and exploitation of gemstones and industrial minerals for the benefit of both the mining and associated sectors of the country. To this end, the Government's plans include: generation and provision of geological information; development of mineral processing technology; empowerment of ASM workers; development of market linkages; provision of strategic environmental assessments etc.

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A hut built by an ASM operator for his family

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Source: Adam A. Garde, GEUS.

r for his family

GUIDELINES FOR ACQUIRING AN ASM LICENSE IN ZAMBIA

By Michael Chibonga, Director of Cadastre Department

General Principles for Mining and Minerals Development in Zambia

Mining and Minerals Development in Zambia is regulated under the Mines and Minerals Development Act No. 11 of 2015 and the General Mining Regulations of 2016. The following principles under the stated legislation apply:

- Mineral Resources are non-renewable resources and shall be conserved, developed and used prudently, taking into account the needs of the present and future generations;
- Mineral Resources shall be explored and developed in a manner that promotes and contributes to socio-economic development and in accordance with international conventions to which Zambia is a party;
- The exploitation of minerals shall ensure safety, health and environmental protection;
- Wasteful mining practices shall be avoided so as to promote sustainable development and prevent adverse environmental effects;
- Citizens shall have equitable access to mineral resources and benefit from mineral resources development; and
- Development of local communities in areas surrounding the mining area based on prioritisation of community needs and health and safety

Artisans and Small-Scale Mining Rights in Zambia

Definition of Artisan and Small-Scale Mining

In Zambia, the ASM Sector is formalised in the sense that individuals, groups or companies have to operate under a legal mining title, such as an Artisan's Mining Right, a Small Scale Exploration Licence or a Small Scale Mining Licence. Anything outside this is termed as illegal mining, under the law.

According to the Mines and Minerals Development Act of 2015, the three operations are defined as follows:

- Artisanal Mining: Artisanal mining means an artisan's mining operation undertaken by a citizen of Zambia pursuant to an Artisan's Mining Right granted under Part III of the Mines and Minerals Development Act of 2015 over an area covering a minimum of 3 hectares and a maximum of 6 hectares;

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- Small-Scale Exploration: Small-scale exploration means exploration under a Small Scale Exploration Licence granted under Part III of the Mines and Minerals Development Act of 2015 over an area covering a minimum of 10 hectares and not exceeding a maximum of 1,000 hectares; and
- Small-Scale Mining: Small-scale mining means mining under a Small Scale Mining Licence granted under Part III of the Mines and Minerals Development Act of 2015 over an area covering a minimum of 10 hectares and not exceeding 400 hectares.

Eligibility to Hold Artisan and Small-Scale Mining Right

According to the Mines and Minerals Development Act of 2015:

I. An Artisan's Mining Right shall only be granted to a Zambian citizen. The mining right shall not be granted to or held by an individual who;
   a. Is under the age of eighteen years;
   b. Is or becomes an undischarged bankrupt, having been adjudged or otherwise declared bankrupt under any written law, or enters into any agreement or com position with creditors, or takes advantage of any legal process for the relief of bankrupt or insolvent debtors; or
   c. Has been convicted, within the previous five (5) years, of an offence involving fraud, dishonesty, or of an offence under this Act or any other written law within or outside Zambia and sentenced to imprisonment without the option of a fine.

II. A Small Scale Exploration Licence and Small Scale Mining Licence shall only be granted to a company incorporated under the Companies Act and not an individual, and such company shall be citizen-influenced; citizen-empowered; and or citizen-owned

III. A Small Scale Exploration Licence and Small Scale Mining Licence shall not be held by a company;
   a.That is in liquidation, other than liquidation which forms part of a scheme for the re-construction of the company or for its amalgamation with another company;
   b.Has not established a registered office in Zambia; or

c. Has among its directors or shareholders holding more than 10% of issued equity of the company, a person who;
   i.Is or becomes an undischarged bankrupt under any written law, or enters into an agreement or composition with creditors, or takes advantage of a legal process for the relief of bankrupt or insolvent debtors; or
   ii.Has been convicted, within the previous five (5) years, of an offence involving fraud, dishonesty, or of an offence under this Act or any other written law within or outside Zambia and sentenced to imprisonment without the option of a fine.

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Application for Artisans and Small-Scale Mining Rights

Priority of Applications

According to the Mines and Minerals Development Act of 2015, where more than one person apply for a mining right over the same area of land, the applications shall be disposed in the order in which they were received. This is the First-Come, First-Serve Principle and no applicant should be allowed to lodge an incomplete application to maintain its position in the queue.

Application for Area under Other Mining Right

An application for a mining right, irrespective of the category in which it falls, over an area subject to another mining right shall apply for consent from the holder of the mining right. The holder of the mining right over an area in respect of which an application is made may give consent to the applicant if:

- The minerals or metals applied for are different from those indicated on the holder's licence;
- The geographical position of the minerals or metals applied for is different from the holder's resource indicated in the approved programme of operations; and
- The geographical location of the application for the mining right does not compromise the integrity of the exploration or mining programme of the holder of the existing mining right.

Application for Small-Scale Exploration Licence
An application for a Small Scale Exploration Licence shall be made to the Director of the Mining Cadastre in the prescribed form upon payment of the prescribed fee.

The prescribed form shall be accompanied by the following:

- A proposed programme of exploration operations, which should include an estimate of investment;
- A proposal for the employment and training of citizens of Zambia;
- A proposal for the promotion of local business development;
- A valid tax clearance certificate issued under the Income Tax Act; and
- Any further information, which the Director of Mining Cadastre may require.

The area of land over which an application for an exploration licence is made shall be represented by a compliant geographical coordinates, which shall form a complete and contiguous cadastre units

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Application for Artisans Mining Right and Small-Scale Mining Licence

An application for a mining licence shall be made to the Director of Mining Cadastre in the prescribed form and upon payment of the prescribed fee.

The application for the Artisan's Mining Right shall be accompanied by the following:

- A copy of the Applicant's National Registration Card;
- An Environmental Commitment Plan;
- Programme of Mining Operations; and
- A valid Tax Clearance Certificate.

The application for the Small Scale Mining Licence shall be accompanied by the following:

- Copy of the relevant Small-Scale Exploration Licence (this is the prerequisite);
- Proposed programme of mining operations, which should include the forecast of capital investment, the estimated recovery rate of ore and mineral products, and the proposed treatment and disposal of ore and minerals recovered;
- Description of the mineral deposit;
- Statement of minerals sought;
- Valid Tax Clearance Certificate;
- Environmental Clearance Decision Letter from ZEMA; and
- Any further information, which the Director of Mining Cadastre may require.

Consideration and Processing of Applications

There is an established Mining Licensing Committee, which:

- Considers applications for mining rights and non-mining rights and grants, renews or refuses to grant or renew mining and non-mining rights;
- Terminates, suspends or cancels mining and non-mining rights;
- Amends the terms and conditions of mining rights and non-mining rights; and
- Advises the Minister on matters relating to its function under the Mines and Minerals Development Act of 2015

Obligations of Artisans Mining Right, Small-Scale Exploration Licence and Small-Scale Mining Licence

Artisan's Mining Right and Small-Scale Mining Licence

An Artisans Mining Right and Small-Scale Mining Licence Holder is subject to the following obligations:

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- Within 180 days of grant of the mining licence, demarcate the area and register a pegging certificate at the Mining Cadastre Office;
- Develop the mining area, and carry on mining operations, with due diligence and in compliance with the programme of mining operations and the environmental impact assessment; and
- Take all measures on or under the surface to mine the mineral to which the mining licence relates.

Small-Scale Exploration Licence

A holder of a small-scale exploration licence shall:

- Within 180 days of grant of the licence, demarcate the area and register a pegging certificate at the Mining Cadastre Office;
- Give notice to the Director of Geological Survey of the discovery of any mineral deposit of possible commercial value within 30 days of discovery;
- Expend on exploration operations not less than the amount prescribed or required by the terms and condition of an exploration licence;
- Undertake exploration in accordance with the programme of exploration;
- Backfill or otherwise make safe any excavation made during the course of the exploration;
- Permanently preserve or otherwise make safe any borehole; and
- Keep and preserve such records as the Director of Mines Safety may determine relating to the protection of the environment.

Types of Minerals Allowed Under ASM

According to Section 29 (4) of the Mines and Minerals Development Act of 2015, applicants for artisanal mining or small-scale mining shall not be granted a mining licence in respect of radioactive minerals.

Enclosures (Forms, Fee Schedules and Conditions of Grant)

Forms, documents, templates, fee and area size schedules, and conditions of granting mining rights are enclosed as Appendix A.

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Housing in a small village north of Lusaka

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SIGNIFICANCE OF GEOLOGICAL KNOWLEDGE TO DEVELOPING AN ASM MINING SITE

By Cryton Phiri, Department of Geology, School of Mines, University of Zambia (UNZA)

Source: John Tychsen, GEUS.

According to Bhagwat and Ipe (2000), utilisation of geological knowledge helps to:

- Better identify mineral resources;
- Make better mining and quality control decisions;
- Increase precision in drilling (location, depth, success rates);
- Improve environmental assessments and make remediation designs and applications;
- Improve the quality of work being carried out at the site;
- Feel more confident in your own work;
- Improve communication with experts (geologists, engineers, planners);
- Educate citizens in managing mineral resources;
- Satisfy regulatory requirements; and
- Aid in court litigation.

Geological Maps

Definitions of Geological Maps

Marjoribanks (2010) defined a geological map as a human artefact constructed according to the theories of geology that are useful to the extent that it permits prediction of those things, which cannot be observed. Similarly, Lisle (2004) and Njue (2010) defined a geological map as a map showing the distribution of rock units and structures across a region, usually on a plane surface. Both definitions of a geological map points to the presentation of geological information whose application is dependent of what kind of information is being sought by the intended user.

Features of Geological Maps

Grids and Map Scale

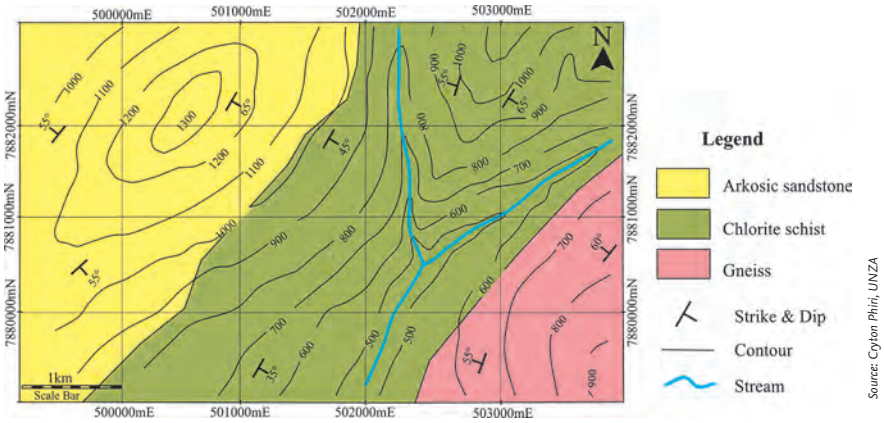
Geological maps are presented according to varying grid coordinate systems and map scales depending on the information being sought by the end user. Grids are used to locate a specific point on a map.

Two types of grid referencing systems are often adopted; 1) the Universal Transverse Mercator (UTM) conformal projection uses a 2-dimensional Cartesian coordinate system to give locations on the surface of the Earth, and 2) the standard geographic projections uses degrees and minutes (longitude/latitude).

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The UTM system divides the Earth into 60 zones, each 6° of longitude in width, making it ideal for relatively 'smaller' ASM license areas. Zone 1 covers longitude 180° to 174° W; zone numbering increases eastward to zone 60, which covers longitude 174°E to 180°. A position on the Earth is given by the UTM zone number and the easting and northing planar co-ordinate pair in that zone. The point of origin of each UTM zone is the intersection of the equator and the zone's central meridian.

Standard geological maps are presented with a scale bar useful to measure the distance of the geological feature on the map in relation to its size on the actual ground. As shown in Figure 19 below, the scale 1:1,000 means that 1cm on the map represents 10m on the actual ground. The smaller the area, the larger the scale and sufficient the detail the information tends to become. The longitude/latitude system usually covers larger areas and should be left to relatively larger mining prospects.



Source: Cyton Phiri, UNZA

Figure 19: Schematic Geological Map

Contours

Contours are imaginary lines that join points of equal altitude above the same reference level and reflects the actual surface relief of an area on a map, as shown in Figure 19 above. The value difference between two contours is called contour interval, e.g. 100m, ref. Figure 19. These contour lines help to infer the surface features of terrain, geologic structures and rock formations, including drainage, soils and other pertinent structures. When contour lines are clustered or closer together to one another they indicate hilly or mountainous terrain, and when further apart they indicate a gentler slope, and when far apart indicate flat terrain. The V and U shape of contours assists in determining the streams and drainages and ridges respectively, i.e.:

- "V" shaped contours indicate streams and drainage, with the point of the "V" pointing uphill.
- "U" shaped contours indicate ridges, with the bottom of the "U" pointing downhill.

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Placer or semi-precious stones have been found along streams (i.e. downstream) indicating that the actual source is upstream; hence, ASM workers can use geological maps as a prospecting and exploration technique to trace deposit source in an area of interest.

Rock Types

The presence of rocks and types constitutes a geological map viz a viz a topographic map. The latter also shows contours and different surfaces, but it does not show information on rocks, e.g. igneous, sedimentary and metamorphic.

- Igneous Rocks: Rocks that have formed from the cooling and solidification of magma or lava. Solidification into rock occurs either below the surface as intrusive rocks (e.g. granites) or on the surface as extrusive rocks (basalts). Igneous rocks hold minerals of interest, such as: semi-precious stones, aggregates and dimension stones (i.e. granites);
- Sedimentary Rocks: Rocks that have formed from the consolidation of sediments, such as sand, pebbles, clay or mud. The common rock types are conglomerates, sandstones, siltstones and shales or mudstones. Sometimes, sediments can contain fragments of rocks, animals and plants. Sedimentary rocks hold minerals of interest, such as construction material, aggregates and dimension stones.
- Metamorphic Rocks: Rocks that have changed their nature (recrystallized) from the original rock material because they have been heated, but not melted, and/or placed under great amounts of pressure. Notably are gneiss, schist and marbles. Metamorphic rocks hold minerals of interest, such as semi-precious stones and dimension stones.

Strike and Dip

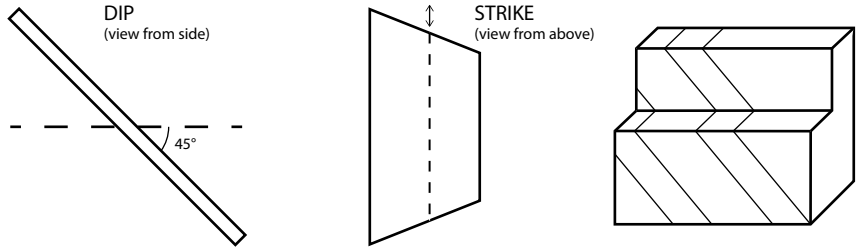
Strike and dip are used to describe the orientation of a rock bed, fault, fracture, cuestas, igneous dikes, and sills, i.e. a 3-dimensional map of a rock area, ref. Figure 20 and Figure 21 next page.

- **Strike:** Refers to horizontal direction of a rock formation, e.g. North-South, East-West etc.
- **Dip:** Refers to the tilting of a rock layer, measured as the angle between the layer and horizontal line (strike). The angle, or dip, is always less than or equal to 90 degrees.

Strike and dip is used to:

- Measure the true thickness of a deposit/bed; and
- Estimate the volume and tonnage of a deposit;

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Source: Fractal Planet, https://fractalplanet.wordpress.com and redrawn by Jacob Lind Bendtsen, GEUS

Figure 20: Strike and Dip



Source: Cyton Phiri, UNZA

Figure 21: Example of Dip And Strike

As shown in Figure 22 below, rock formation, comprising sandstone, mudstone and limestone, was tilted 35 degrees to the southeast after deposition as a result of tectonic (deformational) activities.

To calculate the true thickness of a deposit/bed one has to measure the width of the outcrop and the angle of the dip, i.e.:

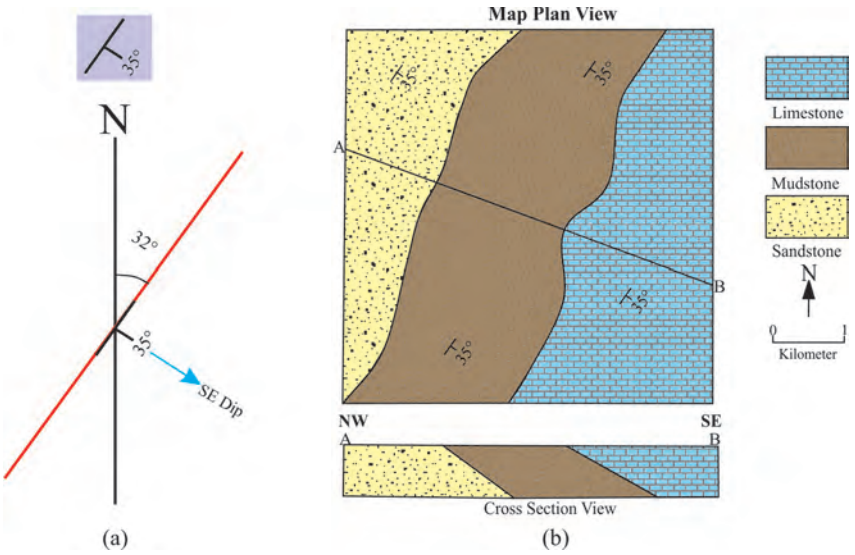
True Thickness (t) = Width of Outcrop (w) x Sin (Angle of Dip)

Example:

t = 50m x Sin (35 Degrees) = 28.7m

To estimate the volume and tonnage of a deposit, one has to determine the area of influence and know the tonnage factor or SG for the rock type/material surveyed, i.e.

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Source: Cryton Phiri, UNZA

Figure 22: Illustrations of Strike and Dip Measurements and Interpretations

Volume (v) = Area of Influence (a) x Lenght Measured (m)

Tonnage (t) = Volume (v) x Tonnage Factor (f) or Specific Gravity (g)

Example:

t = (2,710m x 50m) x 1.2 = 162,600t

Reading and Interpretations of Geological Maps

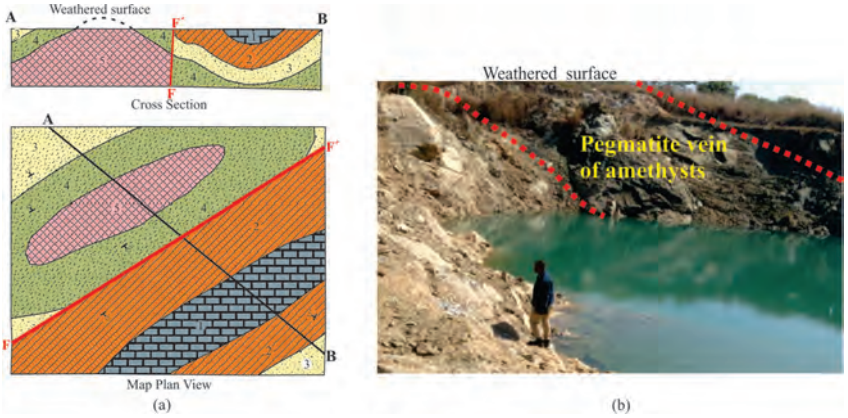
Geological cross-sections are an indispensable complement of geological maps. Geological maps and cross-sections represent interpretations of the arrangement of the rocks using diverse types of data, normally incomplete and with different degrees of uncertainty. Both cross-sections and maps are 2-dimensional representations of the geological reality and jointly allow one to understand the 3-dimensional structure of the rocky volumes and, in consequence, the geological history of a zone.

A geological cross-section is a graphic representation of the intersection of the geological bodies in the subsurface with a vertical plane of a certain orientation. It is a section of the terrain where the different types of rocks, their constitution and internal structure and the geometric relationship between them are represented. It is an approximate model of the real distribution of the rocks in depth, consistent with the information available on the surface and the subsurface.

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The construction of a geological cross-section involves the interpretation of the rocks arrangement, both in depth and on the topographic surface. This consists of interpolating all the available data, of surface and subsurface, with the objective of building a coherent geological model. For this reason, the construction of the geological cross-sections requires the application of all the knowledge of the geological characteristics of the region, interpreted within the framework of the theoretical knowledge of the moment.

The data on the surface are obtained directly on the field (direction and dip of the strata or other structures, types of contact, thickness of the stratigraphical units, lateral relationships between them, etc.), e.g. Figure 23 below, or they are extracted from an existing geological map (geological formation or cartographic unit, type of rock, angle of the intersection with the topographic surface, spot data).



Source: Cryton Phiri, UNZA

Figure 23: Examples of Geological Cross-Sections
The cross section is drawn perpendicular to strike and is intersecting almost all the rock types in the area. The opposite-dipping side of strike and dip measurements shown by rock type labelled no. 4 in the cross-section signifies a hill (anticline). Conversely, the same-dipping side of strike and dip measurements shown by rock type labelled no. 2 shows the presence of a depression (syncline). The projected dashed line indicates the missing (weathered or erosional) lithology surface. This knowledge of strike and dip should therefore guide the ASM worker to make projections and to trace the continuity of a deposit on either side of the prospect area despite its absence on the weathered surface.

As shown in Figure 23 above, a fault sometimes tends to displace the rocks and make an abrupt steep dipping of the beds.

A fault is a fracture, or break, in the Earth's crust (lithosphere). Some faults are active, i.e. sections of rock move past each other, sometimes causing earthquakes.

Faulting occurs when shear stress on a rock overcomes the forces, which hold it together. The fracture itself is called a fault plane. When it is exposed at the Earth's surface, it may form a cliff or steep slope called a fault scarp.

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The angle between the fault plane and an imaginary horizontal plane is called the dip angle of the fault. Faults may dip shallowly or steeply.

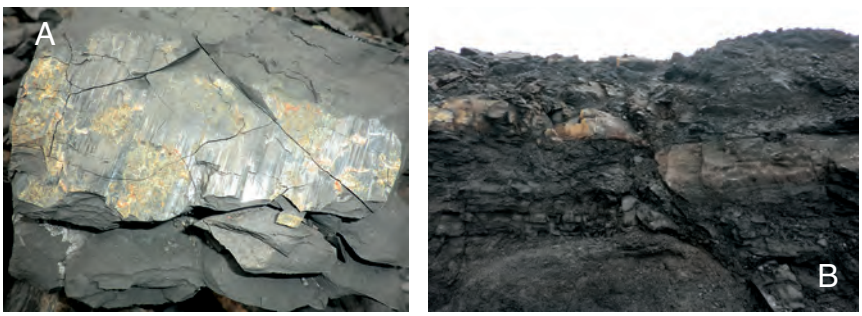
Faults are categorized into three types:

Normal Fault: A normal fault is one where the fault dips toward the downthrown block. Normal faults occur in rifted terranes, such as Mid-Ocean Ridges, the African Rift, and the Basin and Range Province of western North America. It is shown on geologic maps as a black line with either a block pattern on the downthrown side, or the letters U/D showing the upthrown and downthrown sides.

Reverse Fault and Thrust Fault: A reverse fault (if steeply dipping) or thrust fault (if shallowly dipping) is a fault where the fault plane dips toward the upthrown block. It is shown on the geologic map with triangular teeth pointing toward the upthrown side of the fault. Reverse and thrust faults shorten (horizontally) and thicken the crust. They are characteristic of collision origins.

Faults can be observed by means of:

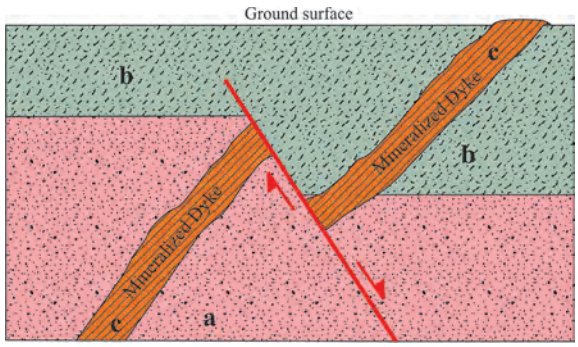
- Direction of movement lineation on the fault plane. Examples of lineation includes striations or slickensides as shown in Figure 24 (a) below;
- Direction of stratigraphic (rock layering) movement or separation, as shown in Figure 24 (b) below. Stratigraphy is the study of rock layering by geologists. According to the principles of stratigraphy, older rocks are placed at the bottom and younger ones at the top. As a result of faulting, missing (omitted) layer can be identified. In other situations, the older rocks appear to lie on top of the younger rock and cause the repetition of rock layering; and
- Direction of throw and displacement. The throw is the vertical distance that a point moves during faulting. The displacement is the distance by which a particular feature, e.g. a bedding horizon, is offset across the fault measured along the fault surface.



Source: Cryton Phiri, UNZA

Figure 24: Examples of Faults Slickedsides and Statigraphic Displacement by Fault

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Source: Cyton Phiri, UNZA

Figure 25: Examples of Fault Displacement of a Mineralised Dyke

By having a basic understanding of faults, ASM workers are able to interpret a fault displacement of a rock deposit. Taking departure in a schematic geological cross-section showing the fault displacement of a mineralised dyke, as shown in Figure 25 below, an ASM worker can easily determine the direction of displacement of a mineralised dyke without having to seize mining operations to obtain assistance from a mining expert.

Mineral Exploitations

Mineral exploitation is associated with the actual extraction (mining) of the deposit from the ground. During this stage, the emphasis is mainly on extracting the resource through various mining methods. When choosing a mining method for a particular mineral deposit, the following list of factors, although not exhaustive, should be considered:

- **Physical Characteristics of the Orebody and Hosts Rocks:** Ground conditions, including texture, joints and faults. Friable ground would pose a danger to loss of human life;
- **Depth of Orebody:** An orebody close to the surface can be mined through an open pit or open casts methods, but other factors, such as dip, should also be considered;
- **Dip of Orebody:** A relatively flat-dipping orebody can be exploited by using simple miming tools or even by hands. A steep dip requires the building of a shaft and more technical mining equipment;
- **Ore Recovery:** Minimizing the ore losses by means of dilution, over burden and mining;
- **Equipment and Technology:** Use of heavy construction equipment, such as bulldozer, to remove overburden to access an orebody.
- **Environmental Concerns:** Waste generated from the host rock may contain toxic/hazardous material harmful to both humans and the surrounding environment. Furthermore, mining material, including waste can be transported by both wind and water streams to far-flung surrounding areas thereby causing pollution of air, soil and water.
- **Economics:** Operational and capital costs, ore grades and mineral value.

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Source: Cryton Phiri, UNZA

Figure 26: Example Of Hazardous Mining Practices

From the above list of factors, it is evident that before commencing on any mineral exploitation, understanding of geological knowledge is key. Lack of geological knowledge can result in the selection of poor, even hazardous, mining methods, as shown in Figure 26 above.

Provision of Geological Services in Zambia

In Zambia, the GSD is mandated by law to provide the following information and services to the public, miners, investors, state agencies etc.:

- Sound and unbiased scientific earth science research;
- Geologic data and maps in digital formats;
- Geological and geological-related information; and
- Outreach campaigns.

Institutions of higher education and learning, such as the University of Zambia and Copper belt University, are also able to provide geological and mining knowledge to the public.

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MINERAL EXPLOITATION METHODS AT A DEVELOPMENT MINERALS MINING SITE

By Mulongwe Simukali, Mining Engineer, Mines Development Department

Introduction

Mining refers to a process of extracting/removing ore minerals from the Earth's surface, subsurface or down deep in the interior of the Earth's' crust. The process of obtaining these minerals can be done by either surface or underground mining methods, subject to the depth of the mineral deposit. Before one can start mining, it is important to establish first the layout of a mine, which depends on the type of mining method being used, i.e. mining by open pit or by underground means.

If the mining method is by open pit, the layout starts with the basic design of the pit itself. This includes pit layouts in intervals up to the final design (ultimate pit). With the pit established, the infrastructure is planned, including surface roads and buildings, dumps, stockpiles and tailing disposal sites, where applicable.

For underground mining, the planning includes locating and sizing pre-production and establishing surface infrastructure. The initial planning for mine layout includes determining primary access, such as adit, ramp and other entries based on the requirements for ore and waste rock handling, ventilation requirements and access for personnel. Once underground planning is achieved, the surface infrastructure is designed, including access roads, dumps, explosive storage, office buildings, plant maintenance etc.

Surface Mining Methods

Surface mining involves driving/making a series of excavations that are entirely open from the surface. The opening, formed in the process of mining out ore, forms an open pit, ref. Figure 27 below. At each given moment of time, the totality of workings called the pit is limited by the top and bottom contour.

Compared to underground mining, surface mining has the following advantages:

- Minimum loss of ore during extraction;
- Useful for mining both small and massive ore-bodies located close to the Earth's' surface;
- Relatively safe method, because nearly all the mining operations are conducted in the open atmosphere and not in an enclosed environment – saves massively on the cost of a ventilation system;
- Better lighting, sanitary and hygienic conditions for workers;
- Higher production output because of its ability to accommodate large and high productive equipment;

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Source: John Thycsen, GEUS

Figure 27: Example of an open pit

- Easily mechanised;
- Simplified auxiliary operations and services, e.g. drainage;
- Lower capital investments and shorter construction terms than those of underground mining; and
- Simple working plan, possibility of selective and more complete extraction of mineral from the Earth.

Excavation Methods

Methods by Hand

This method involves the use of simple tools, such as pick and shovel. It is used for mining loose and semi-consolidated material, such as soil, alluvial gravel, and highly weathered rock see. The majority of small-scale miners in all types of mineable mineral deposits, e.g. industrial material, gemstones etc., use this method due to lack of capital.

In situations where rocks are relatively hard, the rocks are heated up by fire using either charcoal, ordinary firewood or even old vehicle tyres, which are rampant in Lusaka West among unlicensed miners. After heating, the rocks are then allowed to cool down rapidly with the use of water. This method is potentially destructive to gemstone crystals that may be fractured in the heating and cooling process.

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Hammer and Chisel

This method is applied on relatively hard material. It is mainly applied in situations where the use of blasting is not recommended due to possible inducement of cracks in minerals being mined, i.e. blasting may negatively affect the quality of gemstones. The major advantage of this type of excavation is that it is relatively cheap and affordable. Disadvantages include low productivity and limitations of its application.

Mechanical Excavation Methods

This involves the use of mechanical equipment such as bulldozers, excavators and hammers, as shown in Figure 28 below.



Figure 28: Example of Mechanical Excavation Equipment

Hydraulic Excavators

These are used for both excavation and loading purposes. They are ideal for mining soft and not so hard material.

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Open Pit Stripping

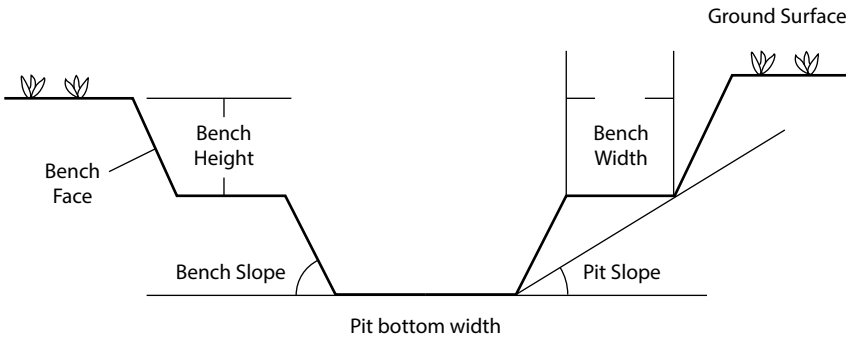
Open pit stripping involves the removal of overburden to expose the mineralisation vein. Mining and stripping are carried out in parallel with stripping leading mining.

Once the mineral deposit has been identified and all relevant information known, such as the detailed geo-technical information relating to rock, strengths and discontinuities, hydro-geological information, which includes groundwater recharge rate, water table depths, nature of surface drainage, and overburden depth and its variation in thickness, the next stage involves determining the pit parameters and size. The size of the pit is determined based on the size and extent of the mineral deposit and on its inclination.

Benching

Benching is one of the critical parameters to pay attention to from the initial development of the pit. A bench consists of the following elements: height, face, slope, pit bottom width, ref. Figure 29 below.

Benches in relatively weak ground are very short and generally sloping while those in strong ground tend to be high with steep bench faces. The bench interval (height) is determined primarily by the size of machines employed and mining system, including other factors. Rock water content and climatic conditions considerably affect the bench interval and angle of slope. Dense and dry rocks allow greater angles of slope. Other factors affecting pit design include: location of waste dumps, physical limitations and production capacity.



Source: Mulongwe Simukoli, Mines Development Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

Figure 29: Parameters of an open pit

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Gaining Access to the Orebody

Before starting mining, one should make sure that a permanent place for locating waste dumps is properly established and that physical limitations are known. Usually, most small-scale miners do not properly plan dumping sites and as a result have to re-handle waste dumps twice in cases where they find out that the vein passes under these waste dumps. A strip ratio of 10:1 implies that for every 1 unit of ore mined 10 times of waste rock are also mined. Traditionally, little attention has been paid to design and planning; therefore, it has been recognised that dump design and planning are integral parts of any pit design.

Drainage around the pit should also be constructed to prevent any flow of water into the pit.

Access to the ore body is provided by open workings, which are usually trapezoidal in cross section, labelled trenches, as shown in Figure 30 below.

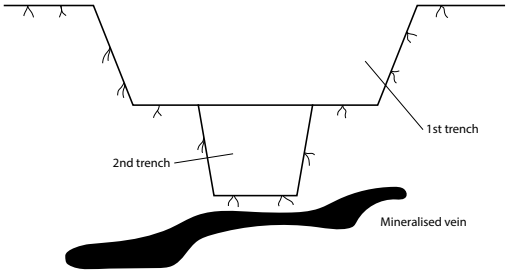


Figure 30: Schematic Example of Trenching

Source: Mulongue Simukali, Mines Development Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

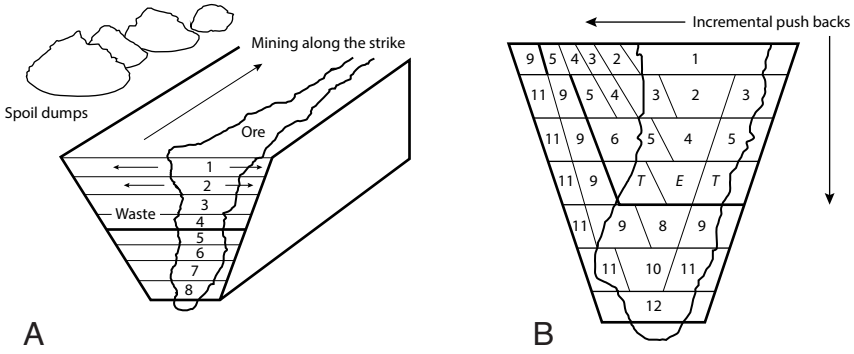
Mining Sequence

The sequence of mining has an impact on the waste to ore ratio. If each bench is mined back to its ultimate design position before commencing on the next bench as shown in Figure 31(b) below, then in the early days of mining, large amounts of waste will be mined in relation to the ore. This simply means that most costs will be incurred in extraction of waste material. The ultimate result of this may be the inability of the mine owner to pay for removal of the early waste generated. It is therefore advisable to use a mining method, which calls for incremental pushback of the bench perimeters both in horizontal and vertical directions as shown in Figure 31(a) below.

Alternatively, bench batters in waste should be given a lower angle at early stages to reduce the amount of waste mined at early stages, as shown in Figure 32 below.

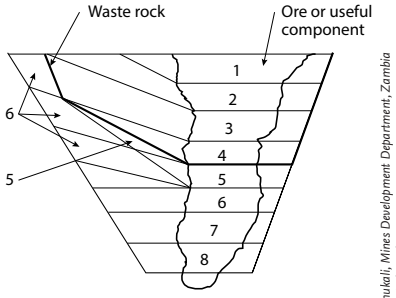
In general, mining sequence and final limit refer to the path or trajectory employed to ex-

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Source: Mulongwe Simukali, Mines Development Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

Figure 31: Schematic Example of mining sequences
(a): Mining sequence in which benches are mined up to the pit boundary before proceeding to the next bench. (b): Mining Sequence with incremental pushbacks.



Source: Mulongwe Simukali, Mines Development Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

Figure 32: Example an Alternative Mining Sequence

ploit a mine – from an initial situation until reaching the final limits or exhausting the ore reserves. Usually, these two variables are treated separately, but because of their co-dependency, they should be handled together. The mining sequence is usually defined in terms of sequential "cuts" of "sectors" in which a final mining envelope is split to guide the mining extraction. These sectors can be phases, i.e. cutbacks or pushbacks, as they are usually called in open-pit mining, or blocks, panels, rooms or stopes, as these are commonly referred to in underground mining. It is worth noting that the partition of a final mining envelope into cuts or sectors is done because the time value of money. In effect, the purpose is to postpone expenditures and bring forward revenue as much as possible from sales of production material.

Underground Mining Methods

Underground mining involves making a series of excavations/openings into the Earth's crust with the aim of getting access to the ore deposit. Once an ore body has been probed and outlined and sufficient information has been collected to warrant further analysis, the important process of selecting the most appropriate method or methods of mining can begin. At this stage, the selection is preliminary, serving only as the basis for a project layout and feasibility study. Later it may be found necessary to revise details, but the basic principles for ore extraction should remain a part of the final layout.

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Stages in Underground Mining

Underground mining consists of the following four major stages:

1. Prospecting
2. Exploration
3. Development
4. Extraction

The process starts by prospecting followed by detailed exploration. The development stage is divided into primary and secondary development. The first stage involves opening up of the ore-body/vein for access. This involves sinking a shaft (or a ramp) from the surface while the second stage is more concerned with development of the stope or block. In order to get access to the mineral, mine openings (drifts) are driven into the rock medium and to the ore-bearing vein, as shown in Figure 33 below.

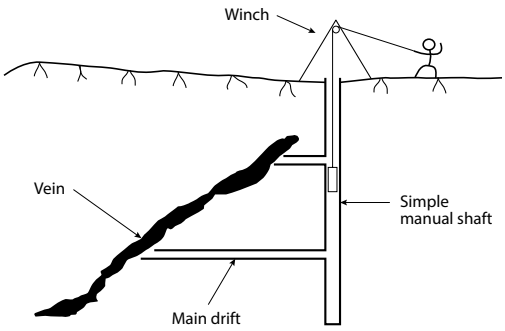


Figure 33: Schematic Layout of A Simple Underground Mine

Source: Mulongwe Simukoli; Mines Development Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

In this case, the simple manual shaft can be used for various functions, such as transportation of equipment, miners and hoisting of extracted minerals and waste. Therefore, in order to carry out the above-mentioned four stages, basic mine planning should be done initially. This mine planning must be correlated to all phases of mining operations. The factors that must be considered in underground mining are numerous and must reflect characteristics and surrounding conditions of the ore deposit.

Mine planning includes the choice of the appropriate mining method, the size of the operation and mine openings, the mine productivity and cost, and eventually, the economic parameters used to determine whether or not the mineral reserve should be developed and of course location and construction of surface infrastructure.

Basically, the technical information required for preliminary mine planning includes: geological and mineralogical information, i.e. the dipping angle of the deposit, continuity or discontinuity of the ore-body, nature of contact with surrounding rocks, hydro-geological conditions, topography etc.; structural information, i.e. the depth of the cover, structure of hoist rock (strength, porosity and permeability etc.); the hardness, toughness, and abrasiveness of the material that will determine the type and class of the equipment to be used for extracting the material efficiently; economic information, i.e. available reserves,

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grade distribution and cut-off grade (the lowest value of metallic or non-metallic mineral content, which can be mined economically); production sizing; and economic factors of operating costs, including capital expenditures, market conditions and prices. All of this information is required for determining mine life, rate of mining and recovery of mineral valuables.

Selection of Mining Method

With respect to the basic principles employed, relatively few mining methods are used today. Because of the uniqueness of each ore deposit, variations on each of these methods are nearly limitless. These mining methods include the following:

Room-and-Pillar Mining

Room-and-pillar mining is designed for flat-bedded deposits of limited thickness, such as copper shale, coal, salt and potash, limestone, and dolomite. This method is used to recover resources in open stopes. The method leaves pillars to support the hanging wall; to recover the maximum amount of ore, miners aim to leave the smallest possible pillars. The roof must remain intact, and rock bolts are often installed to reinforce rock strata. Rooms and pillars are normally arranged in regular patterns.

Sublevel Open Stoping

In sublevel open stoping, an ore is recovered in open stopes, normally backfilled after being mined. Stopes are often large, particularly in the vertical direction. The ore body is divided into separate stopes. Between stopes, ore sections are set aside for pillars to support the hanging wall. Pillars are normally shaped as vertical beams across the ore body. Horizontal sections of an ore, known as crown pillars, are left to support mine workings above the producing stopes. Sublevel stoping is used for mining mineral deposits with following characteristics:

- Steep dip--the inclination of the footwall must exceed the angle of repose;
- Stable rock in both the hanging wall and the footwall;
- Competent ore and host rock; and
- Regular ore boundaries.

Cut-and-Fill Stoping

Cut-and-fill mining removes ore in horizontal slices, starting from the bottom undercut and advancing upward. Ore is drilled and blasted and muck is loaded and removed from the stope. When the stope has been mined out, voids are backfilled with hydraulic sand tailings or waste rock. The fill serves both to support the stope walls and provides a working platform for equipment when the next slice is mined.
Cut-and-fill mining is used in steeply dipping ore bodies in strata having good-to-mod-

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erate stability and comparatively high-grade ore. It provides better selectivity than the alternative sublevel stoping and VCR mining techniques. Hence, cut-and-fill is preferred for ore bodies having an irregular shape and scattered mineralisation. The cut-and-fill method allows for selective mining, separate recovery of high-grade sections, and the leaving of low-grade rock behind in stopes.

Longwall Mining

Longwall mining applies to thin-bedded deposits of uniform thickness and a large horizontal extent. Typical deposits are represented by coal seams, potash layers, or conglomerate reefs mined by the South African gold mining companies. Longwall mining applies to both hard and soft rock as the working area along the mining face can be artificially supported where the hanging wall tends to collapse.

The longwall mining method extracts ore along a straight front having a large longitudinal extension. The stoping area close to the face is kept open to provide space for personnel and mining equipment. The hanging wall may be allowed to subside at some distance behind the working face.

Sublevel Caving

In sublevel caving, the ore is extracted via sublevels developed in the ore body at regular intervals. Each sublevel features a systematic layout with parallel drifts along or across the ore body. In a wide ore body, the sublevel drifts start from the footwall drift and are driven until they reach the hanging wall. This is referred to as transverse sublevel caving. In ore bodies of lesser width, longitudinal sublevel caving is used. In this variant, drifts branch off in both directions from a centre crosscut.

Sublevel caving is used in large, steeply dipping ore bodies. The rock mass must be stable enough to allow the sublevel drifts to remain open with just occasional rock bolting. The hanging wall should fracture and collapse to follow the cave, and the ground on top of the ore body must be permitted to subside.

Block Caving

Block caving is a technique in which gravity is used in conjunction with internal rock stresses to fracture and break the rock mass into pieces that can be handled by miners. "Block" refers to the mining layout in which the ore body is divided into large sections of several thousand square meters. Caving of the rock mass is induced by undercutting a block. The rock slice directly beneath the block is fractured by blasting, which destroys its ability to support the overlaying rock. Gravity forces about millions of tons act on the block, causing the fractures to spread until the whole block is affected. Continued pressure breaks the rock into smaller pieces that pass through draw points where the ore is handled by LHDs.

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Due to advancements in technologies, most of the above-mentioned methods can be modified to enhance efficiency.

Production Planning and Scheduling

Whether surface mining (quarrying inclusive) or underground mining, a production schedule is of paramount important. The objective of production scheduling is to determine the times when each production unit will be used and do the necessary allocation of resources for the required level of production. Production level is important because it affects the output and employment. In addition, inventory levels adjust to sales patterns.

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Exploration drilling at a potential mining site north of Lundazi

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Source: John Tychsen, GEUS.

ial mining site

MINERAL PROCESSING

By Mutumbi Nguni, Principal Metallurgist, Geological Survey Department

Introduction

Mineral processing in Zambia has been practiced for a long time. Before the time of the Kabwe man, aka the Broken Hill Man, who was discovered during mining in Kabwe in 1921, the early Stone Age man used simple mineral processing techniques to process natural materials into tools for household usage. Stone tools were made from round river pebbles by breaking off flakes, sharpening the edges and converting the stones into instruments for cutting and processing of animal skins. From stone pebble tools, other better and more advanced tools were developed, such as hand axes for digging hunting pit-traps and breaking bones, cleavers for scrapping wood and arrow heads, which were assembled with straight wooden poles to create instrument for fishing and hunting.

After the discovery of fire at Kalambo falls, improved techniques were developed that utilised the heat generated to treat natural materials, such as clay, making it into fire-hardened clay pots for collecting water and storing other essential items. The fire made possible the application of metals, such as copper and iron, which could now be refined by heat treatment. The metals produced could easily be cast and forged into ornaments for trade and instruments for domestic purposes. Tools made by these new techniques, such as metal axes and hoes, were very important to the development and spread of agriculture, e.g. metal axes were used to cut trees which were burnt to fertilise the soil after the land had been cultivated using the hoes.

During this period in time, processing technologies, such as smelting furnaces using wood and charcoal were developed. The smelting furnaces were simple cylindrical tower types, constructed of an outer shell made from anthill clay with a hole in the centre were the mineral ores, charcoal and wood were fed. The iron ore treated in these furnaces was first made into pig iron. Then the iron ingots were hammered and forged into tools. It was important for the ironsmith to charge a high metal ore into the furnace in order to generate enough metal for the casting and forging of tools; therefore, it was important to first prepare the material before smelting. The preparation involved selecting ore by sorting it according to colour and texture. These methods of pre-treatment ensured that the furnaces were only fed with enriched ores that would produce metal needed for making quality tools, such as axes, hole, knives and spear heads, that were required to sustain their livelihood.

In considering the life of man in the old Zambia, mineral processing can be identified as the processing and purification of natural materials, fashioning and transforming them into useful tools. In the first instance, considering the treatment of pebble stones – breaking stone with stone to produce sharp cutting tools and in the second, processing ores by sorting, crushing and then purifying them into metal in the smelting furnace.

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Definitions

The definition and importance of mineral processing can be traced back to the time of Georgius Agricola (1556), who stated, "that since nature usually creates metals in an impure state, mixed with earth, stone and solidified juices, it is necessary to separate most of these impurities from the ores as far as can be before they are smelted". In this statement, he was bringing to light the fact that metals and minerals in their natural state cannot be effectively used for tools. He further made it clear the other materials, associated with the metals, which are not good for their applications; in the latter part he makes it clear of the need for systems, i.e. means, that are required to address these needs. In his statement, he is saying that mineral processing is the pre-treatment of natural metal bearing materials in order to clean or enrich them before they are further treated in the smelting furnaces.

This definition is the basis upon which mineral processing in metallurgy as a science was derived. It is considered as the pre-treatment of mineral ores, which comprises of processes, such as crushing, grinding and flotation aimed at concentrating metallic ores before actual metal extraction by means of smelting (pyro-metallurgical) or leaching (hydro-metallurgical) or electro-metallurgical processes.

Zambian Legal Definition

The ASM sector operates under the definition of mineral processing specified in the Mines and Minerals Development Act No. 11 of 2015, which states that mineral processing is "the beneficiation or liberation of valuable minerals from their ores, which may involve a number of unit operations, such as crushing, grinding, sizing, screening, classification, washing, froth flotation, gravity concentration, electrostatic separation, magnetic separation, leaching, smelting, refining, calcining and gasification or any other processes incidental thereto". This definition does not limit mineral processing to only the pre-treatment techniques of physical liberation and concentration of valuable metallic ore, but further considers the actual metal extraction and purification methods, such as smelting and electro-winning/refining.

Artisanal and Small-Scale Mining

ASM operations in Zambia are activities carried out within areas between 3.34 to 6.68 hectares (under the Artisanal Mining Licence) and those conducted under the Small-Scale Mining Right (10.02 to 400.8 hectares). The mineral processing operations performed, being the kind that does not require the use of complex equipment, high-level technologies or large capital investment. In Zambia, the ASM sector began in the late 1800s and by the early 1930s, the sector was undertaking earnest exploitation of large copper bearing minerals in the Copper belt, leading to the development of early mines, such as Bwana Mukubwa, Roan Antelope, Nkana, Kalulushi, Mufulira, Nchanga and Bancroft at Konkola. Apart from copper minerals, other metallic minerals being exploited by the ASM were metals, such as gold, manganese, feldspar and magnetite mainly exploited for the domestic industry to provide import substitutes and improve the self-sufficiency of the country.

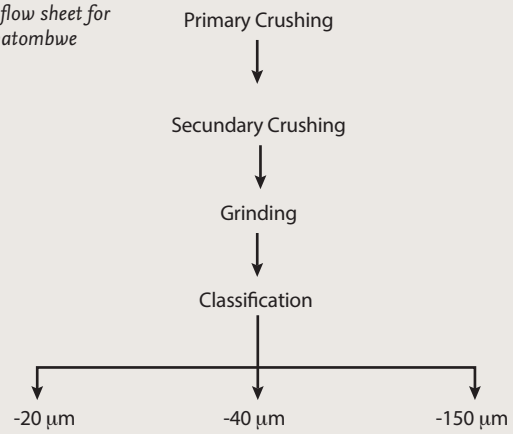
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In the past, the ASM sector was of great benefit to the country. The sector was producing materials for application in the local industries with Mindeco Small Mines exploiting small deposits, such as the Magnetite deposits in Mumbwa, which were processed to provide material used in the preparation of coal as slurry material (a medium for the Dense Media Separation of coal) at Maamba Colliery. Other minerals, such as cassiterite were produced by cooperatives for the foundries, gold and silver for manufacturing of Jewellery, manganese for dry cell batteries and as alloying raw material for foreign steel companies. The processing of these materials was achieved through the application of mineral processing techniques; therefore, in seeking to understand mineral processing one has to look into the processes that were involved in the treatment of magnetite, manganese, copper and gold by the ASM sector in Zambia.

Magnetite Processing at Namatombwe

Magnetite processing at Namatombwe highlights the initial treatment operations carried out in mineral processing. As illustrated in Figure 34 below, the stages involved include primary and secondary crushing, grinding and particle size separation (classification). Magnetite of different mesh sizes was produced for use in the dense media separation of coal at Maamba collieries. The material was about 95% Fe_3O_4 classified into three different categories of particle size: 20-30% less than 20 µm, 40-50% less than 40 µm and 2-10% greater than 150 µm.

Figure 34: Process flow sheet for Magnetite at Namatombwe



The primary objective of comminution is particle size reduction and mineral liberation. Particle size reduction is mainly achieved through crushing in order to produce smaller materials that are easy to handle and move. Mineral liberation, on the other hand, is performed to liberate valuable minerals from the waste minerals thereby rendering them free

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for separation or concentration. Different crushing equipment is used for particle size reduction with the Jaw crusher being most widely applied for the processing of magnetite by the ASM sector. Separation, and thus classification, of different size products is done using screens and cyclones. Screening is most widely applied for separation of coarse particle sizes. This method employs various screen designs, including grizzlies, trommels, rigid and vibrating screens for either wet or dry screening in order to separate crushed material into a coarse product retained on the screen and a fine product passing through the screen. Figure 35 below shows a picture of a trommel used in the wet screening of coal.



Source: Mutumbi Nguni, Geological Survey Department

Figure 35: Trommel Screen

Classification is practiced to effectively separate particles, which are too fine to effectively screen. Two types of classification equipment are in use: mechanical and hydraulic classifiers. The most commonly used mechanical classifier is the spiral classifier and that for hydraulic classification is the hydro cyclone. The hydro cyclones utilising centrifugal forces to accelerate the settling rate of particles, retaining the coarse particles as underflow and floating the fine particles as overflow. This equipment is simple and flexible making it easy to operate for small-scale miners.

Manganese Processing in Mansa

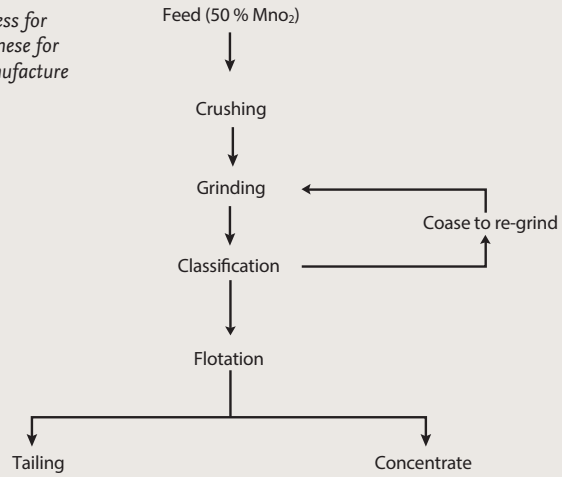
From the manganese deposits from Mansa, known to have contained about 1.5 million tonnes of manganese ore grading, about 57-86% of manganese dioxide has been exploited in the past for use in the manufacture of batteries at the Mansa Batteries and in recent times, it has also been exported as raw material for alloying in the steel industries. Between

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1953 and 1961, about 70,000 tonnes of ore, at a grade of about 50% M_nO_2, was mined and another unspecified quantity was exploited for the Mansa Dry cell battery factory.

The processing stages involved in the treatment of manganese for dry cell battery manufacture included: crushing, grinding, and flotation. In the flow sheet shown in Figure 36 below, the technique of flotation was added after classification in order to enrich the metal content of the manganese.

Figure 36: Flow Process for Treatment of Manganese for Dry Cell Battery Manufacture



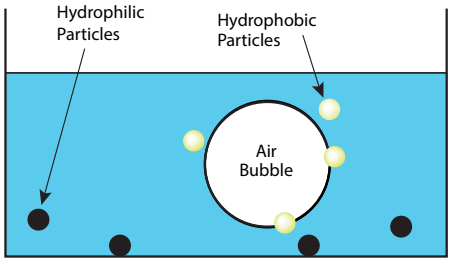
Flotation Theory

Flotation is a mineral processing technique, which was discovered in 1906. Since its discovery, the processing of low-grade complex ore was made possible. Copper deposits containing as low as 0.5% of copper can now be processed by economics of scale due to the benefits of flotation; flotation allows large throughput tonnages of material to be treated and concentrated to about 20-30% of copper in concentrate as can be attested to at Lumwana and Kalumbila mines in the North-western provinces of Zambia. The principals of flotation are the same for large processing facilities and small-scale facilities, such as ASM operations. Though initially developed for the treatment of sulphides of copper, lead and zinc, its application has been extended to the processing of oxides of iron (hematite and magnetite), cassiterite and other minerals. This processing technique was used by the Mindeco small holding to process manganese for the dry cell battery factory in Mansa. Flotation has the advantage of selectivity that can be applied in the separation of minerals by using a chemical reagent that transforms the surface of the valuable minerals making them either water repellent hydrophobic or water liking hydrophilic.

Minerals that are naturally or artificially made hydrophobic easily absorb to the surface of air bubbles rendering them floatable as a froth production - this is called Direct Flotation.

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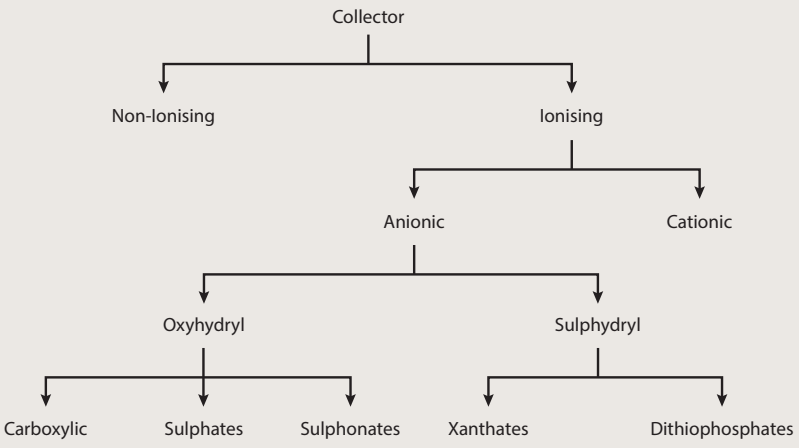
Reverse Flotation, on the other hand, is whereby the surface of the minerals are depressed or made hydrophilic, retaining them as a sink product, while causing the gangue materials to float as the froth product, as illustrated in Figure 37 below.



Source: Mutumbi Nguni, Geological Survey Department and redrawn by Jacob Lind Bendtsen, GEUS

Figure 37: Particle Attachment to Air Bubbles In Flotation

Principals of flotation are based on the differences in physio-chemical surface properties of minerals. In nature some fine materials, such as oxides of metals like copper have an affinity for water and tend to react with water causing them to remain in the water slurry when air bubbles are introduced, while others, such as sulphides of copper and other metals naturally repel the water and get adsorbed on to the surfaces of the air bubbles. The particle size is an important parameter in flotation. The minerals must be small enough to allow for adhesion to the air bubbles and transportation of the material through the pulp media and out into the collecting vessel at the end of the flotation. Flotation mainly makes use of three types of chemical reagents: collectors (chemical substances that adsorb on mineral surfaces rendering them hydrophobic), frother (reagents that stabilise the air bubbles to facilitate for smooth transportation of mineral and bubble to collection vessels), and regulator (substances used to control the flotation process by either activating or depressing the mineral surfaces).



Source: Mutumbi Nguni, Geological Survey Department and redrawn by Jacob Lind Bendtsen, GEUS

Figure 38: Collector Classification

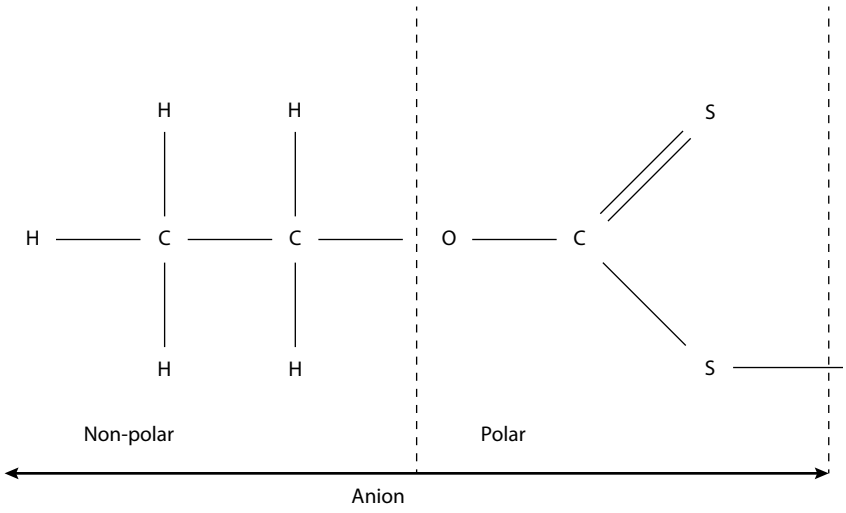
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Types of Collectors

There are mainly two types of collectors ionising and non-ionising collectors. Figure 38 below shows a tree diagram of collector classification.

Ionising Collectors

Ionising collectors are compounds of complex molecules made up of a polar and a non-polar group of hydrocarbons. The polar group reacts with the water, whereas the non-polar is water repellent. Absorption of a collector onto the mineral surface is influenced by the chain length and chain structure. Absorption is usually achieved with the polar end attached to the mineral surface while the non-polar end is oriented towards the bulk of the solution rendering the minerals hydrophobic. Ionising collectors are classified into two: anionic and cationic collectors, but there is also a class of collectors called amphoteric, which possess both cationic and anionic functions depending on the working pH of the solution. An example of a collector is sodium ethyl xanthate as shown in Figure 39 below.



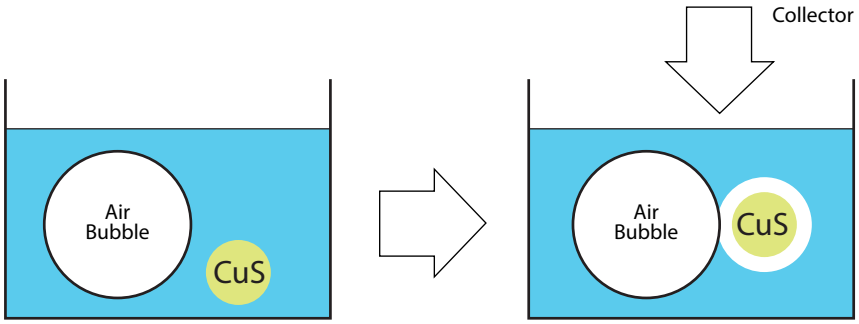
Source: Mutumbi Nguni, Geological Survey Department and redrawn by Jacob Lind Bendtsen, GEUS

Figure 39: Sodium Ethyl Xanthate

Anionic Collectors

Anionic collectors are the most widely use collectors in the flotation of metallic minerals and are of two types, namely: Oxyhydryl collectors, having organic and sulpho-acid anions as their polar groups; and Sulphydryl collectors that a based on bivalent sulphur.

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Source: Mutumbi Nguni, Geological Survey Department and redrawn by Jacob Lind Bendtsen, GEUS

Figure 40: Effect of Collector

Oxyhydryl collectors are made of fatty acids, which naturally occur in vegetable oils and animal fats extracted by distillation and crystallisation. Common among those used are oleic acid and sodium oleate. The Carboxylates are strong collectors, but have relatively low selectivity and are used for the flotation of minerals of calcium, barium, strontium and magnesium, the carbonates of non-ferrous metals and the soluble salts of alkali metals and alkaline earth metals.

Sulphydryl collectors are the most applied in flotation due to their potency and selectivity of sulphide minerals. Those mainly used are the xanthates and dithiophosphates. Common among the xanthates are ethyl, isopropyl, isobutyl, amyl, and hexyl, these have been widely utilised for sulphide mineral flotation. Xanthates are assumed to absorb on sulphide mineral surfaces due to chemical forces between the polar group and the surface resulting in insoluble metal xanthates, which are strongly hydrophobic. The solubilities of the hydrophobic xanthates of copper, lead, silver and mercury are very low, but xanthates of zinc and iron are much more soluble, making it difficult for xanthates to aid the collection of zinc and iron. Ethyl xanthates are only weak collectors of pure sphalerite, but replacement of the crystal lattice zinc atoms by copper improves the flotation properties of the mineral as shown in Figure 41 below. The alkali earth metal xanthates (calcium, barium magnesium) are very soluble and xanthates have no collector action on the minerals of such metals or on oxides, silicates, or alumina silicates, which permits extremely selective flotation of sulphides from gangue minerals. Oxidised minerals, such as malachite, anglesite and native minerals of gold, silver and copper require high concentrations of xanthate for flotation, which is why most industrial practices use amyl xanthates, which is a stronger collector. Figure 40 below shows the effect of collector on mineral attachment to air bubbles

Dithiophosphates are weak when compared to xanthates, but produce better results when applied together with xanthates. Due to their effective selectivity of copper from lead sulphide minerals, Dithiophosphates have wide application in the flotation of these two metal sulphides.

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Cationic Collectors

The polar group for cationic collectors is the amines, which, unlike the xanthates, absorb on mineral surfaces due to electrostatic attraction between the polar head of the collector and the charged electrical double layer of the mineral surface. These electrostatic forces are weak in comparison to the chemical forces characteristic of anionic collection and as a result, cationic collectors tend to have weak collecting power. The sensitivity of this type of collectors to pH of the medium is very high. They are most active in slightly acid solution and inactive in strongly alkaline and acid media. They find most application in flotation of oxides, carbonates, silicates and alkali earth metals.

Frother

Effective flotation is dependent upon the stability of the froth responsible for providing and sustaining the air bubbles, which are the carriers for minerals from the pulp. Frothers are chemical reagents that enhance the stability of bubble attachment especially at the pulp surface. Frothers are chemically similar to ionic collectors, and some collectors, such as oleates, are used efficiently as frothers owing to their production of stable froths efficient to transport minerals from slurry to downward processing.

A good frother should have negligible collecting power and also produce a froth, which is only stable enough to facilitate for transfer of floated minerals from the cell surface to the collecting vessel. The combination of collector and frother properties in one reagent has a negative effect on the efficiency of flotation, as it tends to make selective flotation difficult. The most widely used frothers are acids, amines and alcohols. Alcohols are preferred in comparison to carboxyls (which are also powerful collectors) because alcohols do not possess properties of collectors. Common natural frothers are pine oil and cresylic acid. The other frothers are the synthetic type: methyl isobutyl carbinol (MIBC), polyglycol ethers (Dowfroth 250, Cyanamid R65 and union carbide PG 400) and polyglycol. For effective flotation, a combination of the three synthetic frothers can be used; the Alcohol providing selectivity (a brittle froth for good control and material transfer into the collecting vessels), Polyglycol Ether (providing strength and persistence) and Polyglycol (providing strong surface stability of frother). These are very effective in maximising load support with coarse grind and high-grade feeds at all pH ranges.

Regulators

Regulators are chemical substances used to modify the action of collectors by either increasing or decreasing their water repulsion effect on the mineral surfaces making the collector action more selective towards certain mineral. They are classified as activators or depressants. The activators promote the water repulsion effect while the depressants perform the opposite effect.

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Activators

Activators are soluble salts, which ionise in solution producing ions, which react with mineral surfaces rendering them hydrophobic, e.g. copper in solution, which activates the surface of sphalerite making it floatable by the action of xanthate collector, which otherwise would have no effect due to the fact that the collector product of zinc xanthate is relatively soluble in water; hence, it does not provide a hydrophobic film on the mineral surface. The activation arises from the formation of molecules of copper sulphide at the mineral surface owing to the fact that copper is more electro-negative than zinc and ionises less readily as can be observed in the reaction and Figure 41 below:

$$ZnS + Cu = CuS + Zn$$

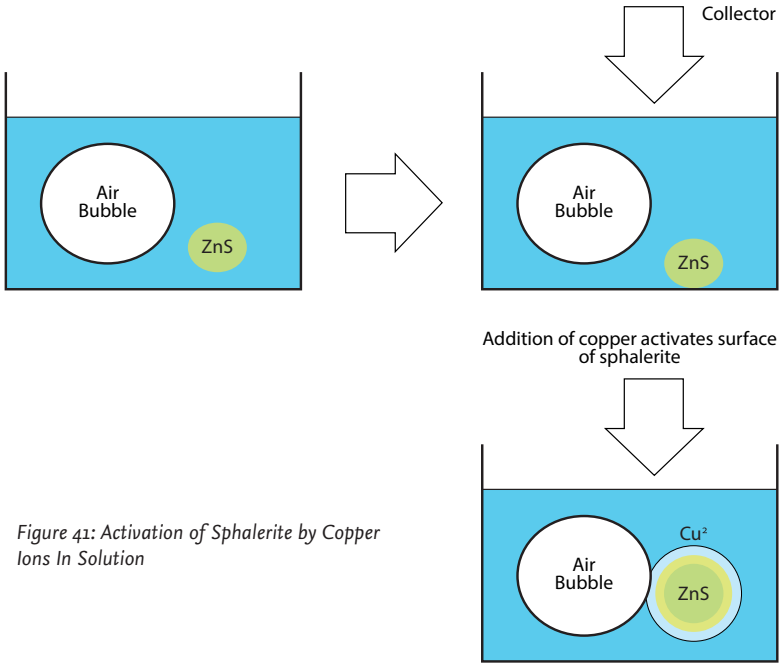


Figure 41: Activation of Sphalerite by Copper Ions In Solution

Source: Mutumbi Nguni, Geological Survey Department and redrawn by Jacob Lind Bendtsen, GEUS

Copper sulphide deposited on the surface of sphalerite reacts with xanthate to form insoluble copper xanthate, which renders the sphalerite surface hydrophobic. Other activators of oxide mineral, such as copper oxides, are sodium sulphide or sodium hydrosulphide. The hydrolysis and dissociation of sodium sulphide releases OH-, S2- and HS- ions into solution and these react with and modify the mineral surfaces. Sulphidation causes sulphur ions to pass into the crystal lattice of the oxidised minerals giving them a relatively insoluble pseudo-sulphide surface coating and allowing them to be floated by Sulphydryl collectors.

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Depressants

Some common natural depressants are slimes, which render certain minerals hydrophilic by coating their surfaces, e.g. starch and sodium silicate, which is used to depress non-sulphide minerals such as scheelite, calcite and fluorite. Cyanides are the other type of depressants, which are widely used for selective flotation of lead-copper-zinc ores. Sodium cyanide hydrolyses in aqueous solution to form free alkali and relatively insoluble hydrogen cyanide:

$$NaCN+H_2O = HCN + NaOH$$

Hydrogen cyanide then dissociates:

$$HCN\ H^+ + CN$$

The xanthates of lead have very low solubilities in cyanide solution; those of copper are soluble, while those of zinc nickel, gold and iron are highly soluble. Iron and zinc can therefore be very easily separated from lead in complex ores.

Flotation of minerals is mainly intended to increase the grade of valuable metal to improve the quality of feed material to smelting and other metal extraction processes. The processing of copper at Silver King mine in Mumbwa introduces a second concentration method of Dense Medium Separation and a metal extraction technique of smelting.

Exploitation of Copper in Mumbwa

Processing of copper bearing minerals in the big concession area of Mumbwa district started in 1906 by a company called Kafue Copper Development Company. The main product produced by the company was copper matte, which was produced using the conventional methods of comminution, concentration and smelting. In the period between 1911 and 1913, about 2,681 tonnes of copper were produced. After Kafue Copper Development Company, a small-scale miner, C.S Ludlam produced about 1,523 tonnes of blister copper containing about 70,000 oz. (2,170 kg) of silver. Information about the activities of the small-scale miners in the area has not been properly documented, but as can be observed from the pits in the area, a lot of mining has taken place and most of the small copper deposits have since been exploited. The mineralisation of the more important occurrences in the area comprised of copper minerals, such as chalcopyrite, bornite, chalcocite and tennantite, occurring primarily in matrix of the breccias close to the margins of the ore body.

The treatment of the ore described by Murray-Hughes (1923), as shown in Figure 43 below, details the unit operations associated with the processing of the silver king ore. The initial stages were hand sorting and screening to produce a coarse and a fine product. The coarse material was treated by water washing using a shaking table to remove the waste with the clean material (concentrate) proceeding to the smelter. The fines were concentrated using

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Source: Mutumbi Nguni, Geological Survey Department

Figure 42: Exploitation of Copper In Mumbwa

a rotary concentrator. The concentrator used emulsion of water and clay as heavy medium to produce a tailing and concentrate of grade 20.31% copper. The concentrates from the washing table and the rotary concentrator were then mixed and then further treated in the smelter. The feed to the smelter was a blend of roasted copper ore mixed with iron stone (18.18% FeO and 29.52% Mn) and silica flux, which was then treated at a high temperature to produce copper metal, matte, foul slag and slag. The matte was then roasted in stalls over wood then re-smelted to produce black copper and an intermediate furnace material called foul slag, which was stockpiled and then re-circulated to the smelting furnace after crushing and concentrating.

According to A.R. Drysdall (1971), specimens from a dumpsite analysed and reported by C. Legg, indicated the presence of arsenopyrite with chalcopyrite and bornite, commonly present as exsolution intergrowths, as the main copper-bearing minerals both of which have been replaced by tennantite and late covellite. Typical analysis of the ore body indicated 17.71% copper, 21% iron oxide, the balance being oxides of calcium and manganese, with some sulphur and other Insolubles.

Heavy Medium Separation

Heavy Medium Separation, also known as Dense Medium Separation, is a gravity separation technique that essentially depends on the specific densities of materials in a fluid medium. The factors that influence DMS are mainly particle size of the minerals, density

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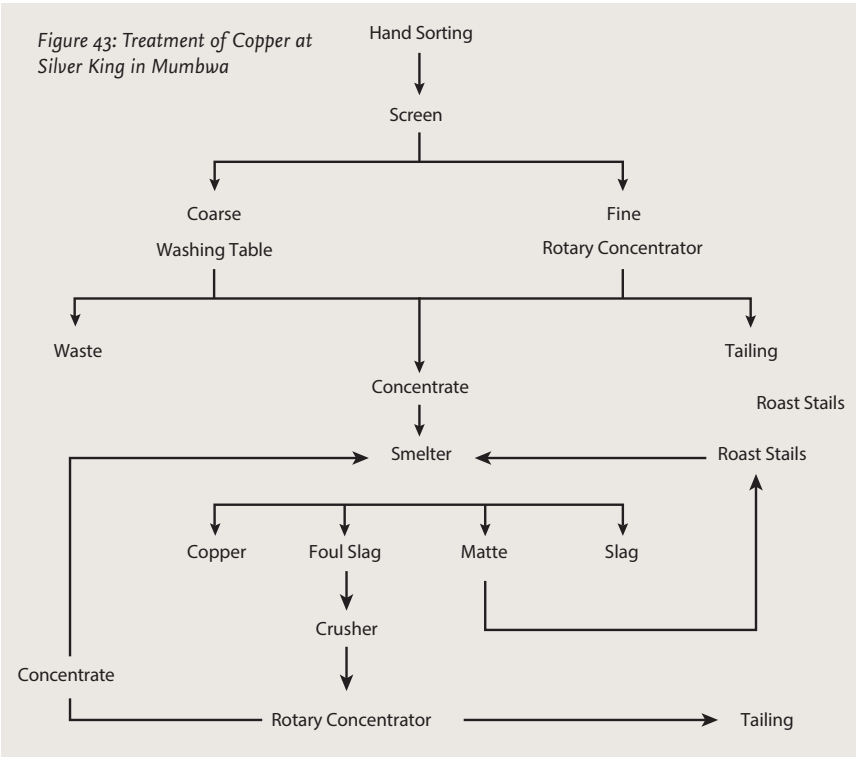


Figure 43: Treatment of Copper at Silver King in Mumbwa

and the properties of the fluid medium, such as viscosity, that provide resistance to the flow of particles falling downward due to the effect of gravity. Dense and large particles tend to settle more quickly than small and lighter particles, the smaller the particles the more the time required for them to settle through the media as illustrated in Figure 44 below.

Free fall of particles in a fluid medium is not very effective for particles less than 100µm; the most effective range of DMS utilising cyclone separators is between 200µm to 1000µm and between 600µm and 1000µm for drum type separators. Most heavy fluids of densities suitable for application in DMS are toxic and expensive. Therefore, in industrial practice DMS uses thick suspensions made-up of some heavy solids in water, which behave in a similar manner to heavy liquids. Control and manipulation of solids to water ratio between 10-30% solids is effective in producing fluids of varying densities, which can be used to separate minerals that are close in specific density with a high degree of efficiency. Common minerals used as dense media include ferrosilicon and magnetite due to their magnetic properties that makes them susceptible to magnetic separation thereby, making it easy to clean and reuse the medium after separation of the recovered minerals. Magnetite, specific gravity 5.1 has found wide application in coal preparation where medium of up-to 2.5kg/l densities are produced. Dense Medium Separation is suitable and efficient for

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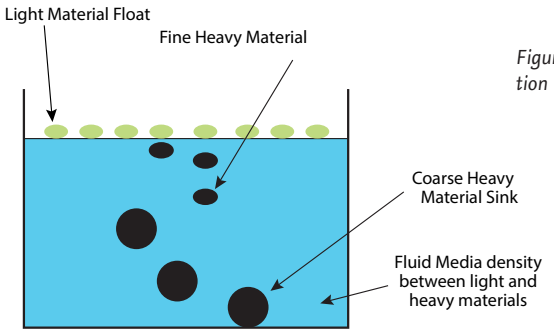
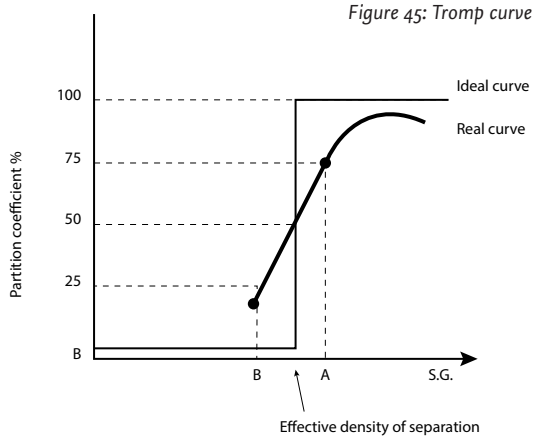


Figure 44: Dense Medium Separation

Source: Mutumbi Nguni, Geological Survey Department and redrawn by Jacob Lind Bendtsen, GEUS

separation of materials containing about 7-25% weight materials in the range ± 0.05kg/l of the separating density. Efficiency of separation can be represented by the slop of a Tromp curve, as shown in Figure 45 below, which can be used for comparison, and estimation of separation performance.

Figure 45: Tromp curve



In a situation of perfect separation, as shown in the ideal Tromp Curve, all particles of density higher than the separating density are recovered as the sink product, while those less than are recovered as the float product. In the real case scenario, efficiency is highest for particles of density far from the operating density and decreases for particles approaching the operating density. Tromp curves give a reasonable straight-line relationship between the distribution of 25% and 75% sink product of which slope is useful for identifying efficiency of the processing operation.

Theory of Copper Smelting

After concentration, using Dense Medium Separation, final copper at Silver King was produced by means of smelting. Smelting of copper is the process by which copper sulphide concentrates are fluidised at high temperatures of about 1250°C to produce two immiscible molten liquids; a copper sulphide matte of density 5.2 for pure Cu_2S and a slag comprising mostly of oxides of silica, iron and other gangue minerals. The smelting of

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chalcopyrite using silica flux to produce a matte, slag and sulphur dioxide gas is shown below:

$$CuFeS_2 + O_2 + SiO_2 = Cu - Fe - S + FeO.SiO_2 + SO_2$$

In oxidising conditions, copper tends to react with the oxygen to form copper oxide and copper metal. Copper smelting reactions can be given as:

$$CuFeS_2 + \tfrac{5}{2}\ O_2 = Cu^o + FeO + 2SO_2$$

$$Cu_2S + O_2 = 2\ Cu^o + SO_2$$

$$FeS_2 + \tfrac{5}{2}\ O_2 = FeO + 2SO_2$$

$$Cu_2S + \tfrac{3}{2}\ O_2 = Cu_2 + SO_2$$

For concentrates with high levels of iron, large amounts of slag are generated and as a result, iron oxides in the slag tend to react with copper in matte to produce copper oxide and iron sulphide, increasing the levels of copper in slag.

Slag

Slag is a molten liquid phase containing most oxides, silica (SiO_2) from flux, iron oxide (FeO) from oxidation of iron in concentrate and other impurities such as As_2O_3, Bi_2O_3 and CaO. It is very important for the purification of the matte as it removes impurity elements, such as Arsenic and Bismuth. Slag is also important for maintaining the temperature of the molten metal keeping the molten metal fluid for easy handling and casting. There are three types of slags: Basic Slag, comprising high levels of calcium and magnesium; Acidic Slag, comprising of silica and alumina; and Neutral Slag. The fluidity of slag is an important parameter in the production of copper; when the slag is viscous, copper losses due to slow settling of the metal through the slag phase increase. In the case of high viscosity arising from increased levels of basic oxides, addition of silica sand to the molten bath can be used to mitigate the problem.

Matte

Matte mostly comprises molten copper sulphide with small amounts of other soluble metals. It has a SG of 5.2, which is greater than the specific gravity of slag; matte therefore, tends to sink to the bottom layer in the smelting furnaces. The most important characteristic of matte is the grade (mass % copper), which typically ranges between 45% and 75% copper, which is equivalent to about 56-94% Cu_2S. When the grade of copper in matte increases above 60%, an increased amount of copper in slag also results as a consequence of the activity of Cu_2S, which reacts with FeO in slag to produce Cu_2O retained in the slag as shown below:

$$FeO + Cu_2S = FeS + Cu_2O$$

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High copper in matte production has the advantages of generating heat from the exothermic reactions associated with the oxidation of the sulphide minerals resulting in low fuel consumption and further, the reduction of sulphur requiring removal in the subsequent metal purification processes.

Oxide Copper Processing

Copper minerals in the big concession area are not only of the sulphide type, there are also oxide mineralisations as can be identified in the oxide zone at Kamiyobo. The mineralisation is typically in the form of vainlets and impregnations of malachite and chrysocolla with relic blebs of chalcocite or bornite, and limonite pseudo morphs after pyrite associated with much hematite and limonite. Oxidation is commonly accomplished by the secondary dissemination resulting in the formation of enlarged gossans capping replacement deposits. Samples from the dumps assay up to 26% Copper and other samples analysed in the more recent past at Sokotela mine assayed up to 23% Copper. The average grades are estimated at about 3% copper. The processing of copper oxide minerals has been achieved by hydrometallurgical methods were sulphuric acid has been used to leach out the copper from the ores. Small scale mineral processing plant such as Surya mineral in Kitwe, and Zalco limited in Kabwe, have in the past utilised this technique to produce copper cathodes from oxide minerals through leaching, solvent extraction and electro wining method.

Hydrometallurgical Processing of Oxide Ores

Leaching, as a method of metal extraction, has long been practiced. It is the process of extracting valuable metals by dissolution of ores, concentrates or secondary materials using an aqueous solution (acidic or alkaline in nature), to produce a gangue residue free of valuable minerals and a solution rich in valuable metal known as Pregnant Leach Solution. The Pregnant Leach Solution is further purified to remove impurities before final metal recovery using electrical (electro winning) or chemical precipitation methods. Before electro winning, the recovery of metals from solution was by the reduction using chemical reductants; the most common practice, which is still used today, is the contact reduction of copper from dilute sulphuric acid solutions using metallic iron, a process known as cementation.

Leaching can be classified into oxidative and non-oxidative processes; oxidative leaching directly utilises oxygen either from the environment or from oxidising agents an example is the cyanide leaching of gold ores. Non-oxidative leaching is the treatment method that does not require the aid of an oxidant to enhance the dissolution of the minerals; it involves chemical and reductive dissolution processes an example of which is the dissolution of copper oxide minerals in sulphuric acid. Some important copper dissolution reactions are:

Malachite dissolution:

$$CuCO_3.Cu\,(OH)_2 + 4\,H^+ = 2\,Cu^{2+} + CO_2 + 3\,H_2O$$

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Azurite dissolution:

$$2\ CuCO_3.Cu\ (OH)_2 + 6\ H^+ = 3\ Cu^{2+} + 2CO_2 + 4\ H_2O$$

Chrysocolla dissolution:

$$CuO.SiO_2.2H_2O + 2\ H^+ = Cu^{2+} + SiO_2 + 3\ H_2O$$

Types of Leachin

There are about four types of leach processing: agitation leaching, percolation or vat leaching, heap leaching and in-situ leaching.

Agitation Leaching

Agitation leaching is high rate dissolution leaching that is performed on fine ore with relatively high metal content in comparison to ores processed by heap and in-situ methods. The stirring or agitation reduces the diffusion layer on the mineral surface and allows for lixiviant contacting new surfaces thereby enhancing on efficiency of leaching. It is usually performed in tank vessels and can be done either at ambient or elevated temperatures, as shown in Figure 46 below. The pregnant solution is collected as overflow when a settling tank is used or separation of liquid can be achieved using filters.



Source: Mukumbi Nguni, Geological Survey Department

Figure 46 | Copper Agitation Leaching

Percolation Leaching

Percolation leaching is usually applied on low-grade ores of coarse particle size in the range of 9-12.5 mm. Leaching is mostly carried out in vats or tanks fitted with filter type bottoms

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to facilitate the flow of solution through the ore bed. Leaching can either be done as a batch or continuous. A batch is widely applied by small practices while semi-continuous utilising a sequence of vats is common for large processing.

Heap Leaching

Heap leaching comprises of crushing low-grade mine ore and piling it up into heaps where acid solution is sprinkled on top and allowed to trickle down leaching out the valuable minerals into a collection pond at the bottom of the heap. The heap is usually mounted on an impervious base constructed of acid resistant materials connected to a collection pond by means of drainage piping, as shown in Figure 47 below. The leaching time varies



Source: Mutumbi Nguni, Geological Survey Department

Figure 47: Heap Leaching

from a few weeks to several years depending on the nature of ore, the amount of material and particle size being treated. Heap leaching is relatively cheap and easy to operate and due to these advantages, it has found wide application at many plants.

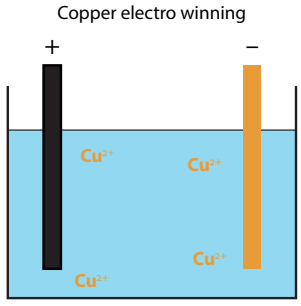
In-Situ Leaching

In-situ leaching or leaching in place is a processing method of extraction of minerals using solution without removing them from the ground. It has been used to exploit very low-grade minerals which otherwise would be uneconomic to mine, ores that are located in areas which are difficult to mine by conventional mining methods and also to recover metals from area that remained as support pillar.

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Metal Recovery from Solution

There are a number of methods that are applied to recover metals from pregnant leach solution; these include; the application of an external potential such as electrical potential, more negative than the half-cell potential, which results in metal reduction by deposition of surface layers at the metal to metal ion electrode surface. An example is given in Figure 48 below, which shows the recovery of copper from the solution.



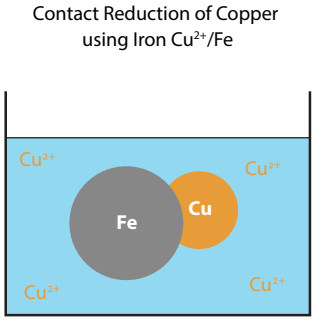
Source: Mutumbi Nguni, Geological Survey Department and redrawn by Jacob Lind Bendtsen, GEUS



Source: Mutumbi Nguni, Geological Survey Department

Figure 48: Copper Electro Winning

The application of metal (M1) more negative than the metal (M2) in solution results in the transfer of an electron from the surface of M2 to an ion of $M1^{2+}$, which deposits on to the surface of M2 in a process known as contact reduction or cementation, ref. Figure 49 below. This method has been extensively used to recover copper from solutions in contact with metallic iron (Cu^{2+}/Fe^{0}). Copper, recovered by means of cementation, is usually re-processed by smelting to upgrade the purity of the metal product.



Source: Mutumbi Nguni, Geological Survey Department and redrawn by Jacob Lind Bendtsen, GEUS

Figure 49: Contact Reduction of Copper Using Iron Cu^{2+}/Fe

Gold Processing

Gold deposits have been discovered and exploited in the Luiri goldfield of Mumbwa district and the Chayinda prospects. The grades obtained from vein deposits at Luiri ranged from about 2.3-26.5 g/t, while those mined at Chayinda were estimated to contain an average of about 3 g/t. The treatment of gold ore at Luiri goldfields was done using cyanidation. Amalgamation was also utilised by the Neilsen brothers to processes gold for domestic jewellery.

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Amalgamation

Amalgamation is a type of dense medium separation where gold of specific gravity 12-20 is separated from gangue mineral using mercury specific gravity 8-8.2 as the medium of separation. A portion of gold ore is mixed with liquid mercury using a system of stirring or agitation until the ore is thoroughly mixed in the mercury. The material is washed with warm water until clear water runs out. Cold water is then applied up-to the point when the mercury carrying the adsorbed gold separates from the other waste materials, mercury is then separated from the gold using either a cloth of cotton or soft leather. The amalgam is poured on the leather or cotton cloth where the mercury is filtered in to a collection vessel leaving solid gold on the leather. The gold is then treated with fire to remove the remaining mercury by evaporation.

Cyanidation

Cyanidation or dissolution of gold in cyanide solutions is a form of oxidative leaching. Some of the dissolution reactions have been suggested as:

Elsners: $4\ Au + 8\ NaCN + O_2 + 2\ H_2O = 4\ NaAu(CN)_2 + 4\ NaOH$

Janin and Ramsay: $Au + 4\ NaCN + O_2 + 2\ H_2O = 2\ NaAu(CN)_2 + 2\ NaOH + H_2$

Bodlaender: $2\ Au + 4\ NaCN + O_2 + 2\ H_2O = 2\ NaAu(CN)_2 + 2\ NaOH + H_2O_2$

Where the products of dissolution are a soluble gold cyanide complex, sodium hydroxide, with hydrogen gas as suggested in the equation by Janin and Ramsay and with hydrogen peroxide as suggested in the equation by Bodlaender.

Leaching is usually followed by metal recovery by adsorption using activated carbon as shown below:

$$C.\ OH + Au(CN)_2^- = C.Au(CN)_2 + OH^-$$

The gold cyanide anion complex is absorbed on an ion exchange site on the surface of the carbon. From where it is removed and concentrated by utilising hot caustic stripping.

$$C.\ Au\ (CN)_2^- = Au^o + 2\ CN^-$$

Electro refining is then applied to extract the metallic gold from the concentrated solution while the carbon is reactivated by thermal treatment and circulated back in the system to be reused.

$$e^- + Au(CN)_2^- = Au^o + 2\ CN^-$$

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VALUE ADDITION IN DEVELOPMENT MINERALS

By Mutumbi Nguni, Principal Metallurgist, Geological Survey Department

Minerals naturally posses specific properties, functional and/or aesthetic, which are of benefit to society. The value of a mineral can be increased by enhancing its specific properties via different treatment methods in order to promote its applications, i.e. functional purpose and/or aesthetic appeal. The treatment of a mineral to enhance its market value is denoted "value addition".

The main benefits of value addition are:

- Production of quality products that are strong, reliable and can be used in an efficient and effective manner;
- Production of products with specific specifications for diverse applications; and
- Increased levels of income for ASM workers etc.

Value Addition of Amethyst

Amethyst is a purple, pale red-violet coloured quartz, ref. Figure 50 below, which occurs in the Zambezi escarpment area of Mapatizya in Kalomo District, Southern Province. It is mostly found as vein deposits of pegmatites, granite and marble, which have been transformed due to heat and pressure resulting in re-crystallisation and formation of the gemstone. Amethyst is considered the most valuable gemstone in the quartz family due to its beautiful colour and its ability to change from purple to yellow at elevated temperatures.



Source: Geological Survey Department, Zambia

Figure 50: Examples Of Amethyst

The stages of value addition to amethyst comprise seven treatment methods: washing, sorting, grading, heating, oiling, cutting and polishing.

Washing, Sorting, and Heating

Washing is usually the initial stage of processing meant to remove the clay minerals attached to the gemstone. After washing, sorting and grading then follows

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in order to select and classify the amethyst into high, medium and low grades. Sequentially, heat treatment may follow to alter the colour and improve on the clarity of the gemstone thereby enhancing its aesthetic appeal. Colourless oil is then applied on the surface of the gem in order to mask the appearance of fractures by seeping into the fissures on the surface rendering them less visible.

Cutting and Polishing

The aim of cutting is mainly two fold; 1) to return as much weight as possible whilst ensuring that the most attractive colour is visible through the table facet, and 2) to maintain certain important angles and proportions in order to maximise on the overall brilliance of the gemstone. Gem cutting or lapidary work involves a series of steps, which include: selecting stone, sawing and choosing of final product type (either faceted or cabochon).

Sawing

Sawing is usually done by slabbing and trimming. Slabbing is the cutting of rough stones into slabs of desired thickness using a slab saw whereas trimming is that which utilises a trim saw to cut stones for subsequent treatment into cabochons (stone of convex form, highly polished not faceted), faceted stones and small plates. Rough stones are either first slabbed prior to trimming or directly trimmed to the desired size and shape depending on the size of the gem. The former is more applicable to larger pieces whereas the latter to smaller ones. After sawing, grinding is then applied.

Polishing

Polishing involves pressing the shaped stones with substantial amount of force against yielding materials, such as felt, leather, cloth or wood applied with polishing agents to produce shining smooth surfaces that are typical of jewellery. Polishing agents used to polish amethyst include:

- Aluminium oxide of particle size between zero and one micron;
- Zirconium oxide;
- Tin oxide;
- Ferric oxide; and
- Diamond (powder of paste) zero to two microns.

Two types of polishers are applied: 1) polishers for cabochons, flats, spheres and other works that do not require much accuracy, and 2) polishers used for geometrically flat surfaces such as on faceted gems that require more accuracy. The polishers used in facet work are called laps and those used for cabochons are called buffs.

Value Addition of Limestone

Limestone is a mineral with many different applications. It is used in the building and con-

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struction industry, e.g. as base material for roads, concrete for building foundation slabs and blocks, cement, and tiles for floor and kitchen toppings. It is also used in the chemical and metal industries, e.g. as fluxing for metal smelting, material for acid neutralisation, and for treatment of water. Finally, it is also used in the agricultural sector, e.g. as treatment of acidic soils.

Value addition of limestone depends on its desired utilisation, i.e. for construction, chemical or agricultural purposes.



Source: Geological Survey Department, Zambia

Figure 51: Examples of Limestones

Making Limestone Aggregates

Processing of limestone for making aggregates used in the construction industries starts with blasting at the mine quarry. Material from mining is crushed in a two-stage process, ref. Figure 52 below: 1) primary crushing to reduce particles of about 50cm to sizes less than 25mm by using a Jaw crusher, and 2) secondary crushing to further reduce particles of 25mm to sizes less than 10mm using an impact crusher. The crushed material is usually separated and classified into different size products using a vibrating screen of different mesh size.

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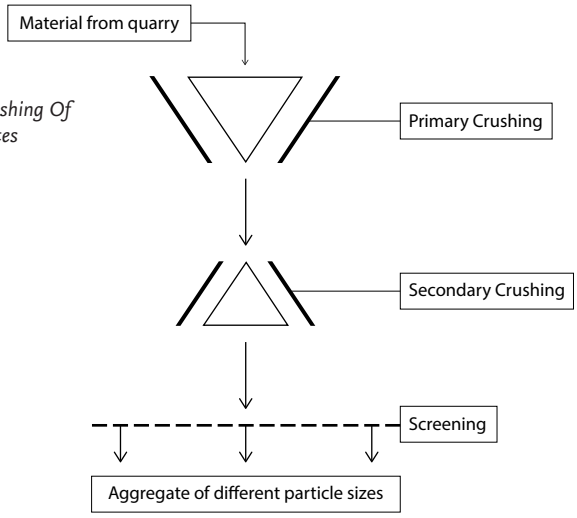


Figure 52: Flow Diagram – Crushing Of Limestone To Produce Aggregates

Source: Geological Survey Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

Cutting and Polishing of Marble (Limestone)

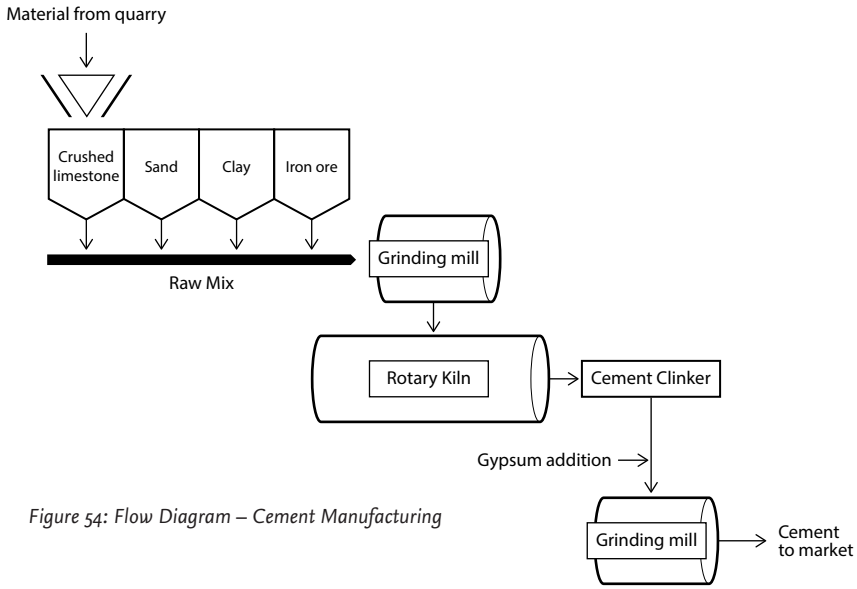
Marble is a product of recrystallized limestone, which has found application in the production of floor tiles, paving slabs and kitchen toppings. The processing of marble starts with the cutting marble rocks into slabs of blocks of at the quarry. The slabs are then polished using polishing grits of different size from coarse to fine producing a smooth, shinning surface, ref. Figure 53 below. The polished slabs are further cut and reduced into the desired shape and sizes.



Figure 53: Example of polished Marble Tile

Source: Geological Survey Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

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Source: Geological Survey Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

Figure 54: Flow Diagram – Cement Manufacturing

Cement Production

The production of cement comprises the four following stages, ref. Figure 54 above:

- Crushing of raw material;
- Blending and grinding of raw material;
- Burning of blended raw mix for clinker production; and
- Grinding of clinker mixed with gypsum to produce cement.

Limestone from the mine is crushed in a two-stage operation: 1) reduction of mine ore to about 120mm size particles, and 2) further reduction of crushed particles to about 20mm size particles. The crushed stone is then blended with sand, clay and iron ore according to a desired mix. The mix is then grinded in a mill to produce a raw mix powder. The raw mix powder then enters the kiln system at a temperature close to room temperature. The temperature gradually rises as the mix passes through the system until it reaches a peak temperature in the sinter zone. During this process, the raw mix materials combine together to form a chemically fused agglomerate called "cement clinker". The clinker is then rapidly cooled for final grinding.

Value Addition of Clay

Clay minerals are minerals of very fine particles less than four micron (- 0.004mm) formed by the weathering of rocks. Rainwater reacts with some gases in the atmospheric environment to produce weak acids, which in turn react with the rocks to produce secondary min-

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erals (clays) and metal ions in a reaction known as hydrolysis. A typical hydrolysis reaction is that of orthoclase feldspar (common in granites and some sedimentary rocks) with acidified water to produce clay minerals and potassium ions.

Some of the properties that make clay minerals useful are: plasticity, shrinkage at elevated temperature, fine grain, ability to retain water, good colour, hardness and capacity of the surface to take decorations. Clay has been used extensively in many industries, e.g. as a source of alumina in the manufacture of cement, material for making moulds for casting, material for making pots and ceramics, material for making bricks used in construction, colouring in paints, and filters for water purification.

Processing of Clay for Pottery and Brick Making

Clay for pottery is required to be of a good plasticity value, able to retain enough moisture for ease of working into desired shapes and to cure without cracking during the drying and burning processes. Treatment of clay minerals is mainly carried out in order to improve the quality of the clay by removing any impurities, which may adversely affect the manufacturing process and consequently affecting the quality of the final clay products. Some of these impurities are:

- Coarse pieces of rocks, which may adversely affect the moulding into shape of the clay and pose as a potential source of crack nucleation and propagation;
- Organic matter, which may leave voids in the pottery after burning; and
- Free metals, which can melt thereby creating holes and unwanted colours during the burning process.

The treatment stages may involve screening to remove organic and coarse materials, grinding the clay to produce a material of uniform fineness and then leaching in a solvent to remove the undesired metallic elements, ref. Figure 55 below.

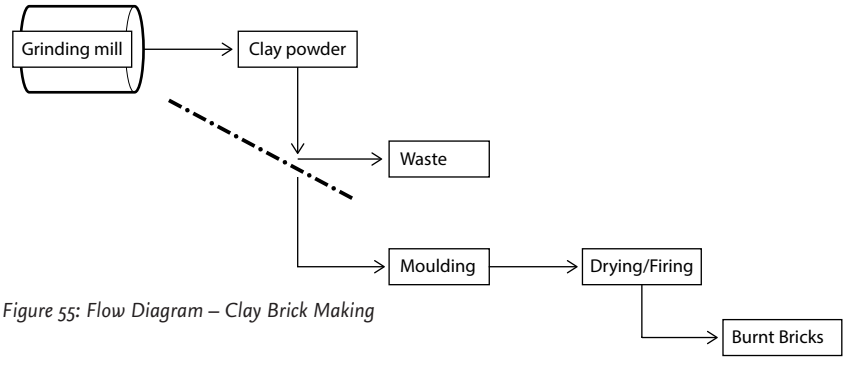


Figure 55: Flow Diagram – Clay Brick Making

Source: Geological Survey Department, Zambia and redrawn by Jacob Lind Bendtsen, GEUS

Source: John Tychsen, GEUS.

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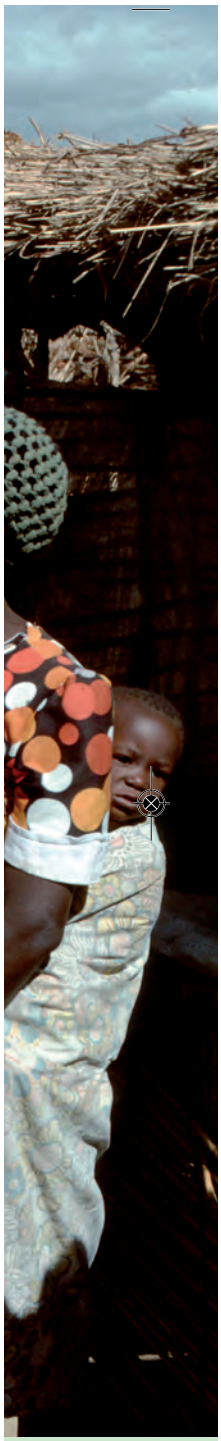
An ASM using rotating drums for crushing the stones.

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A small village close to an ASM mining site in Zambia

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Source: Adam A. Garde, GEUS.

M mining site

HEALTH AND SAFETY ISSUES IN ASM IN ZAMBIA

By Canisius Mwenya, Inspector of Mines, Department of Mines Safety

ASM is a critical poverty reduction strategy for millions of people around the world, but it is mostly undertaken under dangerous conditions. The health and safety hazards associated with ASM activities impact negatively among the miners, their families and their communities. Failure to control these hazards are attributed to a range of reasons, such as lack of resources, remote location of the mines, lack of monitoring by regulatory agencies, and lack of competence in managing the hazards by the mine owners. It is therefore necessary to ensure that efforts are made to address these issues in order to safeguard the safety and health of the miners, their families and the communities where they operate.

Health Hazards

Health hazards are grouped into three categories: chemical, biological and physical, as described below.

Chemicals Hazards

Exposure to chemicals in ASM operations is due to the use of chemicals as a means of extracting minerals and/or due to the harmful nature of the chemical composition of the mineral itself.

Mercury

Despite the financial gain derived from mining gold in ASM, the challenges associated with it are substantial as well. The immediate one of these challenges is the issue of extracting the gold metal from its mined ore. To ensure that a decent mineral is produced, an effective metallurgical process is necessary. In the absence of this process, necessary to facilitate the recovery of the metal, the easiest alternative opted for by ASM workers is usually the use of mercury. This is done despite of the ill-health effects that come with unsafe use of mercury and the availability of other safer alternative methods.

Mercury is a metal that is liquid at room temperature. In its pure form (often called metallic or elemental), mercury is a shiny, silver-white, odourless liquid. If heated, mercury vaporises into a toxic, colourless gas that is odourless to people. The method of purifying gold from ore is a process called amalgamation. The process involves mixing mercury with gold-containing materials, forming a mercury-gold amalgam, which is then heated and then vaporised to obtain the gold. In ASM, this process is often done in unsafe and environmentally damaging ways.

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Improper handling of mercury in gold processing can pollute homes and communities. Miners and their families often inhale toxic mercury vapours through the process. It can also contaminate the air, land and water where gold processing occurs.

Elemental and methylmercury are toxic to the central and peripheral nervous system. Methylmercury is a very poisonous form of mercury. It forms when bacteria react with mercury in water, soil, or plants. Methylmercury causes central nervous system (brain and spinal cord) damage. Elemental mercury as a vapour has the ability to penetrate the central nervous system (CNS), where it is ionised and trapped, attributing to its significant toxic effects. The inhalation of mercury vapour can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal. Neurological and behavioural disorders may be observed after inhalation, ingestion or dermal application of mercury and its compounds. Symptoms include tremors, insomnia, memory loss, neuromuscular effects, headaches and cognitive and motor dysfunction. When mercury enters watercourses, it can cause pollution and can be consumed by fish, which is later consumed by human beings. In this case, even people who may not be involved in gold processing may get affected. When pregnant women consume mercury-contaminated fish, it may lead to neurodevelopmental problems in the developing foetus. Neurological symptoms include mental retardation, seizures, vision and hearing loss, delayed development, and language disorders for the child.

There is a need to ensure that ASM workers are trained in alternative means of processing gold to reduce or eliminate the health risks that come with the use of mercury in this economic sector. Certain production methods, such as gravity concentration, do not require the use of mercury to recover gold. Safe handling of mercury can reduce contamination of watercourses while the use of chemical respirators can reduce exposure to toxic mercury vapour.

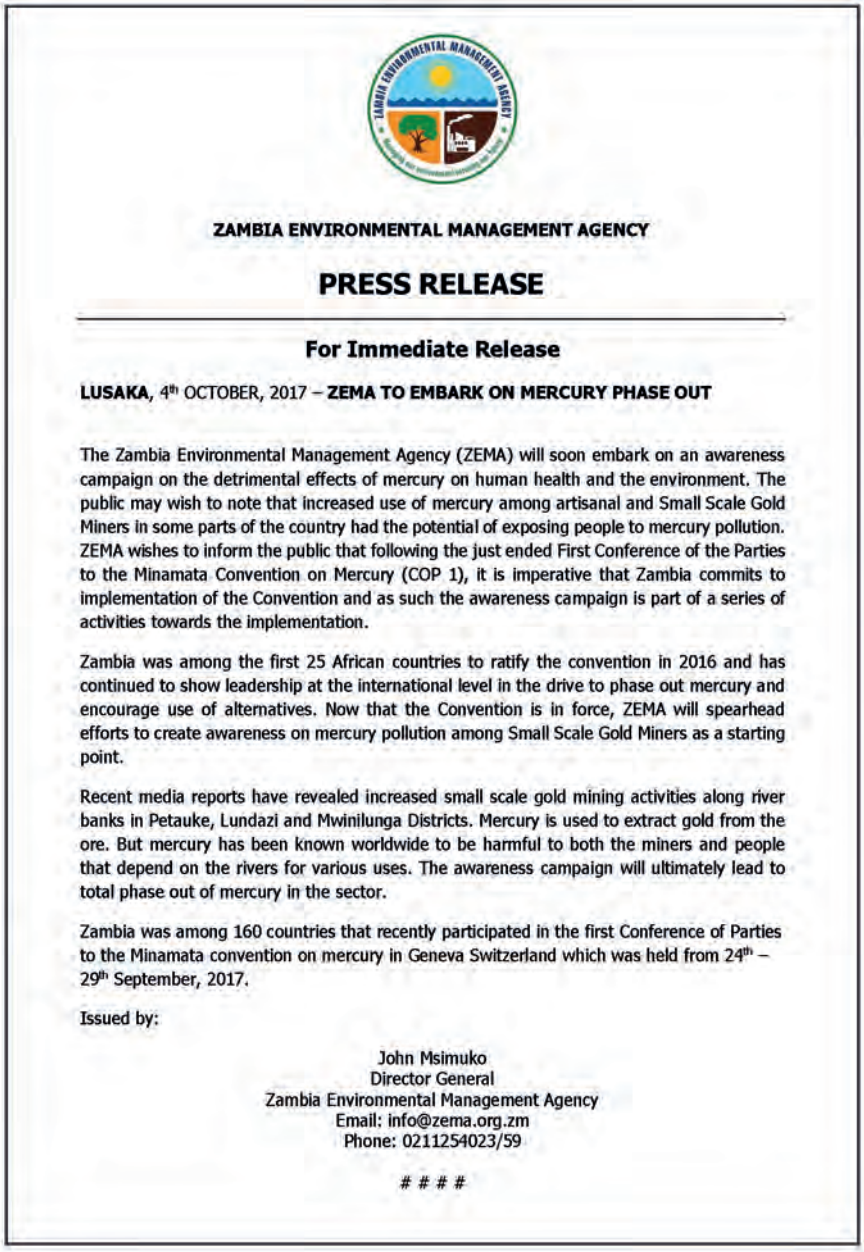
On 4th October 2017, the Zambia Environmental Management Agency issued a press statement on the need to embark on a sensitisation program to phase out the use of mercury in ASM, ref. Figure 56 below.

Furthermore, in 2016, Zambia ratified the Minamata Convention on Mercury. Article 7 of the Minamata Convention deals with artisanal and small-scale gold mining and processing in which mercury amalgamation is used to extract gold from ore. Each Party that has small-scale gold mining and processing within its territory has the general obligation to take steps to reduce the use of mercury and mercury compounds in such mining and processing needs to reduce, and where feasible eliminate, the use of mercury and mercury compounds in mining and processing, as well as the emissions and releases to the environment of mercury from such activities.

Manganese

Mining of manganese is prevalent in the Luapula and Central Provinces of Zambia. Blasting, loading, hauling, dumping and manual sorting of the ore produces harmful man-

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ZAMBIA ENVIRONMENTAL MANAGEMENT AGENCY

PRESS RELEASE

For Immediate Release

LUSAKA, 4th OCTOBER, 2017 – **ZEMA TO EMBARK ON MERCURY PHASE OUT**

The Zambia Environmental Management Agency (ZEMA) will soon embark on an awareness campaign on the detrimental effects of mercury on human health and the environment. The public may wish to note that increased use of mercury among artisanal and Small Scale Gold Miners in some parts of the country had the potential of exposing people to mercury pollution. ZEMA wishes to inform the public that following the just ended First Conference of the Parties to the Minamata Convention on Mercury (COP 1), it is imperative that Zambia commits to implementation of the Convention and as such the awareness campaign is part of a series of activities towards the implementation.

Zambia was among the first 25 African countries to ratify the convention in 2016 and has continued to show leadership at the international level in the drive to phase out mercury and encourage use of alternatives. Now that the Convention is in force, ZEMA will spearhead efforts to create awareness on mercury pollution among Small Scale Gold Miners as a starting point.

Recent media reports have revealed increased small scale gold mining activities along river banks in Petauke, Lundazi and Mwinilunga Districts. Mercury is used to extract gold from the ore. But mercury has been known worldwide to be harmful to both the miners and people that depend on the rivers for various uses. The awareness campaign will ultimately lead to total phase out of mercury in the sector.

Zambia was among 160 countries that recently participated in the first Conference of Parties to the Minamata convention on mercury in Geneva Switzerland which was held from 24th – 29th September, 2017.

Issued by:

John Msimuko
Director General
Zambia Environmental Management Agency
Email: info@zema.org.zm
Phone: 0211254023/59

# # # #

Source: Zambia Environmental Agency (ZEMA)

Figure 56: Press release on the use of Mercury in Zambia

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Source: Mackson Wasamunu, Zambia Daily Mail, 27 June 2017

Figure 57: Asm Workers Panning Gold At Kadya Alendo, Vubwi District, Zambia

ganese dust to which miners are exposed. Manganese effects occur mainly in the respiratory tract and in the brain. Acute inhalation exposure to high levels of manganese dust can cause an inflammatory response in the lung. Symptoms of manganese poisoning are hallucinations, forgetfulness and nerve damage. Manganese can also cause Parkinson's disease (a progressive disorder of the nervous system that affects movement), lung embolism (blockage of the pulmonary artery) and bronchitis. A syndrome caused by manganese often results in symptoms, such as muscle tremor, reduced motor skills, difficulty and slowing of walking, slurred speech, and, sometimes, psychiatric disturbances and insomnia.

Use wet processes, such as wet drilling, crushing wet material, watering down on stock piles and all material before loading, water praying of haul roads and wearing appropriate personal protective equipment (work suits and respiratory protective equipment) to reduce the risk of exposure to manganese dust.

Lead

In the Zambian context and in Kabwe (Capital of Central Province) in particular, local people go through the tailings, slag and rock dumps looking to extract the valued mineral resources with little knowledge or lack of regard for their own health and safety. One form of mining that continues to spread lead as a pollutant is illegal ASM activities on the dumps. Even where ASM activities are legal, there is little knowledge of how the effects of

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Source: Canisius Mwenya, Department of Mines Safety

Figure 58: A Pile of Mined and Sorted Manganese Ore, Mansa District, Luapula Province, Zambia

lead can affect one's health. Children also play in the soil and bath in the contaminated water that run from the mine site. Whether lead enters the body through being inhaled or swallowed, its adverse effects are the same. Lead mainly targets the nervous system. In adults, long-term exposure may cause numbness or weakness in the hands and feet, anaemia, and high blood pressure. Exposure at high levels can cause brain damage and reduced fertility. Children, including developing foetuses, are exceptionally vulnerable to lead poisoning because their still-growing bodies retain the toxin. The risks for them begin with higher rates of miscarriage, premature birth, low birth weight, and continue to harm



Source: Canisius Mwenya, Department of Mines Safety

Figure 59: Boy Scavenging From Lead Slag Dump In Kabwe, Central Zambia

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them throughout life due to brain damage and mental retardation. Miners should avoid being exposed to dust containing lead or water contaminated with lead. This can be done through dust suppression, use of personal protective equipment and treating the effluent before it is discharged into the environment to prevent pollution of watercourses.

Biological Hazards

The following are biological hazards common in ASM activities in Zambia:

HIV/AIDS

Acquired Immune Deficiency Syndrome (AIDS) is a condition caused by the Human Immunodeficiency Virus (HIV), which attacks the immune system by which the human body can resist infections. HIV is spread through contact with certain body fluids from a person with HIV. These body fluids include among others: blood, semen, vaginal and breast milk.

In ASM communities, people migrate from place to place looking for their livelihoods. During these movements they can be exposed to HIV in different ways. The spread of HIV from person to person is called HIV transmission. The spread of HIV from a woman with HIV to her child during pregnancy, childbirth, or breastfeeding is called mother-to-child transmission of HIV. One can contract HIV through sexual contact and the use of syringes used by an infected person. Therefore, sensitisation to avoid contact with body fluids from a person with HIV is vital for prevention of HIV transmission. Encouraging people to go for HIV testing is another way of mitigating the impact. Antiretroviral therapy (ART) is the use of HIV medicines (called antiretroviral drugs, abbreviated as ARVs) to treat HIV infection. People on ART take a combination of HIV medicines every day.

ARVs cannot cure HIV, but they can help people with HIV live longer, healthier lives by preventing HIV from multiplying and therefore reducing the amount of HIV in the body. ART also reduces the risk of HIV transmission. Having less HIV in the body protects the immune system and prevents HIV infection from advancing to AIDS. .

Malaria

Malaria is a common and life-threatening disease in many tropical and subtropical areas. Malaria is caused by the protozoan parasite, Plasmodium. Female mosquitoes transmit the malaria parasite. Young children, pregnant women, people who are immunosuppressed are particularly at risk of severe disease. Patients with malaria typically are very sick with high fevers, shaking chills, muscle aches and tiredness. In ASM operations, dug out areas can accumulate water and become the breeding places for the mosquitos. Stagnant water should not be allowed in and around the mine site, including the communities. Other preventative precautions that may be used against malaria are insect repellent, bed nets, and early diagnosis with use of antimalarial drugs.

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Tuberculosis

Tuberculosis (TB) is caused by bacteria (Mycobacterium Tuberculosis) that most often affect the lungs. Tuberculosis is curable and preventable. TB is spread from person to person through the air. When people with lung TB cough, sneeze or spit, they propel the TB germs into the air. A person who inhales these germs can become infected.

When a person develops active TB disease, the symptoms (such as cough, fever, night sweats, or weight loss) may be mild for many months. This can lead to delays in seeking care, and results in transmission of the bacteria to others. With the exposure to dust, the condition for someone who has TB can deteriorate quickly. In ASM operations and communities, sometimes people work in crowded and confined spaces where the bacteria can easily be transmitted. There is a need to ensure that the areas are adequately ventilated and those who experience the symptoms of TB are encouraged to seek medical attention in order to get them cured and to reduce the risk of transmitting the bacteria to others.

Physical Hazards

A physical hazard is an agent, factor or circumstance that can cause harm with or without contact. Physical hazards in ASM operations in Zambia include: heat stress, manual handling and ergonomics, vibration, dust and noise.

Heat

Operations involving high air temperatures, radiant heat sources, direct physical contact with hot objects, or strenuous physical activities have a high potential for inducing heat stress in workers engaged in such operations. Causal factors such as age, weight, and degree of physical fitness, degree of acclimatisation, metabolism, use of alcohol or drugs, and a variety of medical conditions, such as hypertension can affect a person's sensitivity to heat. The following are the occupational heat-related conditions:

- Heat Stroke: Occurs when the body's system of temperature regulation fails and body temperature rises to critical levels. The primary signs and symptoms of a heat stroke are confusion, irrational behaviour, and loss of consciousness, convulsions, hot and dry skin and an abnormally high body temperature.
- Heat Exhaustion: The signs and symptoms of heat exhaustion are headache, nausea, weakness, thirst, and giddiness (a temporary feeling that your sense of balance is not good and that you may fall down).
- Heat Cramps: Heat cramps are usually caused by performing hard physical labour in a hot environment. These cramps have been attributed to an electrolyte imbalance caused by sweating.

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Vibration

This is the term given to an oscillatory motion involving an object moving back and forth. Workers operating hand-held tools/machinery e.g. jackhammers, during chiselling or manual digging used in ASM operations can develop vibration induced ill-health effects. Exposure of the fingers or hand to regular and prolonged vibration can result in the following range of disorders: circulatory (vascular) disorders; vibration-induced white finger; sensorineural disorders (numbness, tingling), where the compression of the median nerve, which transmits sensory and motor signals to and from the thumb and first three fingers causes pain; numbness and tingling; and muscular effects causing difficulty with grip and reduced dexterity. Use of machinery, such as excavators and articulated dump trucks, can cause a whole body vibration syndrome, which shows as back pain, increased blood pressure, circulatory and/or digestive problems.

Control measures can be implemented by means of suitable and sufficient information and training to workers to ensure that work equipment is used correctly and safely. Another way is by limiting the duration and magnitude of exposure to vibration, use of modern vibration dampened equipment, repair and replace old equipment or fit anti-vibration handles and support heavy tools so that a lighter grip can be used. Ensuring correct tyre pressure and suspension for mobile equipment and moving at correct speed according to the terrain should be enforced.

Dust

Dust is a generic term used to describe fine particles that are suspended in the atmosphere. The nature of mining involves disturbing the ground, removing and handling soil and rock, and the subsequent transport, dumping, crushing and processing of this material. These processes generate dust, which become airborne. The most hazardous dust is the respiratory fraction of total airborne particles, which is inhaled through the nose and mouth. When inhaled, these particles are deposited in the lungs. Inhalation of dust can result in pneumoconiosis, a broad generic term used to describe diseases resulting from the lodgement of any inhaled dusts in the lungs, e.g. silicosis, caused by silica dust, asbestosis, caused by asbestos dust, or anthracosis, caused by the accumulation of carbon in the lungs due to repeated exposure to smoke or coal dust particles. The common name for the lung disease that develops from inhaling coal dust is called black lung. In general, the effects of pneumoconiosis are irreversible. In the Zambian mining industry, the common dust related disease is silicosis caused by exposure to respiratory crystalline silica. Common silicosis symptoms are shortness of breath following physical exertion, severe cough, fatigue, chest pains and fever. Silicosis is an incurable disease and is irreversible and is progressive even when exposure stops.

Controlling Dust Exposure - Safe Work Procedures:

- Wetting down dusty work areas or processes prior to work;
- Providing adequate ventilation to reduce dust by dilution and by displacement;

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- Working upwind of dust sources where possible;
- Posting warning signs where necessary so that people keep away from dust sources whenever possible;
- Limiting exposure time;
- Training all employees on appropriate work procedures; and
- Undertaking good housekeeping practices.

Controlling Dust Exposure - Respiratory Protection:

- Fit testing of all employees required to wear respiratory devices;
- Training employees in the proper use of respiratory devices;
- Making sure employees understand the hazards of dust and the importance of respirator use; and
- Regular checking and cleaning of non-disposable respirators.

Additional Control Measures:

- Changing into disposable or washable work clothes at the worksite;
- Smoking away from dusty areas; and
- Showering and changing into clean clothes after completing work.

Noise

In operations, which involve blasting, use of compressors, drilling machines, hammering/chiselling, grinding and crushing operations, noise can be a source of concern. Exposure to high levels of noise can cause a physiological effect, hearing, and/or psychological effect, e.g. annoyance/irritability, distraction, headaches, concentration, which may result in reduced performance and accidents. Noise can result in temporary (acute) or permanent (chronic) damage to the ear.

Acute Effects of Noise:

- Temporary threshold shift caused by short excessive noise exposure. Affects the sensory cells by reducing the flow of nerve impulses to the brain. It is reversible when the noise is removed;
- Tinnitus. Ringing in the ears caused by intense and sustained noise. The ringing sensation continues for up to 24 hours after exposure; and
- Acute caustic trauma caused by very loud noise, such as an explosion. Affects the eardrum or bones in the middle ear and is reversible.

Chronic Effects of Noise:

- Noise induced hearing loss caused by damage to the hair cells. Affects the ability to hear speech clearly but ability to hear is not completely lost;
- Permanent threshold shift caused by prolonged exposure to loud noise. Is irreversible; and
- Tinnitus. Same as the acute one but it is permanent, i.e. chronic.

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Control measures can be implemented through the following means:

- Dumping/mounting and/or improving maintenance of the noise producing equipment to reduce vibration;
- Isolating the operation involving the noise source with (increase distance) away from the workforce;
- Enclosing the noise source, e.g. surrounding the noise source with a sound-insulating material;
- Reducing the exposure time through job rotation; and
- Providing hearing protection equipment (ear muffs, ear plugs etc. as a last resort) and putting up warning signs on all noise sources to warn any person who may access a noisy area.

Manual Handling/Ergonomics:
Manual handling refers to the movement of articles by the use of muscular strength, movement and body weight. Ergonomics refer to the relationship between man, the equipment with which he works and the physical environment in which this "man-machine system" operates. Many activities in ASM operations carry a risk of injury to the upper and the lower limbs or spine. This is due to a lot of manual handling involved and working with awkward postures.

Manual handling involves such movements as lifting, pushing, pulling, carrying and lowering. Manual handling may result in musculoskeletal disorders, the severity of which may vary from of immediate aches, pains and discomfort of the affected part through to well defined and specific longer-term, chronic mobility problems. Loss of function may result in reduced work capacity. The effects are: general fatigue and loss of concentration or coordination; inflammation of the tendon; muscle tendon junction; inflammation of the tissue of the hand (or elbow, or even knee), caused by constant bruising or friction; compression of the peripheral nerves serving the upper limb; stiffness or soreness of the muscles. When deciding on the control measures for manual handling, four things should be considered:

1. **Task:** A task is defined as "a discrete work segment, a specific work assignment, or a set of actions to complete a work directive". Type, frequency and duration of movements should be analysed with the intention of identifying those movements most likely to cause injury so that they are reduced;
2. **Individual Capability:** Each person has individual capabilities and limitations that will affect the ability to do a job well and safely. If a task requires strong or healthy people to perform/carry it out, then it should be assigned to such people. Every task should be redesigned to suit the individual's capacity;
3. **Load:** A load is defined as any discrete movable object. A load may constitute a hazard because of its weight, size, shape, resistance to movement, rigidity or lack of it; the position of the centre of gravity, presence or absence of handles, or surface texture. An assessment should be made on the need for any of these aspects to be addressed; and

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4. **Work Environment:** An assessment of the manual-handling environment should study the routes taken by loads to identify unnecessary, dangerous and/or lengthy distances. Constraint of posture (enough space) is also a factor, including the amount of manual effort needed, e.g. twisting, bending, stretching. Extreme temperatures should be avoided where possible, i.e. high temperatures or humidity can cause rapid fatigue, and low temperatures can cause numbness and loss of dexterity. There should be sufficient lighting to illuminate the work clearly. Weather conditions should be taken into account, e.g. strong air movement. High noise levels can be distracting and cause reduced vigilance.

Ergonomics

The major risks to health in relation to poor ergonomics include: physical stress (resulting in injury or general fatigue), visual problems (principally through excessive brightness or prolonged concentrated work on small objects) and mental stress (through excessive demands of task performance and lack of control over working processes).

In controlling ergonomic aspects consideration should be given to the person and then fit everything around him/her. That means consideration should be given to the workplace layout and design of equipment and tools. Consider providing enough working space, rest time patterns, avoid repeated twisting, and reaching out or stooping.

Safety Hazards

Safety hazards are unsafe working conditions that that can cause injury, illness and death. Common safety issues in ASM sector include: slips, trips and falls, transport and vehicle related, confined space and unstable pit walls and excavations.

Slips, Trips and Falls

Poor housekeeping and poor drainage can make floors and walkways obstructed, wet and slippery. One can also fall from heights if an open excavation is not protected or not provided with fall protection equipment, such as restraint belts, harnesses, guardrails or safe ladders. If an excavation or opening in the ground, such as an open shaft, has unprotected edges, people or vehicles are at risk of falling in, often due to it not being noticed. Even material stored near an open excavation can also fall into it and injure people. Open excavations must be barricaded and notices posted around them to alert people about the danger of falling into them.

Work Equipment and Vehicles

Operators of vehicles and equipment can be injured or cause injury to pedestrians if equipment is unsafe (poor working conditions), operated unsafely or the operator is not properly trained. Poor road conditions, e.g. unsafe gradients, potholes etc., overloading and fatigue

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Source: Canisius Mwenya, Department of Mines Safety

Figure 60: Manual Tools Employed In An Asm Operation Without Personal Protective Equipment

also constitute risk factors. To control these factors use trained drivers/operators, maintain roads properly, avoid overloading equipment or vehicles and provide for breaks during the shift to avoid fatigue.

Where possible, specific routes should be provided for pedestrians with the aim of keeping people and vehicles apart, including signage to indicate such. Vehicles and equipment should be maintained in good working conditions while excessive gradients should be avoided to prevent vehicles from overturning.

Confined Spaces

A confined space is an area with restricted means of entry and exit. In ASM operations, some excavations have small openings, which cannot be entered and exited safely. Workers can become unconscious due to lack of oxygen in such areas. Poisonous gasses and vapours such as hydrogen sulphide or carbon monoxide may also build up in confined spaces. Confined spaces can also accumulate flammable or explosive gasses and water. The latter, which can result in drowning of workers.

Testing for the presence of toxic gasses and providing adequate ventilation are both vital for making worker areas safe, including draining or pumping out water from pits and excavations. Some workers may suffer from claustrophobia, i.e. fear of confined spaces. Such workers may panic and, if severely claustrophobic, will be incapable of rational thought

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Source: Canisius Mwenya, Department of Mines Safety

Figure 61: Example of Poor Housekeeping at an Asm Site

and unable to control their actions as the desire to escape overwhelms controlled thought. In such instances, it is possible that the workers will, through their panicked actions, injure themselves and/or their colleagues. Such workers should be identified so that they are not assigned to work in confined spaces.

Unstable Pit Walls and Excavations

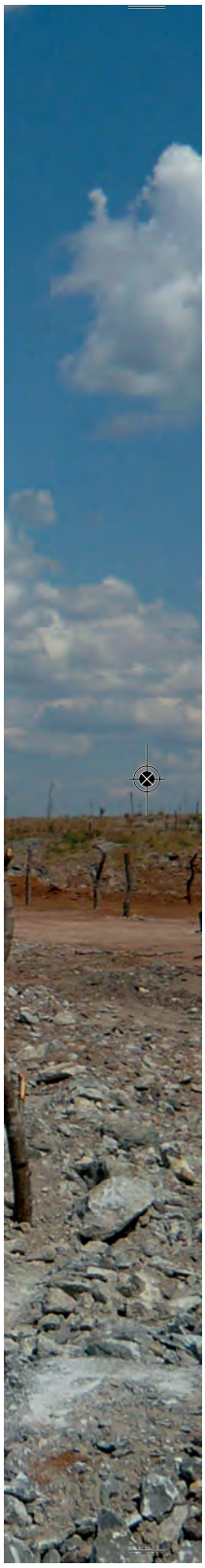
There is very little or no attention paid to the design of excavations and pits in most ASM operations. When a collapse occurs, the worker will most likely be knocked over and the weight of the rock/soil on the body will be sufficient to cause a serious crushing injury (or be fatal). If an open excavation cannot be battered (sloped back) to a safe angle, or benched or stepped, the sides will require support to prevent the possibility of collapse. Underground excavations need to be supported properly so that the roof and sidewalls can stand for as long as the excavations are used. If materials are stored near excavations, precautions must be taken to prevent them falling into it, such as chocks, wedges and toe boards for preventing smaller materials, such as tools, being knocked in. Barriers with appropriate signage should be constructed around any open excavation to prevent any one or material from falling in.

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Mining site for construction material in Zambia

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Source: John Tychsen, GEUS.

ENVIRONMENTAL ISSUES IN ASM IN ZAMBIA

By Labson Chibonga Chinyamuka, Inspector of Environment, Department of Mines Safety

ASM has seen an unprecedented growth in Zambia during the past few decades. The ASM sector now produces a variety of commodities, such as manganese, limestone and industrial minerals. From a structural and technical perspective, ASM operations are conducted at a very rudimentary level using basic tools, such as picks and shovel, and occasionally, mechanised equipment.

With the massive growth of the ASM sector, the environmental degradation of the country caused by ASM operations has also spread and intensified. The main environmental issues resulting from ASM activities include:

- Siltation;
- Loss of Flora and Fauna;
- Water Pollution;
- Air Pollution; and
- Land Degradation.

Today, it is therefore mandatory for all mining operations, including ASM operations, to submit an EIA Report prior to developing and exploiting a mining site. Based on a thorough review of the EIA Report and supporting documentation, the relevant authority will either grant or reject granting a mining license to the owner of the mining site.

Regulatory Framework Governing Environmental Issues in Mining Industry

The Mines and Minerals Development Act No. 31 of 2015, Cap. 213, is the primary and sectoral regulation, which governs environmental management in the country's mining industry. Other relevant legislations include:

- The Mines and Minerals (Environmental) Regulations 1997, Statutory Instrument No.29: Provides the framework for conducting, preparing, reviewing and auditing EIAs, Environmental Management Plans (EMP) for the mining sector;
- The Mining (Mineral Resource Extraction) Regulations 1994, SI No. 119;
- The Mines and Minerals (Environmental Protection Fund) Regulations 1998, SI No. 102: Provides assurance to the Director that the developer shall execute the environmental impacts statement as required and also provides protection to the Government against the risk of having the obligation to undertake the rehabilitation of a mining area where the holder of a mining license fails to do so;
- The mining industry is also regulated under the Zambia Management Act of 2011: Provides for the integrated environmental management, protection, conservation, prevention and control of natural resources;

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- The Air Pollution Control (Licensing and Permitting of Emissions from Stationary Sources) Regulations, SI No. 141 of 1996: Provides for licensing of gaseous waste emission to the environment and also provide for statutory discharge limits for respective parameters;
- The Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, SI No. 28 of 1997: Requires that before a developer commences implementing a project, a project brief/EIA for that particular project be prepared and submitted for approval to ZEMA and MSD;
- The Waste Management Regulations, SI No. 71 of 1993; and
- The Water Pollution Control (Effluent and Wastewater) Regulations, SI No. 72 of 1993.

The Mines and Minerals (Environmental Protection Fund) Regulations

The objective of the EPF is to provide assurance to the Director that the developer shall execute the environmental impacts statement in accordance with the Mines and Minerals (Environmental) Regulations of 1997.

The EPF shall provide protection to the Government against the risk of having the obligation to undertake the rehabilitation of a mining area where the holder of a mining license fails to do so.

All mines are mandated to submit annual environmental audits and updated environmental management plans to MSD and to contribute total closure costs into the EPF as required by the Regulations.

All mine facilities depending on environmental performance to be re-categorised, ref. Table 1 below. The best category, category (1), pays 5% of the total cost of rehabilitation, whereas new mines and non-performers, making up category (3), pay 20%.

CATEGORY 1 ACTION TAKEN TO REHABILITATE	CATEGORY 2 ENVIRONMENTAL COMPLIANCE CAPABILITY	CATEGORY 3 BASIS OPERATIONAL AND STRATEGY ENVIRONMENTAL PROTECTION REQUIREMENTS
a) progressive rehabilitation carried out; b) whether rehabilitation has been Properly monitored; and c) whether the annual rehabilitation audits show progress to meet the target of the environmental impact statement to manage environmental pollution.	a) the financial capability to complete the rehabilitation of the mine area; b) the materials in place for total mine area rehabilitation; c) whether suitable expertise is provided for the organizational structure; and d) whether the developer or the person who holds a mining license or permit has an approved e) environmental impact statement or project brief.	a) an approved environmental impact statement or project brief; b) discharges of mining operations are permitted or licensed; c) post-mining land use and slop and profile design, allowing stable land rehabilitation within the mining or permit area; and d) a water management system is in place or designed to contain, treat, discharge or dispose of contaminated water.

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Physical Environmental Impacts

Potential physical environmental impacts, resulting from mining activities, include, but are not limited to:

- Destruction of the natural habitat at the mining site and at waste disposal sites;
- Destruction of adjacent habitats as a result of emissions and discharges;
- Destruction of habitats arising from the influx of settlers;
- Changes in river regime and ecology due to siltation and flow modification;
- Pollution from mining operations in riverbeds;
- Effluent from mineral processing operations;
- Sewage effluent from the site;
- Oil and fuel spills;
- Soil contamination from treatment residues and spillage of chemicals;
- Leaching of pollutants from tailings and disposal areas and contamination of soils;
- Air emissions from mineral processing operations, e.g. roasting and smelting;
- Dust emissions from sites close to living areas or habitats;
- Release of methane from mines;
- Danger from failure of structures and dams;
- Alteration in water tables;
- Change in landform;
- Land degradation due to inadequate or no rehabilitation after closure; and
- Land instability.



Source: Labson Chinyamuka, Department of Mines Safety

Figure 62: Example of A Tailings Discharge From A Tailings Dam Facility

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Source: Labson Chinyamuka, Department of Mines Safety

Figure 63: Example of Effluent Discharged from Tailings Dam Into Natural Water Stream



Source: Labson Chinyamuka, Department of Mines Safety

Figure 64: Example of Siltation in Water Stream

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Social, Economic and Cultural Impacts

The social, economic and cultural issues and impacts, caused by mining operations, include, but are not limited to:

- Conflicts regarding the use of land, wildlife and water resources;
- Dislocations of local populations;
- Changes in social, cultural and economic patterns within the local community;
- Need for learning new skills; and
- Effects on historic and religious sites.

Environmental and Safety Challenges of ASM Operations

To properly comply with both environmental and safety rules and regulations, ASM operators face a number of challenges, such as:

- Lack of investors;
- Lack of proper equipment and machinery;
- Lack of finances to rehabilitate degraded mine facilities and comply with environmental regulations and.
- Non-availability of mined benches in the open pits.

Areas of Concern for Management of Environmental Issues in ASM Operations

Areas of concern for management of environmental issues in ASM operations for relevant authorities and agencies include:

- Submission of EIAs for approval before commencement of any development;
- Compliance on management of mine dumps;
- Compliance on air quality, effluent and emissions standards;
- Compliance on storage, transportation, handling, processing of hazardous materials;
- Inspections on general duties within the mining right areas as required in the regulations;
- Monitoring of issuance of licenses to only compliant mines with approved EIAs;
- Renewals of licenses to be in possession of approved environmental reports; and
- Coordination of geological data in terms of mineralisation, tremors etc. to safety department.

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How to Promote Sound and Sustainable Environmental Management Practices

To achieve sound and sustainable environmental management practices in the country's ASM operations, the following initiatives should be implemented/promoted:

- Employment of qualified personnel with environmental knowledge and skills/education;
- Provision of environmental tools and templates for ASM operators, e.g. Environmental Management Plans (EMP), Environmental Management Systems (EMS);
- Provision of a budget for environmental monitoring;
- Stationary and mobile monitoring equipment, e.g. piezometers, for measuring prehetic surface on perimeter bund walls of tailings dams and sampling equipment for effluents; and
- Awareness campaigns on Occupational Health and Safety (OHS).



Source: Labson Chinyamuka, Department of Mines Safety

Figure 65: Example of Effective Sedimentation Ponfs Trapping Silt From Open Pit Before Discharge

Mine Closure and Environmental Remediation

Remodelling of the Area

The idea behind this objective will be to remodel the area so that it can be useful again. Prior to mining, there was no open pit and it will not be possible to backfill the removed waste rock back into the pit. Management may plan to remodel the area by

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stabilising the slopes of the open pit and let water collect in there for restoration of land to be reused as a pressure resort or introduce fish species for fishing.

Rehabilitation Objectives

The waste rock dumps should also be stabilised by levelling them and then trees should be planted. The rehabilitation objectives should not wait for the time of mine closure. Any area that is not being used but has been previously disturbed should be rehabilitated. Trees will be planted on waste rock dumps that are not in use in order to encourage revegetation and ultimately reduce on erosion during the rainy and windy seasons.

Decommissioning and Closure Cost Estimates

The decommissioning and closure cost estimates of mining components (i.e. buildings, open pits, mining equipment, overburden dumps, camp area and magazines etc.) should be conducted to estimate accurate closure costs of mine sites to allow effective restoration of damaged land to an acceptable level by the society.

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It is often observed that women are allowed to do crushing at the tailing from the mining site

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Source: John Tychsen, GEUS.

n are allowed to do
e mining site

SOCIO-ECONOMICAL PROFILE OF ASM IN ZAMBIA

By Charlotte Wonani Sanga, Associate Professor, University of Zambia

Socio-Economic Context of ASM Sector

The mineral mining sector in Zambia is dominated by ASM workers, who operate both formally and informally (without operating licenses). Their mining operations are characterised by the use of rudimentary tools and with limited consideration for health and safety issues. Hentschen et. al. (2003) further state that ASM is characterised by: a lack of or limited use of mechanisation and a lot of physically demanding work; a low level of care for occupational health and safety aspects; poor qualification of personnel at all levels of the operation; inefficiency in exploitation and processing of mineral production (low recovery value); and exploitation of marginal and/or very small deposits, which are not economically exploitable by mechanised mining and low level of productivity.

Overall, the ASM sector is synonymous with low level of salaries, lack of or limited safety, health and environmental standards, and absence of social security. Gender inequality is also prevalent as evident from the number of women participating in the sector compared to their male counterparts. The number of women in the ASM sector, who own and operate mines, is very low and the number of women employed in the mines does not match that of men. The number of women working in the ASM sector varies significantly by commodity, however. While womens participation in the mining of metals is low, up to 41% of miners of Development Minerals are women, according to a census undertaken by the ACP-EU Development Minerals Programme and the Ministry of Mines and Minerals Development. The level of sexual harassment and Gender Based Violence (GBV) is higher amongst women although data is not readily available to support this, but anecdotal evidence suggests so.

At present, there is a chronic lack of working and investment capital for ASM operations in Zambia resulting in a large number of dormant and thus non-value adding ASM operations, which are subject to withdrawal of operating licenses by the Government.

In Zambia, ASM operations are most dominant in the mining of gemstones, such as Emeralds, Amethyst, Tomalin, Red Garnet, Topaz, Manganese, Gold, Copper (from copper ore dumpsites) and other minerals. Such ASM operations are spread across the,country, but most prevalent in the Copper belt Province (Lufwanyama and Kitwe), Southern Province (Kalomo and Itezi Thezi), Eastern Province (Lundazi), Luapula Province (Mansa), and Central Province (Serenje). In addition to these minerals, ASM operations are also actively involved in the mining and quarrying of development minerals, such as sand, stones, quarry dust, lime and aggregates.

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ASM Operations and Poverty

From a livelihoods perspective, ASM operations are often poverty driven and located in rural areas. ASM workers are generally unskilled and earn very little money. Individuals may be involved in a number of different types of activities, which may be seasonal or permanent. The relationship between ASM operations and poverty is very complex. The majority of ASM workers, whether at the extraction, processing or trading level, live in abject poverty.

According to Mwaipopo et. al. (2004), the ASM sector has considerable potential to reduce poverty, i.e. ASM communities fare better in terms of poverty levels than other communities. In addition to being a source of wealth creation, asset accumulation and investment, the ASM sector has the potential to increase people's livelihood security and contribute to vulnerability reduction. The issue of vulnerability reduction is by no means clear-cut, however, and simple conclusions cannot be drawn. While involvement in ASM operations has significant potential to reduce vulnerability through providing people with a source of income, it is also associated with high levels of risk. When this risk collides with chronic poverty, levels of vulnerability can be extreme for certain categories of people – particularly vulnerable children and elderly women making a living from mineral processing activities. However, the ASM does offer them an opportunity to graduate from their poverty status to one of basic survival and income. This income, low as it may be, enables them to improve their daily sustenance, even though to a limited extent. The gains from ASM operations tend to be short-term and limited to subsistence level, yet the ASM sector has vast potential for long-term and sustainable wealth creation for a great number of people.

Social Status

Social status and forms of exclusion also influence people's capacity to make demands.. This is especially the case for elderly women, who lack basic assets, such as physical strength or relatives, and the ability to accumulate capital. Unless such women hold upper positions in the ASM operations' organisational set-up, such as claim holders, they are offered no protection or sufficient compensation for their work. Furthermore, the lack of direct bylaws or regulations protecting women and the work they tend to undertake make matters worse. Children are often worse off than women are. The problems of both women and children are not just due to a lack of voice, but apparent exclusion from local systems of protection making these groups of people vulnerable to the consequences of physical and environmental hazards of ASM operations.

Women in ASM Operations

Ruzvidzo (2015) argues that despite significant involvement and contribution of women to the ASM sector, a growing body of evidence reveals that women are differently and more negatively impacted by their engagement in ASM sector in their communities. This is usu-

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ally a reflection of existing gender inequalities (division of labour and cultural norms that lower the status and authority of women relative to men), which are compounded by the stratification and social, environmental and economic pressures the ASM sector can create.

Women in Zambia constitute a large percentage of the workforce in the ASM sector, although still a smaller percentage compared to men – participating at all stages of the value chain. A few women own mines, but the vast majority are labourers. Comparatively, women involved in ASM operations have limited education, are poor and support huge families, which are heavily dependent on their labour and meagre income. The traditional and cultural disposition of most women in rural Zambia, where the ASM sector is dominant, prevents them from active engagement in ASM operations thereby restricting their access to and control over the means of production. A study undertaken in five African countries, i.e. the Democratic Republic of Congo (DRC), Ghana, Guinea, Tanzania and Zambia, by the United Nations Economic Commission for Africa's (UNECA) African Centre for Gender in collaboration with the African Minerals Development Centre of UNECA and UN Women Eastern and Southern Africa Regional Office revealed the challenges and prospects for women in the ASM sector. The findings of the research clearly highlight a number of key genderrelated challenges that women face in this sector, namely: critical inaccessibility of capital and financing for the mining operations from mainstream financial facilities; lack of appropriate machinery and technology; lack of access to information on availability of mining claims; extreme difficulty in acquiring mining licenses; lack of geological information on the output capacity of their mines due to a lack of finances for the employment of surveyors/geologists; lack of technical know-how of the sector due to unavailability of capacity building opportunities; lack of information on the market dynamics including tax incentives; labourintensive unpaid care work in the home that takes up time that could have otherwise been utilised in productive mining activities; and prevailing patriarchal ideologies that mining is a man's job, thereby obstructing crucial information from trickling down to the women miners.

The gender division of labour in ASM operations places most women in the less lucrative functions, such as sorting, washing, and providing auxiliary services, such as catering, the mining site. Most women work as part-time workers and are therefore not beneficiaries of some of the benefits that accrue to their male counterparts, who, in most cases, are employed on a permanent basis.

According to the Hentschel et. al. (2003), the participation of women in ASM operations can bring direct benefits through better control of family revenues and spending. However, where women participate in ASM operations in a family context, it is often the male head of household, who controls the mining income and women do not necessarily receive a fair share. A gendersensitive approach seeking to empower women and increase their participation at all levels of the ASM sector is necessary. This is particularly true as far as more women are entering the ASM sector as an alternative to subsistence agriculture. Furthermore, evidence shows that women are more likely to spend their incomes on family maintenance compared to men, who tend to spend more income on prostitution, gambling and alcohol. Empowering women in these communities could lead to substantial

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alleviation of poverty. There are some stages of the mining process, however, where women should not participate, particularly where contact with chemical substances might present a health risk to unborn or breastfed children.

Assisting Women in the Mining Industry

Buxton (2013) argues that although women play a central role in many ASM operations they have frequently been bypassed by programs of assistance. Future programs will need to focus more sharply on gender issues by looking for ways to give women more power in their communities and their households.

A good starting point for this kind of work is a mining association for women. The Southern African Development Community (SADC) has a Women in Mining Trust, which was founded in Zambia in 1997. This Trust now has Chapters in a number of other African countries, including Angola, Botswana, Democratic Republic of Congo, Kenya, Mozambique, Namibia, Swaziland, Tanzania and Zimbabwe. The Trust's main objectives include: lobbying for support of women in mining; training women in environmentally sound mining methods; establishing revolving loan funds; and facilitating the marketing of members' products. Another example is the Association of Zambian Women in Mining (AZWIM), which has the mandate to facilitate capacity building programs, financial and technological support and market linkages for its members. In addition, the AZWIM has the mandate to train its members technically and offer business skills. The role of the Association is very critical and building the capacity of the Association is key in ensuring that it delivers on its mandate.

Child Labour in ASM Communities

According to ILO Convention 138 and 182, child labour is defined as a sub-set of working children. It includes all children in the age cohort 5-11 years, who are working; all children between the ages of 12-14 years, who are performing work not considered as light work and working more than 14 hours a week; and all those between the ages of 15-17 years, whose work may be deemed hazardous.

Child labour in ASM communities is an issue of concern in Zambia. Although data is not accurate on the number of children working as labourers in ASM operations, it is evident that there are many children that are engaged as labourers in ASM operations at different levels. The persistence of this phenomenon can be attributed to the following factors:

- High levels of poverty in families resulting in child labour as a key strategy for family survival;
- Distance to schools as well as the high cost of sending children to school leaving them no alternative but to work in ASM operations;

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- Poor education standards and facilities forcing learners to leave school to earn an income in ASM operations; and
- Lack of adherence to laws governing child labour.

Children are the most vulnerable workers in ASM operations, particularly the girls, who are victims of both economic and sexual exploitation.

A study undertaken by Matenga (2008) revealed that children in the mining sector are involved in almost all tasks of the mining enterprise, such as: digging, shovelling, crushing stones, sorting gemstones, sieving and washing gemstones and carrying the products. The youngest of the children (some as young as 7 years) do other tasks, such as cooking and fetching water for elders and older groups of children. Children, who were involved in mining activities, worked under harsh and hazardous conditions, such as working long hours, working all days of the week, exposure to excess heat, both from the sun and fire, and dangerous chemical substances. Most of the working children had serious wounds or scars on their limbs, head and other exposed parts of their bodies from accidents they were involved in at the mining sites. Children, who were employed, were paid in either cash or kind. Some, who worked with their parents in the mining operations, were not paid anything as their work is regarded as part of their family's responsibilities. Usually those paid in kind receive a proportion of gemstones or food rations.
According to Matenga (2008), children working in mines are exposed to the following hazards:

- Intense heat and direct light from the sun, i.e. working in open pit mines.
- Altitude sickness, i.e. working at extreme heights of over 1,000 meters from the ground surface;
- Attack by wild animals, i.e. some mines are located in game management area, such as in Lundazi District;
- Work injuries, e.g. from use of a hammer, shovel etc.
- Muscle aches and spasms due to lifting heavy loads and working long hours;
- Psychological stress due to working long hours, including working at night;
- Drugs abuse, especially marijuana, from trying to cope with the magnitude of work assigned;
- Contracting malaria due to sleeping in open makeshift huts and working at night; and
- Other illnesses, such as chest pains, coughing, tiredness, nausea and dizziness.

Addressing Child Labour in ASM Operations

No children should be working in mines; hence, the objective must be to eliminate child labour altogether. In the interim and short-term, it is important to try to reduce the dangers and to improve the conditions for children currently involved in mining. The ILO is

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one of the leaders in this field through its International Programme on the Elimination of Child Labour. It is expected that in the future children will no longer be working in the mining industry altogether.

Occupational Health and Safety

Occupational health and personal safety issues are very critical in the context of ASM operations. Reliable data or official statistics about accidents or diseases related to occupational health and safety are not readily available within the ASM community.

According to the ILO (1999), the five major health risks related to small-scale mining and processing include:

- Exposure to dust (silicosis);
- Exposure to mercury and other chemicals;
- Effects of noise and vibration;
- Effects of poor ventilation (heat, humidity, lack of oxygen); and
- Effects of over-exertion, inadequate work space and inappropriate equipment.

Accidents often happen in ASM operations. There are several causes of these, which may include:

- Rock falls associated with collapse of mines;
- Lack of ventilation;
- Misuse of explosives;
- Lack of knowledge on mine topography;
- Lack of training in mining operations;
- Violation of regulations; and
- Use of obsolete and poorly maintained equipment.

The acquisition and use of safety equipment, such as helmets, safety boots, gloves and dust masks, are often considered a huge investment amongst ASM operators. Employees of ASM operators are also unwilling to invest in their own personal safety equipment because they can ill afford it and see it as a drain on their meagre resources. The fact that the ASM sector remains unregulated and uninspected results in low adherence to safety and health standards.

In summary, the causes of occupational health and safety deficiencies and shortcomings in ASM operations are as follows:

- The majority of ASM sites operate under marginal economic conditions, characterised by very low wages, which deter the acquisition of safety equipment. Acquisition of

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safety equipment is seen as a cost to the operations and not related to productivity and therefore not perceived as a priority. It does not generate income and therefore seen as a liability to the operation.

- The safety regulations for medium- or large-scale mining operations are often not appropriate or adaptable by ASM operations. Rigorous and exaggerated safety requirements are a discouraging factor for ASM workers leading them to overlook all the requirements for health and safety.
- Enforcement of mine safety regulations often takes a punitive approach. The use of severe sanctions and fines results in under-reporting of mine accidents and incidences of mining related diseases act as obstacles to improvements.

HIV and AIDS in ASM Communities

HIV and Aids affect the most productive segments of the population and labour force, i.e. people between 15-49 years of age. The scourge of AIDS has had devastating impacts on the population of Zambia in the last three decades. According to the UNAIDS (2016), Zambia had 59,000 new HIV infections and 21,000 Aids related deaths in 2016. There were 1.2 million people living with HIV out of which 65% had access to Anti-Retroviral Therapy (ART). Among people living with HIV, approximately 58% had suppressed vial loads. Populations that are most affected by Aids are commercial sex workers (56%) and prisoners (27%). Since 2010, new infections decreased to 27% and Aids related deaths have decreased by 11%.

Conditions in the ASM communities place both men and women in very vulnerable positions from an HIV and Aids perspective. This is associated with the high-risk behaviour resulting in the spread of HIV and Aids. Some of the causes of this high-risk behaviour are as follows:

- Some mining sites are remotely located thereby forcing miners to be disengaged from their families intermittently. This forces them to engage in illicit sex with commercial sex workers resulting in the contraction of HIV and Aids.
- Women and girls, who are engaged in mining activities, are most vulnerable to sexual abuse. Because they earn relatively lower incomes than men do, they end up engaging in sexual favours in exchange for increased incomes or jobs or to earn a little extra money.
- The remoteness of these mining sites accounts for the inability to access condoms for use, which compounds the epidemic.

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Summary of Problems and Challenges of ASM Operations in Zambia

HOW THE IMPACT OR PROBLEM IS EXPRESSED	WHAT WE KNOW ABOUT THE STRUCTURAL CAUSES OR CHALLENGES
Women are often involved in processing and waste disposal, exposing them to harmful chemicals, with severe consequences for family well-being and health, including during pregnancy. Women are involved in less rewarding activities due to the part time nature of the work as well as their domestic responsibilities.	The Cultural and traditional disposition of women determine roles, affecting resources rights and decision-making. Women are often 'invisible' on mine sites, transporting and processing materials often done in domestic/private spaces rather than digging (which, on the other hand, render them less vulnerable to some types of pit-related dangers that male diggers face) Their contributions are difficult to identify, poorly researched, informal and therefore perceived as marginal by policymakers. Women's unique role and challenges are often overlooked in policy responses where they are considered in the same bracket as children or treated the same as men. Policies tend to be 'gender neutral'. Mechanisation and organisa tional development reduces opportunities for women's employment – making them most unlikely to benefit from these developments.
ASM is one of the worst forms of child labour because of widespread and severe hazards that risk, injury, disease and death. Children undertake arduous activities such as working underground, lifting heavy equipment or mineral ore, digging, ore haulage and transport the ore. Child labour can range from help after school to full time slave-like employment in the most hazardous conditions.	The ILO identifies a number of structural challenges leading to child labour in ASM: Low barriers to entry, minimal mechanisation and a lot of physically demanding work with no need for education makes it easy to use children. Access tunnels may be so small that only children can fit down them. Poor regulation of health and safety expose children to extreme risks. ASM's poverty-driven nature and low margins force families to use child labour.

Source: Buxton (2013)

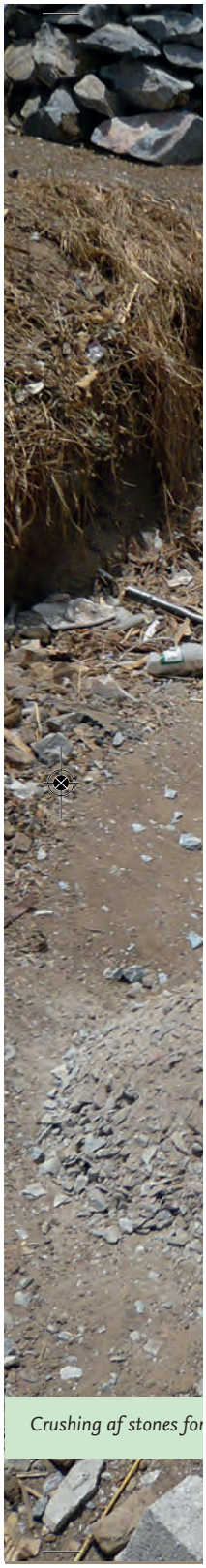
Table 2: Summary of Problems And Challenges Of Asm Operations In Zambia

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HOW THE IMPACT OR PROBLEM IS EXPRESSED	WHAT WE KNOW ABOUT THE STRUCTURAL CAUSES OR CHALLENGES
	Migration patterns associated with ASM disrupts children's schooling. Mining's health and environmental hazards are poorly understood or merely ignored, especially for children. Child labour is closely linked to women's burdens (both at the mine and at home) and to their extreme poverty, lack of education and lack of control over earnings.
Conflicts between ASM and LSM activities are increasing as ASM increases and as LSM targets more remote areas. Violent interactions between the two (including deaths) necessitate security protocols. Although LSM can bring better infrastructure and ways of working, it can also force ASM into less lucrative alternatives, restrict the land mined and damage other natural resources that communities rely on (ibid). ASM can undermine a company's social licence to operate by creating environmental and public health problems, conflicts with security and allegations of human rights abuse, and by disputing rights to land and ownership of the resources. Managing interactions with ASM can take huge amounts of time, present a serious security issue, disrupt operations and undermine efforts to rehabilitate certain areas. The legal impacts can be huge and ongoing – preventing mines from securing project financing.	ASM workers often do not have formally recognised land rights making it difficult for them to defend their activities and making it difficult for LSM to identify them and determine the best way to interact with them. Governments tend to favour LSM with its large investments and government returns, and ignore ASM's role and contribution. This is reflected in laws and policies that fail to protect ASM. Long-term conflicts and resistance arise where LSM and ASM compete for the same resources. Pre-existing ASM workers often act as 'unpaid geologists' for LSM to identify resources. ASM miners may flock to an LSM site, re-mining waste products and taking advantage of easy access — either passively or with criminal intent. (e.g. the "Black Mountain in Kitwe District") Policies for resettlement can be poorly thought through and fail to understand, or address, existing livelihoods' social, economic and political contexts. Remoteness and social and political marginalisation increase the likelihood of ASM getting poor concessions. There is much mutual distrust and misunderstanding between the sectors.
Occupational and community health and safety tends to be very poor in ASM. Self-employed miners in the smallest underground mines typically work in unsupported tunnels drilling and removing rock with hand tools and carrying the ore to the surface in sacks. Most miners do not have protective wear and wear. Helmets are only occasionally worn. Use of earplugs, masks and gloves is rare. The most common accidents are trips or falls, being hit by machinery or a moving object, and cave-ins, rock falls, or the mine collapses.	The high levels of health and safety risks for ASM miners have several causes Informal and unregulated, much ASM activity operates outside of health and safety legislation or enforcement. Protective equipment, from helmets and dust masks through to guarding shields in front of operating blades, may be cost-prohibitive for ASM miners. Few, if any, small mines have facilities for medical care. Apart from workers in government-owned or controlled mines, there is no regular health screening of ASM miners, and attendance at hospitals and clinics generally only follows serious injury or illness.

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HOW THE IMPACT OR PROBLEM IS EXPRESSED	WHAT WE KNOW ABOUT THE STRUCTURAL CAUSES OR CHALLENGES
Women are often involved in processing and waste disposal, exposing them to harmful chemicals, with severe consequences for family well-being and health, including during pregnancy. Women are involved in less rewarding activities due to the part time nature of the work as well as their domestic responsibilities.	The Cultural and traditional disposition of women determine roles, affecting resources rights and decision-making. Women are often 'invisible' on mine sites, transporting and processing materials often done in domestic/private spaces rather than digging (which, on the other hand, render them less vulnerable to some types of pit-related dangers that male diggers face) Their contributions are difficult to identify, poorly researched, informal and therefore perceived as marginal by policymakers. Women's unique role and challenges are often overlooked in policy responses where they are considered in the same bracket as children or treated the same as men. Policies tend to be 'gender neutral'. Mechanisation and organisa tional development reduces opportunities for women's employment – making them most unlikely to benefit from these developments.
ASM is one of the worst forms of child labour because of widespread and severe hazards that risk, injury, disease and death. Children undertake arduous activities such as working underground, lifting heavy equipment or mineral ore, digging, ore haulage and transport the ore. Child labour can range from help after school to full time slave-like employment in the most hazardous conditions.	The ILO identifies a number of structural challenges leading to child labour in ASM: Low barriers to entry, minimal mechanisation and a lot of physically demanding work with no need for education makes it easy to use children. Access tunnels may be so small that only children can fit down them. Poor regulation of health and safety expose children to extreme risks. ASM's poverty-driven nature and low margins force families to use child labour.



Source: John Tychsen, GEUS.

Crushing af stones for

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Crushing af stones for use in construction industry.

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Training of representatives from ZEMA and local representatives in Chipata

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Source: John Tychsen, GEUS.

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BUSINESS PLANNING FOR ASM IN ZAMBIA

By Theresah Chuula, Manager Enterprise Development, Zambia Development Agency (ZDA)

Brief Introduction to the Concept of Entrepreneurship

There are various definitions of the term "entrepreneurship". The most commonly used definition of entrepreneurship is "the art of creating or developing a business through innovation, creativity, progressive imagination and risk taking initiative". From this definition, it is very clear that the concept of entrepreneurship calls for: an artistic mind; being focused about development; being innovative, being creative, imaginative and the ability to take calculated risks.

Going by this definition of entrepreneurship, an entrepreneur is therefore a person, who, upon identifying a viable business opportunity, uses innovation, creativity, progressive imagination and risk taking initiative, to start a new business enterprise or develop an existing one.

The Business Environment and Stakeholders

When establishing an enterprise, it is important for the entrepreneur to note that the enterprise will not operate in isolation for it to be successful. Every enterprise, whether micro, small, medium or large, operates in an environment that has various players or stakeholders, who will influence the business' success or failure. The strategic business stakeholders include:

- Customers
- Suppliers
- Owner/Family
- Employees
- Competitors
- Business Associations
- Financial Institutions
- Government

It is therefore important that the entrepreneur identifies these business stakeholders and establishes very effective and efficient networks and relationships with all of them. The key in this process is effective **business planning**.

Planning in Business

It is important to note that starting and running a successful and growing enterprise is a daunting and risky undertaking, even under the best business conditions. In many developing countries, Zambia included, most start-ups are trapped in the informal sector be-

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cause they do not have adequate business planning and management skills to grow their business, among other challenges. Entrepreneurs may possess strong technical skills but may lack capabilities to run a lucrative business mainly because they lack business management skills. The key in setting up a business is business planning, as discussed below.

Relationship between Management and Planning

Most entrepreneurs give themselves titles such as: Managing Director, Manager, Director, Chief Executive Officer, Chairman, etc. Every entrepreneur, who bears any of the above titles, must understand that by their nature, the titles entail being involved in management of their businesses no matter how small.

What is Management?

In very simple terms, "management" means "to be in-charge" of drawing up and implementing programs that achieve success continuously. This entails that every entrepreneur, who ventures into business, has certain functions, which he or she must perform orderly and correctly in order for business to run smoothly and profitably. Some critical management functions include:

- Planning
- Organising
- Motivating
- Directing
- Controlling

The most important function of a manager is **planning**. This is not to say the other functions are not important. They are equally important, but planning becomes very critical because it is the starting point for every manager, whether in a micro, small, medium or large enterprise.

Basic Planning Method – The 5 Ws & 1 H

Planning can be done using various methodologies depending on the complexity of the project. The 5 Ws and 1 H is a simple method that can be used in planning in a business.

- **WHAT** – the list of required activities;
- **WHEN** – the time frame for each activity;
- **WHERE** – the strategic location for each activity;
- **WHY** – the rationale or reason for each activity;
- **WHOM** – the division of labour or responsibilities based on the right skills, experience and qualification for the right job; and
- **HOW** – the methodology to be used for each activity.

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Importance of Planning

However, why should an entrepreneur plan?

- In order to clearly define a path to follow in one's business operations, by utilising profound knowledge of several/available options;
- In order to allocate scarce resources effectively and efficiently so that the returns (profits) are maximised;
- In order for contingency factors, for the uncertainties in future, to be put in place;
- In order for the exploration of all possible alternatives available to be ascertained and facilitate effectiveness and efficiency by picking the best; and
- In order for one to understand the environment in which operation(s) will take place, so that obligations, threats and opportunities are apparent.

The What in Planning
Under the WHAT factor some of the key questions include:

- What business idea have you settled for?
- What are some of the critical requirements for such a business?
- What are the quantities required for each of the critical requirements?
- What would it cost me to acquire all the requirements for such a business? Psychologically prepared to handle them.
- What are some of the major problems associated with this business?
- What are your capabilities in managing such a business?
- What have you done to gather any additional and useful information about such a business?
- What are your possible sources of useful information for your proposed business?

Ensure that you understand all the possible problems, which you are likely to encounter in the type of business that you are embarking on.

The WHY in Planning

Under the WHY factor you must examine the following:

- Why of all businesses did you choose this business?
- Is the business idea a feasible and viable one?
- Will this business be profitable?
- Will this business be on going?
- Do you have the right attitude, capacity and resources for this business? Have you done your homework well?

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The WHERE in Planning

Under the WHERE factor you want to critically examine, the following:

- How suitable is the location you have chosen for your business?
- Are customers available in that location?
- How stiff is the competition in that location?
- Does the location have all the necessary support structures such as a good road network and telecommunications?
- Are suppliers of various products and services such as raw materials, stock, Transport, repairs and maintenance services, utilities (fuel, oil, electricity, water, etc.) readily available in the location?
- Is the location secure and free from any forms of trouble? Is the area economically very active?

The WHOM in Planning

Under this factor areas to be examined are:

- What type and number of jobs will be required for this business?
- What type of skills will be required for each job?
- What type of experience and qualifications will be necessary for each job?
- Can these skills and experience be found and at how much?
- Are these skills readily available when you need them?
- What are you going to do to get the best out of these jobholders?

The WHEN in Planning

Under the WHEN factor of planning it is important that an entrepreneur learns to give himself sufficient time to mobilise and gather all the required resources before he starts, meaning that he should not rush nor delay. When you rush into starting something, you may end up making too many unnecessary and costly mistakes. On the other hand, a delay in starting increases the risk of losing the drive and desire for that business idea. You may end up losing or giving away the idea to someone else, i.e. you will be overtaken by events. Additionally, start-up costs may even shoot-up to unaffordable levels. Many other factors may change within the environment, such as completion, technology, government policies, etc. which might negatively affect your plan.

The HOW in Planning

Under the HOW factor one critical question is: “how are you going to raise the funds to finance your proposed business idea?”

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Normally the following sources of funds are available but each one of them has its own considerations:

- Loans – are you ready as an entrepreneur for the prevailing interest rates, repayments and security (collateral)?
- Personal Savings - how long can you save and do you have the financial discipline?
- Partnership – with whom are you going to partner? How well do you know your proposed partner? Can you trust your proposed partner? Can you work well with your partner without conflict of interest?
- Sales of assets – are you certain of using the proceeds from the sale of assets for your business? Make sure you do not miss both your asset and the proposed business.
- Inheritance – is it a dependable source of finance?

Finally, you must always bear in mind that planning is a continuous process and each plan you make must be constantly reviewed to make improvements, to check deviations and to incorporate new ideas based on changing circumstances.

Other Management Functions

Organising

It is generally accepted that planning is the most complicated and involving function of a manager. After planning, the rest of the functions become rather routine and straightforward and are dependant of the plans made. After planning, the manager is now required to organise all resources for proper implementation of the plan. Organising is simply charting out an organisational structure or arrangement, which stipulates who will do what, when, how, where and why. With comprehensive organisation, it is easy to trace a mistake and/or anomaly because everybody knows what is expected of them, where, how when and why and who to report to.

Motivating

Another function of a good manager is that of providing motivation in the work environment. Every manager must be inspiring in nature, learning to give rewards, praises and encouragements to deserving workers within the business. Assuming that workers are performing their respective roles very well, a good environment demands that a manger must motivate these workers in order to continue getting even more of the desired results. Motivation can come in many forms and varies from one manager to another. It is up to each manager to determine the best method of motivating the workers. Where employees are putting in their best but management is not creating a highly motivating environment, the following may result:

- Increased cases of theft and pilferage;
- Low morale and lack of interest among workers;

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- Low productivity and poor quality products/services resulting in poor sales and low or no profits;
- Possibilities of sabotage of assets by the employees/workers;
- Frustrations among workers, which may lead to poor customer services and care; and
- Increased labour turnover (high rate of resignations).

Directing (Coaching)

In directing, the role of a manager is to ensure that he is always alert and following all business operations/activities closely, in order to give the enterprise some guidance, direction and focus, based on the original intended objectives and goals. In directing, the manager is providing the required leadership and sense of goal-achieving responsibility. Directing entails constant checking and monitoring of all functional departments within the enterprises, to ensure conformity with plans.

Coordinating

Just like in directing above, the manager has to coordinate the different functions of his enterprise's different departments to ensure that all departments are bent on achieving a common goal. It is the function of a manager in a quarry mine, for instance, to ensure that the one who buys supplies has bought the right type and right quantities of supplies as may be required by those who make quarry products. Moreover, those who prepare meals must have them ready in the right quality and quantity, at the right time as may be required by those serving customers.

Controlling

Another critical and important function of a manager is to control all the activities within the enterprise to ensure that mistakes are corrected and any deviations from the original plan are checked. In control, the manager ensures that the enterprise is always following the path originally made and reviewing progress to incorporate new ideas and discard outdated ideas, if any.

All these aspects of management and planning that have been discussed may best be summarised in what is referred to as a Business Plan.

The Business Plan

A business plan, by its nature, is a document, which clearly outlines the business idea in terms of services and products to be pooled, the vision, mission, purpose and objectives of the organisational arrangements and management structure, personnel and other resource requirements as well as financial forecasts in terms of costs, revenues and cash needs.

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Why is a Business Plan Useful?

A business plan is a road map or guide on how to fulfil the set goal. When you start developing your business plan, you should remember that the greatest winner coming out of this project is not your banker, investor or accountant, it is you. A well thought out and complete business plan is perhaps the best tool that you could have to help you achieve your long run goals. Developing a business plan merely to satisfy some external request has the effect of transforming the planning from an opportunity into a burden.

Whether your company is big or small, if it is starting up or is already up and running, creating a business plan will allow you to:

- Take important business decisions to help you focus your activities and maximize the use of your resources;
- Understand the financial aspects of your business, including the flow of income and expenditure and the capital requirements;
- Obtain important information on the industry and the market context of your business;
- Anticipate and avoid obstacles that your business could face;
- Establish specific objectives and indicators that will allow you to be aware of the progress made over time;
- Diversify into new and profitable activities; and
- Be more persuasive for obtaining financing.

Creating a business plan will enable you to consider all details of a business before investing your money in otherwise incomplete ideas or simple gut feelings about what could be a good business. The creation of this plan will put to the test your determination to bring your business idea to life, since the correct preparation of the plan requires both time and effort. If the idea of developing and writing up a business plan does not appeal to you, it is possible that you do not possess the necessary disposition to start up your business. However, once you have created your plan, you will have much more confidence in your capacity to manage a company successfully.

Contents of a Business Plan

- **Executive Summary:** The executive summary shows the results of the planning process and gives a concise picture of the whole business. It is important that it is prepared at the end, after careful consideration of all business aspects.
- **Company/Business Description:**
  - Name of Business
  - Business Directors
  - Business Address
  - Contact Phone
  - Business Main Products

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  - Business Bankers
  - Business Documents
  - Business Lawyers
  - Business Advisors
  - Stages of Development
  - Patents and Licenses
- **Business Vision:** A clear and specific long run vision of the business.
- **Business Mission Statement:** A mission statement is the central objective of the business, which declares the product or services being provided differentiating it from similar businesses.
- **Analysis of the Industrial Sector:** In what context does your company operate? An industrial sector is formed by all the companies that offer a similar product or service, by companies that offer different products or services but that can be substitutes, and/or by companies that provide the inputs for and distribute the products and services of those companies. The objective of this component is to provide a brief description of the industrial sector in which your company operates and to identify the most important trends in that sector and determine the strategic opportunities and risks to be found there. Analysis includes: sector size and growth; seasonality; technology change; regulations; inter-company rivalry; entry to new competitors; substitutes pressure; negotiation power of buyers; and negotiating power of suppliers.
- **Production Plan:** This considers aspects of Production Processes, Fixed Assets to be used in production and operations, repairs and maintenance and availability of spares, sources of machinery, capacity utilization, acquisition of machinery/equipment and other capital requirements, location of the enterprise, raw materials stock/ requirements, direct labour, indirect labour and staff motivation.
- **Marketing Plan:** The areas to consider under the marketing plan include: Company Products; Quality and Pricing; Business Location; Business Geographical Coverage and Target Customers; Estimated Sales Volume; Estimated Market Share; and Company Marketing Strategy. Furthermore, under this subheading the areas to also expand on include: Organisation Chart; Management and Operations; Board of Directors; Management; Production Staff; Supporting Staff; Business Experience and Qualifications of the Entrepreneurs; Pre-operating Activities and Pre-operating Expenses.

- **Financial Plan:**
  - Total Project Cost
  - Means of Financing
  - Proposed Security (Collateral)
  - Analysis of Financial Projection
  - Profitability Ratio
  - Liquidity Ratio

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- Debt/Equity Ratio
- Interest Cover

- **Summary of Assumptions (Appendix):** These are the assumptions that you will make when creating a plan. It is advisable that one starts with the assumptions because they will help in compiling the quantitative numerical information that is required to write narration and qualitative information.
- **Operating Programme:**
  - Working hours per day: Morning: from 08:00 hours to 13:00 hours; Afternoon: from 14:00 hours to 17:00 hours; Total working hours per day: 8 hours
  - Working days per week: Monday to Friday: 8 hour shift; Saturdays, Sundays and Public holidays: closed for business
  - Estimated working days per month: 20 days
  - Estimated working days per annum: 240 days
- **Product/Services Offered:** Services offered and/or list of products offered.
- Production Output: Installed Capacity and Capacity Utilisation. For purposes of projections, it is important to estimate capacity utilization level e.g. 80% in the first year of operations. This is to take care of the following factors: consideration of effects of power outages/ load shedding; consideration of delays in the delivery of raw materials from suppliers; and considering that the business is new on the market and it is not well known.
- **Input/Raw Material Requirements**
- **Direct Labour Cost**
- **Indirect Labour Costs**
- **Overhead Costs per Month:** Machines/Equipment/Tools; Furniture and Fittings; Motor Vehicles, and Land and Buildings.
- **Depreciation of Fixed Assets**
- **Price List and Projected Sales Revenue per Month**
- **Total Project Costs**
- **Means of Finance**
- **Production/Operation Costs Schedule per Month**
- **Loan Repayment Schedule:** Loan Amount; Repayment Period; Grace Period; Interest Rate; and Monthly Instalment
- **Income (Profit and Loss) Statement**
- **Cash Flow Statement**
- **Balance Sheet**

Managing Finance – An Overview

Good financial management begins by analysing and matching the financial needs of the organisation during each phase of production or service cycle, i.e. procurement/purchases, production, stock, sale and payment cycle. This includes: how to plan, monitor and reduce expenses, reduce financial risks and to smooth payments to the advantage of the organ-

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isation. In addition, it matches the needs for finance at each stage of the supply chain either by using internal financial resources or by creating a suitable and well-timed financial cushion by means of short-term lines of credit or an overdraft from banks and financial institutions. The main documents in business are Cash Flow, Income statement and Balance Sheet.

Cash Flow Statement

Managing cash flow is the most important aspect of running your business and this is where most entrepreneurs are stuck. A cash flow statement:

- Measures the flow of cash in and out of the business;
- Summarises a business' inflow and out flow of cash, meaning where money came from (cash receipts) and where it went (cash paid);
- Predicts if your cash is getting low and this will help you plan how to deal with this.

Income Statement

An Income Statement documents a company's revenues and expenses for a given period. From this information, you are able to determine if the business made a profit or incurred a loss. By reading the Income Statement, you can identify the sources of your business' income and the sources of expenses to determine the operating performance of the business.

The simple rule for determining profit or loss is the equation:

Net Income = Revenue-Expenses

Using this information in the Income Statement, you can determine:

- Areas of the business that are over or under budget;
- Specific items that are causing unexpected or higher than expected expenses;
- Services or sales that are lower or higher than expected; and
- Many business owners develop an income statement at the end of every month and compare them from period to period.

The income statement shows the business' profitability which reflects the business performance and how much can be reinvested into the business.

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Balance Sheet

A balance sheet is a document that lists the value of all assets that the business owns or owes to others at a specific date, normally at the end of the year. A Balance Sheet thus measures the financial strength at a specific date. A business that owes more than it owns is in jeopardy, i.e. it cannot sell enough assets to pay off the debts. In contrast, a business that has more assets than liabilities has "equity", also denoted net worth.

The basic accounting equation is:

Equity = Assets-Liabilities

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Discussions with ASM operators at a mining site north of Chipata

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STRENGTHENING COMMUNITY VOICES IN MINERAL RESOURCE GOVERNANCE IN ZAMBIA

Source: John Tychsen, GEUS.

By Ian Milimo, Assistant Resident Representative, UNDP

Introduction

The 2030 Sustainable Development Goals (SDG) Agenda has called on all nations to ensure that no one will be left behind and that all people and groups will participate in the realisation of the stated goals and targets. This is the world envisaged even in the extractive sector, which has seen little space for local people to participate in the governance of the mining sector, including development minerals. The SDG Agenda calls for a renewed partnership at all levels with all stakeholders working in solidarity to achieve the goals (UN, 2015). Accountability and transparency will be increasingly important at all levels of society, with revised regulatory mechanisms needed to ensure human, civil, and environmental rights. Participatory processes in natural resource management allow stakeholders to give voice to the needs and interests of the people they represent, enabling better-planned and better-informed initiatives.

Background

Mining in Zambia

Zambia's legacy in the mining sector, especially that of copper, dates back to the early 1900s, when the first mining operation was established in the country. The copper mining industry has, in one way or another, influenced much of the economic development landscape of Zambia. It has been mentioned by economic spectators that it is easy to notice when copper prices are high because it is often seen on people's faces. Zambia boasts a wide range of mineral resources capable of underpinning growth in the mining, manufacturing, agricultural and construction sectors.

Development Minerals

The mining of development minerals, or industrial minerals, as they may be known by in other literature, has been undertaken in Zambia for a long time. Zambia's construction sector has been supported over the years by these minerals. The minerals being referred to here include a variety of low value minerals, such as semi-precious stones, limestone, granite, marble, phosphate (in carbonatite and syenite), barite, clay sand and aggregates. Minor deposits of gypsum, feldspar and graphite are also present. There are large deposits of limestone, especially in Lusaka and Ndola, which have attracted large-scale players in the cement-manufacturing sector alongside the small-scale players mainly concentrating

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in aggregates and stones. Semi-precious stones are present in the Copper belt, Southern, Central, Eastern and Northwestern Provinces. These include aquamarine, amethyst, tourmaline (green, pink and watermelon), citrine and low-grade emerald.

African Mining Vision (AMV)

Adopted by the African Heads of State and Government in February 2009, the AMV seeks to create a "transparent, equitable and optimal exploitation of mineral resources to underpin broad-based sustainable growth and socio-economic development" (African Union, 2009). The AMV was inspired by persistent inequities in the African mineral sector that preferentially reward investors while poverty, deprivation and underdevelopment continue to plaque mineral rich African countries. With all its positive intents, many African countries have moved beyond ratification of the AMV. There may be varied reasons for this, including lack of political interest, absence of advocacy voice, lacklustre development partners, weak institutional frameworks and selfish interests in which those with power to do so, do not see any benefit for them. The AMV envisions a mutually beneficial partnership between the state, the private sector, civil society, local communities and other stakeholders (African Union, 2009).

Development Challenge

Despite the high potential to help people out of poverty, the presence of minerals has not played their key role in transforming societies. The off-takers of building materials, such as sand, aggregate and lime, only negotiate with the most powerful in society, who are only interested in immediate gains at the expense of long-term developmental, environmental and social consequences. In many cases, the frameworks around resource governance are negotiated by those who hold power at either national or subnational levels, including local authorities, traditional leaders, and to some extent men in those respective areas. As a result, the local people end up as spectators and recipients of outlandishly agreed development agreements in which they had no voice or role. Transparency in the mining industry, including development minerals that are regarded as community minerals, is currently weak. Often, the lack of participatory structures allowing mining communities to effectively participate in the decision-making processes leads to violations of human rights resulting in conflicts between the industry and the communities (African Union, 2009).

Participation and the Sustainable Development Agenda

Many of the critical challenges of implementing the SDG Agenda will depend heavily on community buy-in and local leadership, coordinated with the work of other levels of governance. Community voices and participation are vital parts of resource governance and the benefits of it are well documented, such as better outcomes for all stakeholders, community ownership and lower project costs. Effective community voices, participation and engagement are about recognising that involving the public in the mining sector is no longer about information dissemination and telling the people what is being done, but is

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a two-way information-sharing tool. Regardless of qualifications that local people possess, everyone knows what they like and dislike, has an opinion about what needs to be done and where priorities should lay. Community participation and engagement are often heavily one-sided, and engagement projects can be inundated with input only from those community members who have a strong opinion, including traditional leaders and, largely, men. It is important to get community voices as they can tell their own unique stories, life experiences and the future they want. Engaging broader community groups, including Ward Development Committees, Area Development Committees or women saving groups that exist in many parts of the country is not only good for local buy-in, but will be addressing the real needs of the people being consulted. The absence of incorporating people's voices has led to mining firms investing their Corporate Social Responsibility (CSR) allocations to projects that do not address the needs of the community.

There is documented evidence of development projects that have ended up being white elephants, simply because they were not conceived with input from community groupings. Instead of investing in human development, including education, health and livelihood, investors tend to focus on cheap and less sustainable investment just to buy off the local people, spending so much money on village soccer as it is most often in Zambia. Such tend to erode within a short period. Getting an additional insight from those affected is a sure way of expanding options and enhancing the value of the ultimate decision, increasing ownership of the resulting products. Evidence shows that community participation and involvement bring more information to the decision, including scientific or technical knowledge, knowledge about the context where decisions are implemented, history and personalities. When the community is involved in a project, it has ownership of it and the decision-making process, which is key to a successful project outcome, even if not all individuals necessarily agree with the outcome. This is the level of community satisfaction that many investors have mistakenly neglected in the past.

Possible Solutions to Expanding Community Voices!

Possible solutions to expand community voices include, but are not limited to:

- Strengthening Legal and Policy Framework: To increase participation and voice for the local people, there is a need for Government to create a framework that will compel all actors to ensure that such structures are part of the mining regime in Zambia.

- Setting Up Community Structures: In some cases, community sounding boards have been set up to hold the mining firm accountable not only to the Government but to the people who are affected by the mining activities. Zambia should, within its policy framework, introduce development of social licences between mining firms and communities. Community members, through these structures, should be given a more central role in the management of their own resources because they through their descendants may stay there for generations. Setting up community actions would

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bring increased community dividends, insurance and prosperity. It enhances people's ability to demand their rights and requirement for equal share.

- Undertaking Advocacy and Education: Non-state actors, including Civil Society Organisations (CSOs), should include within their agenda the need to sensitise people of their rights, responsibilities and duties. There is a need for concerted education efforts to ensure that all community members ensure that they see this as their responsibility rather than that of their leaders. CSOs have managed to achieve this fate elsewhere, including HIV and AIDS, where dividends have already trickled down to communities in the form of reduced infection and proper management levels.

- Expanding Responsibility to Other Line Ministries: The Ministry of Mines and Minerals Development, with whom the mandate to manage and regulate mining activities in Zambia rests, does not have decentralised structures beyond the mining bureaus, only located in a few provinces, yet mining takes place far and beyond. It is important to ensure that other line ministries, such as Community Development, which has structures at the community levels, should be recognised in its role of strengthening community structures. Other lower level government structures, such the District Development Committees should equally be able to see the beneficiation process as one of their responsibilities.

Source: Adam A. Garde, GEUS.

Conclusion

There must be deliberate policies put in place by Government to protect, not only the interest of the State or mining firms, but communities that live within the precinct of the mining operations. Community voices must be incorporated in all stages of mining - from exploration to the last stage of the process. In this way, they would be more prepared to offer workable solutions to the process and be more able to deal with negative consequences of mining. The role of ensuring strong governance processes must be expanded beyond the current architecture that mainly recognises the role of the Ministry of Mines and mineral Development.

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Beobab tree

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African elephant on the savannah

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Source: Kasper Nørgaard , GEUS

SMALL-SCALE MINING SECTOR OF BOTSWANA

By Karabo Tlhabiwe and Otlhogile Rulele of Botswana Geoscience Institute

Botswana is endowed with vast mineral resources, such as diamonds, base metals (copper, nickel and cobalt), soda ash, salt, and coal minerals. Mining in Botswana dates back to ancient times although modern mining began in the late 1960s with the establishment of the Orapa Kimberlite Mine in 1971. Since then a number of modern mines have opened and today copper, nickel, coal, soda ash, salt and diamond minerals are being mined in Botswana. Potential exists for further discoveries and opening of more new mines.

Small-Scale Mining Operations in Botswana

Small-scale mining operations in Botswana cover the following minerals and production methods:

Sand Mining

Sand is extracted from the rivers using open pit mining methods. The demand for river sand has increased dramatically during the past decade. This high demand for sand is generated by the high rate of developments in the Greater Gaborone area. These development projects need high tonnages of river sand, most of which has been mined out illegally from most rivers all over the country with a few tonnages extracted legally to meet the demand. However, this illegal sand mining has a negative environmental impact on the river ecosystems.

Quarry/Crushed Stone Production

Several crushed stone productions and quarries are distributed throughout the country. The quarries are mainly used to provide both fine and coarse aggregates, which are mainly used for road construction and buildings. There are a few quarries, which produce manufactured sand and all of them are located in Southern Botswana where there is little to no river sand in rivers due to illegal mining, which has resulted in overharvesting and illegal mining of river sand. Botswana Geoscience Institute's predecessor, the Department of Geological Survey, took an initiative to identify and assess suitable rocks for production of manufactured sand clay deposits. The quarry sites and clay deposits were identified and assessed up to a pre-feasibility stage, where after the quarry sites were then tendered out and given to locals for further development and production.

Clay

Clay is mainly used for making bricks although some people use it for making pottery. However, clay mining is not as big as construction aggregates.

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Gravel

Gravel is prevalent in all districts of Botswana and is used mainly for road and building construction.

Gemstones

There is a small operation in Bobonong in the Central District where gemstones, agates, are being collected on a very small scale. There is no excavation but just collection of loose agates by individuals who sell their collections to dealers who are licenced by the Department of Mines (Semi Precious Stone Dealers Licence). The dealers sort the agates based on their colour, size and texture and then sell the finished product at the local market.

Legislation

In Botswana, the exploration and exploitation of minerals is governed by the Mines and Minerals Act, first enacted in 1969 with revisions in 1976, 1999 and currently under review, administered by the Department of Mines.

A prospecting license is issued for an initial period of 3 years, with an option for renewal for a period 2 years twice, i.e. a total period of 7 years.

A retention licence is issued for an initial period of 3 years, with an option for renewal for up to 3 years once. A retention licence is issued for projects, which cannot be mined economically after prospecting.

A mining license is issued for up to 25 years, with an option for renewal.

A minerals permits is issued for up to 5 years, with an option for renewal.

At present, there is no legislative framework that directly addresses small-scale mining operations. All mining activities are regulated by means of the Mines and Minerals Act of 1999, complimented by other relevant acts that address particular commodities.

Mines and Mineral Act of 1999

The Mines and Mineral Act of 1999 is the main act that regulates all mining activities in Botswana. The act states that:

- All rights of ownership in minerals are vested in the Republic of Botswana;
- In recognition of the Republic's land tenure system, with regard to tribal land, the tribal leadership ceded mineral rights to the Republic under the Mineral Rights in Tribal Territories Act; and

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- The Acquisition of Property Act further allows the Government to compulsorily acquire property in the public's interest and land has been so acquired to allow mining with adequate compensation in accordance with the Constitution.

Other Applicable Acts

Other Acts include:

- Precious and Semi-Precious Stones (Protection) Act. CAP. 66:03•
- Export and Import of Rough Diamonds Regulations, 2004
- Diamond Cutting Act, CAP. 66:04
- Unwrought Precious Metals Act
- Mines, Quarries, Works and Machinery Act and Regulation, CAP. 44:02
- Explosives Act and Regulations, CAP. 24:02
- Petroleum (Exploration and Production) Act, CAP. 67:01

Application Requirements for a Prospecting and Mining License

An applicant, who should, in the case of small-scale mining operation, be a citizen of Botswana or a Botswana registered company wholly owned by Batswana, is required to fill in Form 1 for prospecting license application and show:

- Detailed prospecting program;
- Proof of access to sufficient funds;
- Proof of technical competence; and
- Environmental Management Plan.

For a mineral permit and mining license an applicant is required to have:

- Environmental Impact Assessment plus Environmental Management Plan approved by the Department of Environmental Affairs;
- Archaeological Impact Assessment clearance from Department of National Museum and Monuments;
- Clearance from Department of Wildlife and National Parks if area is within game reserve or national park;
- Application for mining license/minerals permit submitted to Department of Mines after fulfilling above requirements;
- Form V for a mining license; and
- Form VII for a minerals permit.

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The Role of Botswana Geoscience Institute

The Botswana Geoscience Institute was established through an Act of Parliament passed in 2014. Its main purposes are to:

- Undertake research in the field of geosciences and provide specialized geoscientific services;
- Empower the Institute to be the custodian of geoscience information;
- Promote the search for, and exploration of any mineral in Botswana; and
- To act as an advisory body in respect of geo-hazards and other incidental matters.

The Botswana Geoscience Institute continues the role fulfilled by the former Department of Geological Survey of being the main driver in promoting the global attractiveness of Botswana's mineral resource exploration opportunities.

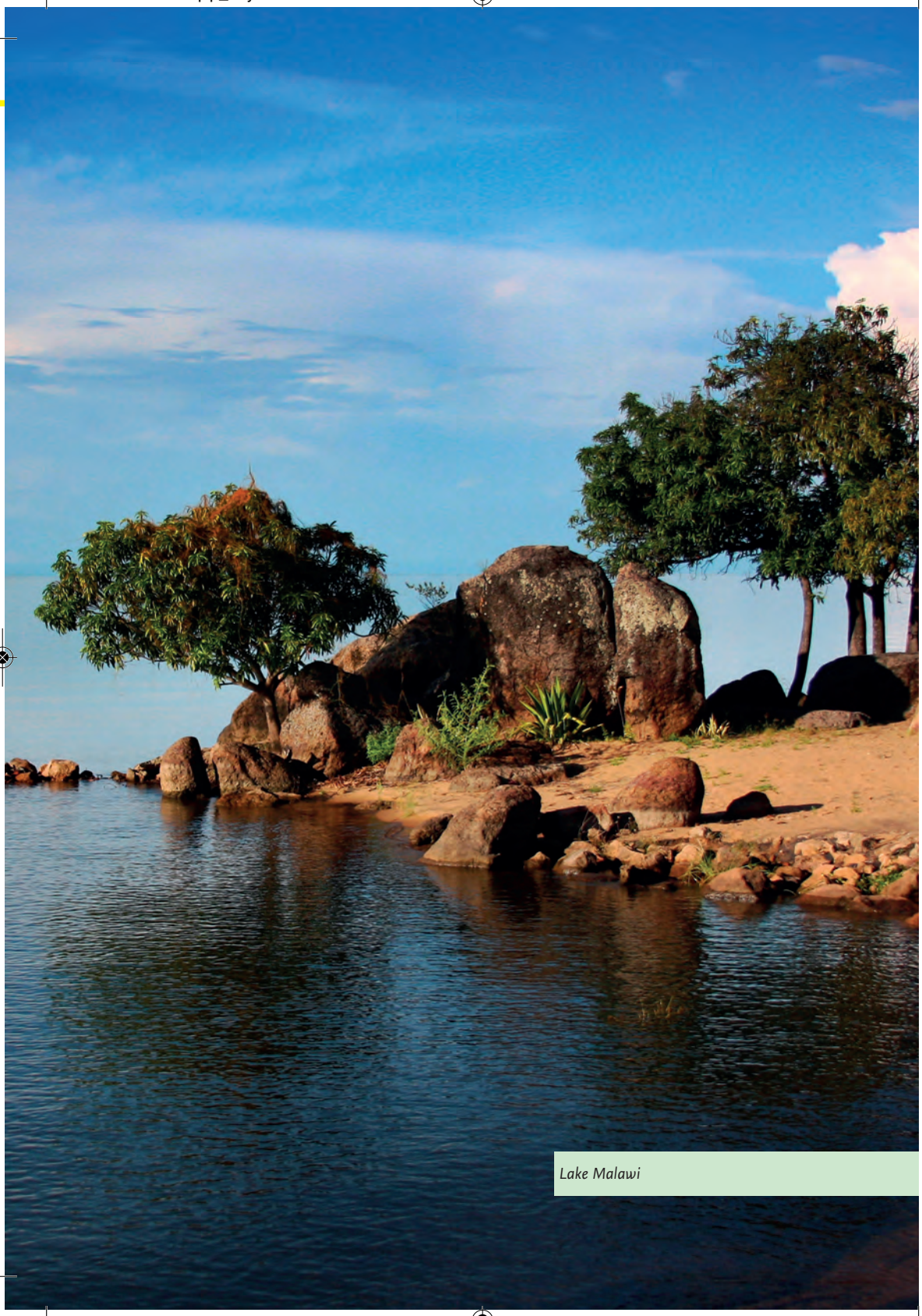
Source: Kasper Nørgaard, GEUS

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Woman splashing bowl for use in the kitchen

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Lake Malawi

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CHALLENGES OF ASM SECTOR IN MALAWI AND THE ROLE OF GSD

By Kondwani H.A. Dombola, Chief Geologist

Source: Shutterstock, Giovanni De Core,

In Malawi, ASM activities usually operate in an informal setting and without social and environmental consideration. Commonly known ASM operations in the country include: gemstone mining, gold panning, stone aggregate quarrying, limestone and marbles, kaolinitic clay mining for ceramic ware production, salt making, brick making and sand mining among others. Most of these ASM activities operate without licences that could have provided them with legal protection, formal source of capital and avenue to formal market points. Only 400 operators are legally registered while unregistered operators amount to approx. 1,600. The ASM sector indirectly benefits/employs between 20,000 to 40,000 people in the country.

The ASM sector is mainly governed by the Mines and Minerals Act of 1981, which is under review and to be tabled in Parliament in 2018. The Mines and Minerals Policy of 2013 also governs the sector. A draft Artisanal and Small-Scale Mining Policy has also been produced and submitted to the Cabinet for approval. In terms of a licence, an ASM operator is required under the laws of Malawi to obtain a Non-Exclusive Prospecting Licence (NEPL), the Mining Claim Licence and the Reserved Mineral Licence.

As mentioned above, then Malawi is home to a number of gemstones, such as aquamarines in Mzimba, Chitipa, Kasungu and part of Dedza; rubies and sapphires in Ntcheu; garnets spread across the country but dominantly in Lilongwe, Salima and Mzimba; amethyst in Chitipa and Mzimba; rose quartz in Mzimba and Balaka; and agates in Chikhwawa and Nsanje.

The country's notable areas of gold potential include: the Kirk Range area, which is mainly spread across the Ntcheu, Balaka, Neno and Mwanza districts; Makanjila in the Mangochi district; the Malingunde-Nathenje-Dzalanyama area in Lilongwe district; Dwangwa in the Nkhotakota district; the Misuku Hills in Chitipa district; and some other occurrences in the Kasungu and Nsanje districts. Until now, no conclusive work has been done to identify major sources of rocks for gold mineralisation. Due to the alluvial nature of the gold occurrences in some of these areas, ASM operators have infiltrated these and subjected them to gold panning. Major gold panning operations have been established in and round the water streams of the Kirk Range area and around Unga River in Makanjila in the Mangochi district.

Challenges of ASM Operations

Similar to other African countries, the ASM sector of Malawi faces several challenges, such as organisational issues, human resources issues, environmental concerns, access to finance and use of low-level technology in operations. For Malawi specifically, the following

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challenges stand out at present for the ASM sector:

- Operations tend to be informal and unsustainable in nature;
- Collaboration with medium to large-scale mining companies is poor;
- Lack of appropriate technology results in low productivity and environmental degradation;
- Poor occupational health and safety conditions of operations;
- Lack of capital;
- Lack of organised, defined and orderly domestic and export markets, especially for gemstones;
- Smuggling of precious and semi-precious minerals is rife;
- Little attempt to add value to products;
- Inadequate training of workers;
- Activities are rarely taxed; hence, huge revenue losses to the Government; and
- Use of child labour.

Initiatives by the Government to Alleviate Challenges

The Government of Malawi has taken deliberate steps to address some of the challenges faced by the ASM sector and the mining sector in general. Some of these steps are:

- Updating of geological information, e.g. the 2013-14 countrywide airborne geophysical surveys followed up by the geological mapping and mineral assessment project of the whole country;
- Providing training and equipment for the ASM sector specifically and formalising ASM cooperatives via the Geological Mapping and Mineral Assessment Project (GEMMAP). At present 8 cooperatives have been formalised and 12 more are in the pipeline;
- Introducing mining related disciplines in the universities in order to provide the much needed exploration, mining and value addition skills to the ASM operations;
- Drafting an Artisanal and Small-Scale Mining Constitution, which will bring together all ASM operations in a form of a Trust. The draft was championed by Small and Medium Enterprise Development Institute (SMEDI); and
- Providing and promoting sustainable mining techniques in order to minimise negative impacts on the environment.

The Role of the Malawi Geological Survey Department

The main objective of the Malawi Geological Survey Department (GSD) is to acquire, monitor, update, archive and disseminate geo-scientific information of Malawi in order to foster socio-economic development of the country. GSD which is one of the departments in the Ministry of Natural Resources, Energy and Mining is mainly organised into three tech-

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nical divisions, namely: Geomapping Division; Mineral Exploration and Evaluation Division; and Geoscientific Research and Laboratories Division. At the helm of GSD is Director of Geological Survey Department. GSD was established in 1922 by the British Colonial Government with the aim of expediting the development of mineral resources of Nyasaland (today, Malawi) and development of water resources. Currently, the water part is delinked to the ministry responsible for water development.

GSD's major functions include the following:

- Systematic map and document the geology of Malawi;
- Carry out mineral exploration to unveil the mineral potential of the country;
- Map and document geological hazards for proper land use planning and institute possible mitigation measures;
- Collect, update, curate and disseminate geo-scientific data;
- Provide technical services to ASM operators in prospecting and mineral identification;
- Undertake collaborative geo-scientific research with local and international institutions; and
- Provide technical and advisory services to the general public, other government institutions and the private sector on geo- scientific matters.

Apart from the core functions listed above, GSD also helps out with regard to the socio-economic development of Malawi in the following ways:

- GSD provides geological information to all parties interested in mining, including the ASM sector;
- GSD, in collaboration with Mines Department, provides training to the ASM sector in areas of prospecting, health and safety and sustainable mining etc.;
- GSD provides laboratory services for mineral identification for the ASM sector;
- GSD provides certificates of inspections to the ASM operators, which enable them to get export permits from the Commissioner of Mines and Minerals; and
- GSD, on request, may assist ASM operators in interpreting potential prospecting areas.

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Namibia landscape

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ASM SECTOR OF NAMIBIA

By Sarti Makili

Source: Henrik Højmark Thomsen, GEUS.

Namibia hosts a variety of quality semi-precious stones most of which are exploited by small-scale miners. Semi-precious stones, which are mostly mined in three regions of Namibia, namely Karas, Erongo and Kunene, include quartz (rose, clear, strawberry and smoky), tourmaline, sodalite, topaz, varieties of beryl (aquamarine, heliodore and morganite), garnet and amethyst among others.

In Namibia, the term small-scale mining (SSM), and not ASM, is used. The term refers to simple technology mining with minimal machinery, requiring low financial input. Small-scale miners typically exploit small orebodies that are uneconomical for large-scale mining operations. In Nambia, the SSM sector involves a number of unemployed Namibians. As such, it has the ability to improve local economic development, reduce poverty and combat urban migration. It is estimated that there are approximately 8,000 small-scale miners in the country - a significant number for a country, which has a population of just over 2 million people.

In Namibia, SSM is recognised by law and is regulated by the Government through the Small-Scale Mining Division (SSMD) within the Ministry of Mines and Energy. The SSMD has the following responsibilities:

- Providing geotechnical support services to SSM operators, especially laboratory sample analysis, free of charge to SSM operators with a valid mineral license;
- Facilitating the formation of SSM legal groups/bodies (associations or co-operatives) so that any form of support from Government, non-governmental organisations, development partners and financial institutions can be channelled through legal entities;
- Facilitating the formation of regional SSM marketing centres to display and market the products of SSM operations;
- Providing training to SSM operators on legal procedures of acquiring mineral rights/claims;
- Promoting the potential for SSM operations at exhibitions and conferences;
- Monitoring and evaluating of potential as well as existing SSM projects;
- Liaising with development partners to optimise support to the SSM sector;
- Assisting SSM operators with the pegging of claims; and
- Settling of land/farm access disputes.

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Mining Regulations for SSM in Namibia

The mining sector in Namibia is regulated by the Minerals (Prospecting and Mining) Act, No. 33 of 1992 under the Ministry of Mines and Energy and the Environmental Management Act, No. 7 of 2007 under the Ministry of Environment and Tourism. The Minerals (Prospecting and Mining) Act, No. 33 of 1992 makes provisions for Non-Exclusive Prospecting Licenses (NEPL) and Mining Claims (MC) to be reserved for Namibians only. The Act stipulates that Namibians (18 years and older), or 100% owned Namibian companies, who want to take part in SSM activities should apply for NEPLs before acquiring mining claims. The NEPL holder is authorised to prospect anywhere in the country for a period of one year. The NEPL gives potential prospectors authorisation to seek permission to access private farms for the purpose of prospecting. Upon identification of an area of interest, a MC can then be pegged and registered. A MC is valid for three years, and can be renewed every two years for an unlimited period of time. It gives exclusive rights to the holder to extract minerals with the purpose of trading. Namibians are allowed to peg up to 10 MCs of 18 ha in size (600 x 300 m) per area or in several areas across the country, except in protected areas such as National Parks. Both NEPL and MC holders receive free geotechnical support services from the Ministry of Mines and Energy.

The Environmental Management Act stipulates that before a MC can be registered, the holder of an NEPL needs to complete a questionnaire or enter into an environmental contract with the Ministry of Environment and Tourism in order to obtain an Environmental Clearance Certificate (ECC). The ECC is a prerequisite for granting MCs. Proposed operational methods, anticipated environmental impacts and rehabilitation measures are some of the information requested by the questionnaire. If the anticipated impact is low, the certificate is granted without any need for further assessment, but if this impact is high, the Ministry of Environment and Tourism will request the applicant to provide an EIA as well as an Environmental Management Plan (EMP). In most cases, SSM operations have low impact and therefore the EIA and EMP are not required.

Challenges Faced by the SSM Sector

On the regulator's side, the following factors are a constraint in the effective regulation of the SSM sector:

- Poor reporting of SSM activities makes it difficult to regulate the sector;
- Financial and human resources are a constraint on the ability of the Ministry to carry out effective mine inspections and verifications, as well as monitor exploration sites as per the mandate of the Ministry; and
- Non-compliance of Mineral Right holders with the requirements of the Minerals, Prospecting & Mining Act No. 33 of 1992, especially pertaining to post-mining transition/rehabilitation.

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SSM operators face many challenges, such as:

- Lack of capital from financial institutions as the business is regarded as risky;
- Lack of capacity among SSM operators regarding financial management and business development;
- Harsh working conditions;
- Unsafe or inappropriate mining methods;
- Lack of proper mining equipment;
- Lack of geological information;
- Limited access into private farms to conduct exploration and mining operations; and
- Lack of expertise and finance to rehabilitate mining sites.

The Role of the Namibian Geological Survey in the ASM Sector

All successful mining operations on various scales are based on reliable baseline geological information, collected and disseminated by the Geological Survey of Namibia. The regional geological information includes regional geological maps and map sheet explanations. This information can be obtained from the Geological Survey's Sales unit at a minimal cost. Other geological information pertaining to mineral occurrence potential and specific questions regarding the geology and mineral potential of the proposed mining area can be discussed with the Economic Geology and the Regional Mapping divisions, respectively, upon appointment.

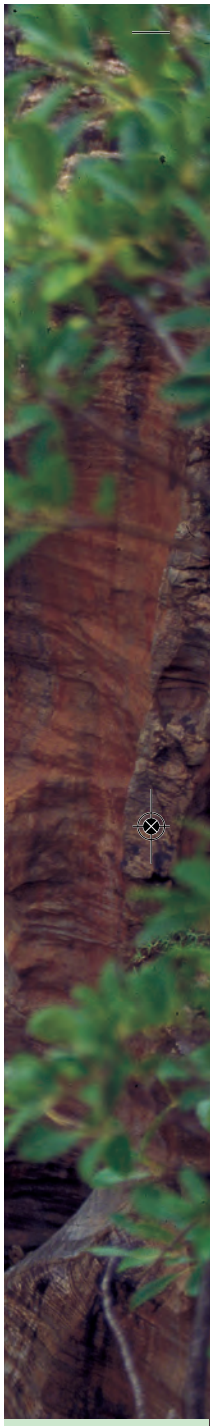
Additionally, the Geochemistry and Laboratory Division offers free analytical services to registered SSM operators. The analytical services rendered to SSM operators include: sample preparation (cutting, crushing, sieving, polishing and milling); geochemical analysis, using the handheld Niton XRF analyser; and mineral identification, using the X-ray diffraction.

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Bourke´s Luck Potholes are a natural water feature within Mpumalanga province. The potholes named after unsuccessful gold prospector Tom Bourke who discovered sign of alluvial gold in the late 1880s.

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Source: Carsten E. Thuesen, GEUS.

natural water feature The potholes named ctor Tom Bourke who d in the late 1880s.

ASM SECTOR OF SOUTH AFRICA AND THE ROLE OF THE COUNCIL FOR GEOSCIENCE

By T. Mudau and S.P Gcasamba, Geoscientists, Council for Geoscience

In South Africa, ASM is defined as a "mining activity employing less than 50 people, and has an annual turnover of less than R10 million with fixed and moveable assets of less than R15 million. It is estimated that the ASM sector employs between 10,000 and 30,000 people (Mutemeri & Petersen, 2002; Hoadley & Limpitlaw, 2004; Buxton, 2013). These figures include both the legal and informal ASM sector. The Department of Mineral Resources has been the leading agent in the development of the ASM sector in South Africa in collaboration with other key role-players in the sector. ASM operations in South Africa are not restricted to specific mineral commodities. ASM operators are allowed to exploit any type of mineral as long as it is within the required provisions of the mining license. Minerals exploited by ASM operators range from precious minerals and metals to industrial minerals and construction materials.

According to the Department of Mineral Resources (2011), most ASM operations exploit industrial minerals, such as sand, slate, clay, sandstone, dolerites and granites. Prospective ASM operators must apply for and be granted a right under the Mineral and Petroleum Resources Development Act (MPRDA) before commencing any prospecting or mining activities. The ASM sector in South Africa became an item on the national agenda after the country had a change in Government in 1994 (Ledwaba, 2017). The ASM sector was developed to eradicate injustices of the previous Government by promoting social and economic growth for previously disadvantaged South Africans as part of the Reconstruction and Development Program (Mkubukeli & Tengeh 2015).

Legal and Regulatory Framework of the ASM sector

All mining activities in South Africa, including that of the ASM sector, are regulated and recognised under the Mineral and Petroleum Resources Development Act 28 of 2002 supported by:

- National Environmental Management Act 108 of 1997 (NEMA 108 of 1997);
- Mine Health and Safety Act 29 of 1996;
- National Environmental Management: Air Quality Act, 2004 (Act 39 of 2004);
- National Water Act 36 of 1998 (NWA 36 of 1998);
- Explosives Act, 2003; and
- National Business Amendment Act, 2003.

Section 3 of the MPRDA 28 of 2002 provides for the State to be custodian of all mineral resources for the benefit of South Africans. The State therefore, through the Department of Mineral Resources, may grant mineral rights as contemplated in the Act. Section 27 (1)

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(a)(b) of the MPRDA 2002 makes provisions for ASM operators to mine under a mining permit on an extent not exceeding 1.5 hectares with no depth restrictions for 2 years. There is no depth restriction for ASM operations; however, granting of the mining permit is subject to the applicant meeting the requirements of the act. ASM operators are required to meet requirements with respect to an EMP and consultation with the landowner/occupier and affected parties as contemplated in section 27 (5)(a)(b). Applications for a mineral right can be done at the office of the Regional Manager in whose region the land is situated as contemplated in section 27 (2)(a). It can take more than six months to obtain a mining permit.

Challenges of the ASM Sector in South Africa

The ASM sector in South Africa, similar to other developing countries, is faced with many challenges owing to the complexities in mineral regulation of the country. The challenges of ASM operations range from access to capital, access to markets, lack of technical and business skills, access to appropriate technologies and skills, and health and safety issues. Often these challenges are drivers of illegal ASM operations.

Access to Financial Assistance

Mining, no matter large or small, is a risky business given the great level of uncertainty. As a result of this, most financial institutions do not offer any financial assistance to ASM operators. ASM operations have always depended on Government and related organisations to provide channels for funding. There are very few institutions that offer financial support to miners, but these include a few development agencies. The Eastern Cape Development Corporation (ECDC) assists with the development of business plans and feasibility studies required to obtain funding, and the Small Enterprise Finance Agency (SEFA) provides loans to small and medium-sized businesses, from R50 000 to the maximum R5 million. However, providing the collateral to secure these loans prevents many miners from accessing them.

Legislative Requirements

According to MPRDA and NEMA, ASM operators are required to meet requirements with respect to EMP authorisation, consultation with the landowner/occupier and affected parties, financial provision for land rehabilitation, and proof of technical ability. All these requirements carry substantial costs, which often require the service of professional consultants. The application process for rights is also tedious and time-consuming – it can take more than six months to obtain a mining permit. In addition, applications are completed online, disadvantaging those in rural areas without access to computers or the Internet. These barriers have forced the majority of miners to operate outside the legal framework.

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Availability of Markets

Access to markets is a major challenge for most ASM operations; this is because most of these operations are located in remote areas. The majority of ASM operators lack marketing skills and knowledge to identify and compete in major markets. Most operations rely on word of mouth advertising and referrals. The majority of the operations depend largely on surrounding communities as their principal markets. The provisions of the mining permit also present barriers even to those that managed to acquire them. The size, extent and total duration of mining permits limit growth in the sub-sector. Most ASM operations find themselves in a situation where they cannot secure funding because the payback period does not make sense, whereby they fail to secure long-term market contracts because they can only operate for a few years, and they fail to invest back into their businesses because there are few growth prospects.

Lack of Technology and Skills

Most ASM activities rely on manual labour and basic tools for mining and processing. The majority of operations depend on manual labour and the use of basic tools such as pick and shovel (Ledwaba, 2017). Most miners do not have a formal education; the lack of skills in the sector is still a major concern. Low-level skills have resulted in poor practices, inefficient mining techniques, poor working conditions, and lack of compliance with and understanding of Government regulation, poor adherence to mine health and safety requirements, and damaging environmental impact.

Role of the Council for Geoscience

The main objectives underlying the establishment of the Council for Geoscience (CGS) are to develop and publish world-class geoscience knowledge products and to render geoscience-related services to the South African public and industry. The mandate of the CGS, as defined in the Geoscience Act 100 of 1993 includes:

- The systematic reconnaissance and documentation of the geology of the earth's surface and continental crust, including all offshore areas within the territorial boundaries of South Africa;
- The compilation of all geoscience data and information, particularly the geological, geophysical, geochemical and engineering-geological data in the form of maps and documents, which are placed in the public domain;
- The collection and curation of all geoscience data and knowledge on South Africa in the National Geoscience Repository; and
- The rendering of geoscience knowledge services and advice to the State to enable informed and scientifically based decisions on the use of the earth's surface and the earth's resources within the territory of South Africa.

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The main role of the CGS in ASM operations is the promotion and provision of access to information on minerals deposits amenable to small-scale mining through provision of technical expertise; geoscience information produced; and through conducting geological investigations for mineral occurrence that can be possible for development by small-scale mining initiatives. Technical support/services to ASM operations include: mineral potential investigations; review of available historical data (geological and borehole data); geological and mineral maps; geological reports; mineral resources estimation; compilation of documents for license/rights application; and analytical work.

Source: Carsten E. Thuesen, GEUS.

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Rock formation at Valley of Desolation.
Graaff Reinet, Karoo, Eastern Cape, South Africa.

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Victoria Falls Bridge over Zambesi, between Zambia and Zimbabwe.

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ASM SECTOR OF ZIMBABWE AND THE ROLE THE GEOLOGICAL SURVEY

By Ernest T. Mugandani

Source: Kasper Nørgaard , GEUS

ASM operations in Zimbabwe constitute the illegal panning activities mainly by communities and other groups of youths from other areas. These activities are mainly undertaken along major rivers originating from the greenstone belts. At present, the country does not have a legal framework to support ASM activities in Zimbabwe.

ASM activities in Zimbabwe date back to the pre-historic Iron Age, long before the colonial era, which marked the beginning of conventional mining and record keeping. Evidence suggests that gold production and trade were vital for the pre-colonial Zimbabwe states of Great Zimbabwe, Khami and Mutapa. Such a long history clearly shows that the ASM sector is not new to Zimbabwe and that it holds great capacity for its economic development.

The following elements have been proposed to constitute the definition of a small-scale miner for the Mines and Minerals Act (MMA) amendments:

- Nationality
- Labour
- Production/Year
- Area size
- Output/Year

After consideration of the above elements the following definition is being proposed for the MMA amendments:

"A small-scale miner is "an Indigenous Zimbabwean person employing not more than 50 people including contractors, on a registered mining location of not more than 40hectares (ha) in extent, that produces and or processes no more than 1200 tonnes of ore per year and with an annual turnover of not more than US$ 1,200,000."

In practice, one can distinguish between two broad types of ASM operators in Zimbabwe, namely:

- Registered miners, i.e. those who have registered small claims and gold processing mills with the Ministry of Mines and Mining Development. These are usually individuals, families and companies; and
- Informal, unregistered, or illegal producers, known locally as 'Makorokoza'. These are both full-time, often nomadic artisanal miners targeting auriferous reefs, abandoned mines, old workings and dumps, or rural subsistence farmers engaging in artisanal mining between farming seasons.

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ASM activities sustain the livelihood of many people and families in Zimbabwe. Even though the processes involved are arduous and laborious, many people rely on the ASM sector as a panacea to poverty. ASM activities can contribute to:

- Slowing of urban migration;
- Employment opportunities;
- Reduction in poverty; and
- Stimulation of local economic growth.

Key Features of ASM Operations

An ASM operations is often characterised by its key features, which include:

- Minimal machinery or technology used. ASM operations rely on simple techniques and physical labour;
- Low productivity, since ASM operations often take place in very small or marginal plots. It is limited to surface or alluvial mining, and uses inefficient techniques;
- Lack of adequate safety measures, health care or environmental protections; and
- May be practised seasonally, e.g. to supplement farm incomes, or temporarily in response to high commodity prices.

ASM activities include excavation of the land and the illegal digging in riverbanks and riverbeds causing land degradation, erosion as well as siltation and if uncontrolled, it has the potential to turn the hazard into an ecological disaster.

Several Government agencies, which include the Minerals and Border Control Unit, the Environmental Management Agency and the Ministry of Mines Inspectors, monitor and enforce mining and environmental regulations on a daily basis. Such operations have been compromised by informality and remote location of some mining operations, and sometimes lack of resources.

ASM operations in Zimbabwe, similar to many other jurisdictions, contribute to social, environmental and financial challenges some of which are listed below:

Social Concerns

- Conflicts: In some areas, ASM operations are associated with an influx of people which creates conflicts with existing formal miners and communities;
- Sexual and Psychological Abuse: Sexual abuse is rampant mainly to women and young girls, who either join the trade or are lured by money for survival. Children around mining sites are exposed to bad language, substance abuse and premature sexual activity resulting in early unwanted pregnancies;
- Sanitation and Basic Health Care: Alcoholism, substance abuse, and communicable

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diseases often increase due to lack of basic sanitation and health care in the mining areas; and

- Safety: The lack of formality increases workers safety concerns such as poor ventilation, lack of safety equipment, improper use of chemicals, and use of obsolete equipment. Some sink shaft on incompetent ground, which tends to collapse and many have died to date.

Environmental Concerns

- Environmental Impacts: In most instances, mining activities occur illegally causing land degradation as there are no mine closure procedures and lack of land reclamation requirements, which result in acid mine drainage; and
- Mercury Contamination/Pollution: Use of mercury in the processing of gold (gold amalgamation) without proper control has posed a threat to the health of human, animals and aquatic life. It ends up contaminating water bodies, waterways and soils.

Fiscus Concern

- Tax Evasion: Though efforts to curb leakages are in place, some miners dispose their outputs (gold and other minerals) informally and do not pay tax or royalties undercutting the viability of legal mining. No proper records of proceedings are maintained.

The Role of the Zimbabwe Geological Survey

The Zimbabwe Geological Survey, a department under the Ministry of Mines and Mining Development, was established in 1910. Its mandate is to generate, archive and disseminate geological data for use in various sectors.

Overall functions of the department include:

- Map the geology of the country;
- Generate information on mineral resources potential of the country;
- Provide technical, consultative and advisory services on mining geology and mineral exploration mostly to small-scale miners;
- Monitor and provide information on mineral exploration and exploitation;
- Collate and archive national geological data and information.

Assistance to the ASM Sector

Since 2014, the Geological Survey has decentralised its extension technical services to the eight provinces of the country. The technical services offered by the Geological Survey free

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of charge in order to promote investment and continuous gathering of information on mineral deposits and occurrences.

ASM operations require geological data and technical support services from the Geological Survey. The services listed below are rendered to small- and medium-scale mines:

- Desktop studies;
- Sample/mineral element identification and analysis. Specimens are also analysed through the use of a handheld XRF and laboratory assaying;
- Ground geophysical surveys for mineral exploration. These include Magnetics, Induced Polarization, Electromagnetics, Micro-gravity and radiometric surveys;
- Underground mine evaluations, auditing and monitoring; and
- Free library and museum services.

The Ministry of Mines and Mining Development has technical departments that are there to assist small-scale miners in the complete mining cycle, from exploration of virgin ground to mineral processing. The services are free of charge and miners are encouraged to utilise the expertise to their advantage. All the departments are decentralised and are in all mining districts of the country. The departments are:

- **Mining Engineering:** This department assists with the technical experts of mining, such as mining methods, safety and environmental issues, inspections, licensing of explosives and their handlers etc. The department has an active mines inspectorate section that is always out in the field monitoring the mining operations. The department also administers the Mining Industry Loan Fund (MILF) providing mining equipment to ASM operations.

- **Metallurgy:** The department of metallurgy is the official government laboratory and offers analytical services, metallurgical advice on plant establishment, design and efficiency, and mineral dressing. The department's metallurgists are also charged with monitoring duties.

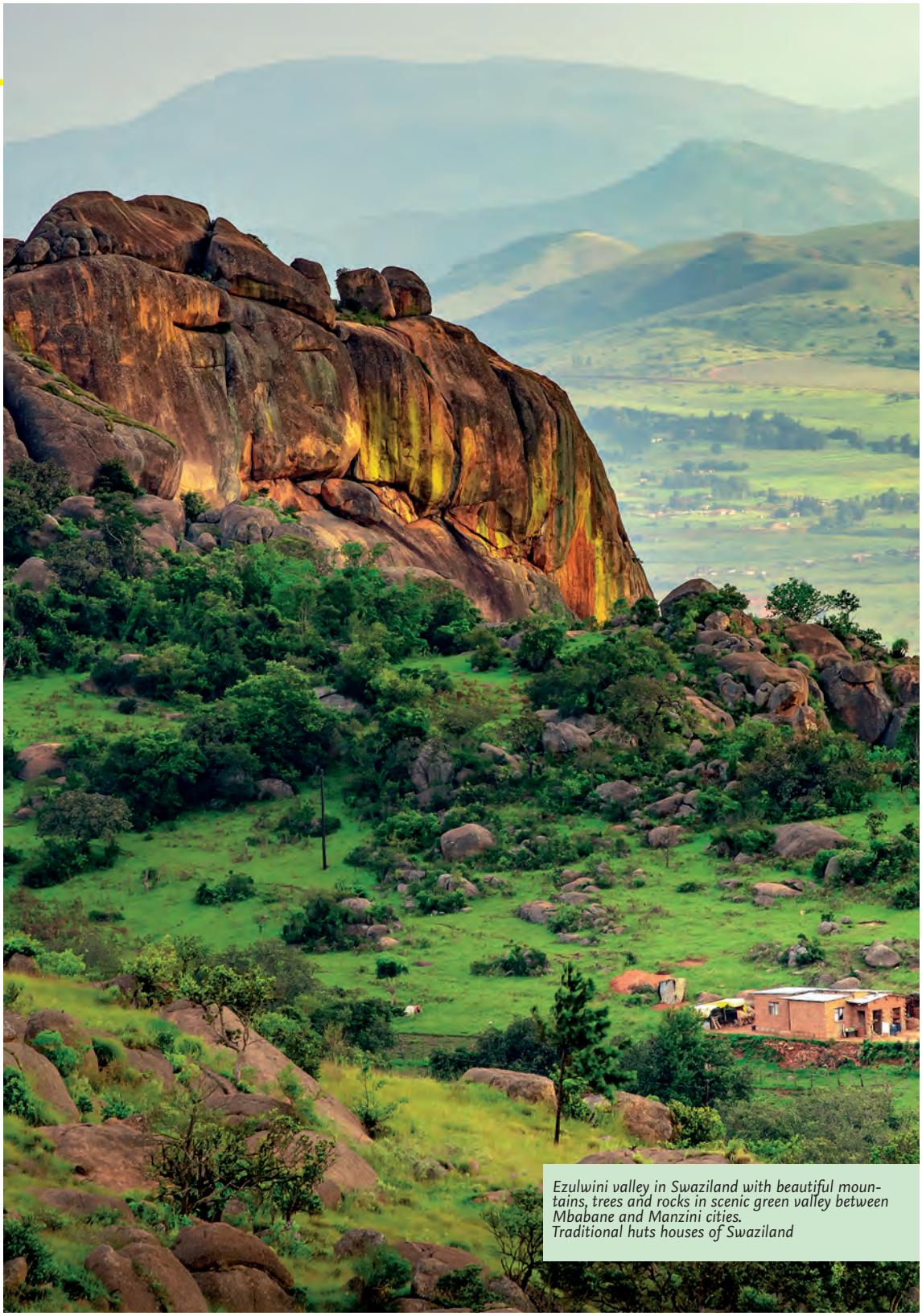
- **Mine Survey:** Although they fall under the Mining Engineering Department, the surveyors carry out work on sitting of structures, waste disposal sites, surface and underground excavations etc.

- **Institute of Mining Research:** This is an institute based at the University of Zimbabwe, funded by the Ministry of Mines, which offers analytical, mineral economics, geological, environmental and metallurgical services to the mining industry at a cost.

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- **Minerals Marketing Corporation of Zimbabwe:** This is a parastatal that markets all mineral produced in the country except gold and silver. Miners can get useful information on market trends and current prices.

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Ezulwini valley in Swaziland with beautiful mountains, trees and rocks in scenic green valley between Mbabane and Manzini cities.
Traditional huts houses of Swaziland

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SMALL-SCALE MINING IN SWAZILAND

By Ncamsile Sigwane

Source: Shutterstock, mBrands85.

In order to diversify the sources of economic development in Swaziland, the Government of the Kingdom of Swaziland wishes to foster development of a thriving mining industry that will contribute to sustainable economic development. The Government recognises the positive contribution that mining can make as an engine for the economic development of Swaziland by diversifying the export base, widening the tax base, generating skilled employment, creating demand for local goods and services, contributing to infrastructure development, producing raw materials for local usage and acting as a catalyst for wider investment in the economy.

The Government wishes to reverse the decline of the mining industry by attracting new investment in the exploration for and exploitation of mineral resources. The Government recognises that to do this it must establish an enabling environment for investors that is based upon modern regulatory arrangements and competitive terms.

Whilst the Government is seeking to encourage investment by mining companies, there is also a need to ensure that mining operations are conducted responsibly. The neglect of the environment and harm to local communities as a result of mining operations are not acceptable. The intention is to ensure that Swaziland is securing the full economic and social benefits which mining development promises.

The Government's policies are directed not only at large-scale mining but also at small-scale mining operations, which offer opportunities to support the rural livelihoods of the Swazi nation. Small-scale mines need to be assisted in their efforts to operate in an economically and environmentally sustainable manner. The Government recognises its duty to discharge its regulatory responsibilities in an effective, even-handed and co-ordinated way. A process to establish appropriate legal and administrative arrangements and the requisite institutional capacity is in progress. The legal framework being created will ensure that Swaziland's mineral endowment is managed on a sustainable economic, social and environmental basis and that there is an equitable sharing of the financial and developmental benefits of mining between investors and all Swazi stakeholders.

The Geological Survey and Mines Department within the Ministry of Natural Resources of Energy has technical reports and bulletins together with geological maps that are available to the public with the relevant information pertaining to the minerals mined in the country.

Small-Scale Mining

The Government realises that small-scale mining (SSM) operations may provide additional or alternative rural livelihoods opportunities for Swazi citizens. The Government has in-

ith beautiful moun-
green valley between

ziland

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tervened in a way so that some minerals and mineral deposits or occurrences are reserved exclusively to be exploited by indigenous Swazi citizens. The obligation of the SSM sector to exploit the minerals in an economically and environmentally sustainable manner is enforced by the Geological Survey, Minerals and Mines Department.

The SSM sector in Swaziland is mainly mining building and construction materials, such as:

- Gravel – mined or not mined at barrow pits;
- River sand;
- Plaster sand;
- Quarried stone; and
- Slate stones.

The SSM sector is a new sector and must be adequately regulated, as such the Government has embarked on a project to train existing and aspiring SSM operators. The educational exercises deal with themes including licensing, environment, health and safety, finance, taxation, reporting and labour laws.

The criteria for distinguishing between small-scale and large-scale prospecting and mining operations includes:

1. A prospecting or mining operation or a proposed prospecting or mining operation shall be classified as a small-scale operation for the purposes of this Act if:
   a. In the case of prospecting operations, the proposed prospecting area does not exceed 5 km^2
   b. In the case of mining operations, the proposed mining area does not exceed 0.05km^2

2. Notwithstanding sub-paragraph (1), a prospecting or mining operation may also be classified as a small-scale operation for the purposes of this Act if:
   a. In the case of mining operations, the actual or estimated annual extraction of minerals or material bearing minerals does not or will not exceed 25,000 cubic meters; or,
   b. The proposed prospecting or mining operations do not or will not employ specialized prospecting or mining technologies; or
   c. The proposed prospecting or mining operations do not or will not involve substantial expenditure.

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The Role of the Geological Survey and Mines Department

The vision is to facilitate the creation of wealth and promote sustainable development for all stakeholders through responsible exploitation, value addition, management and use of the Kingdom Of Swaziland's mineral resources.

The mission is to provide reliable, consistent, effective administrative services, monitoring and enforcement of legislation and implementing development programmes through reconnaissance, prospecting, exploitation, processing of minerals and preventing mining occupational diseases, injuries and minimizing degradation of the environment.

The Mining Department is responsible for the administration of the mining and minerals industry in the Kingdom of Swaziland. The responsibilities involve the enforcement of the provisions of the Constitution; legislation namely: Mines and Minerals Act No. 4 of 2011, Diamond Act No. 3 of 2011, Explosives Act, Mines; Works and Machinery Regulations, Mines and Quarries (Safety) Regulations. The mandate also includes an enforcement of the terms and conditions of mineral rights leases or licences issued through the Minerals Management Board for reconnaissance, prospecting and mining.

The objectives of the Mining Department are to:

- Implement and continuously review the National Mining Policy to achieve the National Development Strategy, Sectoral Development Plans and the Poverty Reduction and Action Programme goals.
- Establish, administer and maintain a modern, effective and visionary regulatory framework to govern the mining industry in the Kingdom of Swaziland that shall be custodian of an effective organisation.
- Enhance socio-economic, financial and other benefits to all Swazi Stakeholders arising from the exploitation of mineral resources.
- Establish more stringent social safeguards and improved fiscal management and achieve equitable sharing of the financial and development benefits derived from mineral extraction between investors and all Swazi stakeholders.
- Establish measures and initiatives for better environmental management in collaboration with other Agencies responsible for such.
- Advise on and disseminate all geo-scientific data related to the mineral resources of the country.
- Govern and provide professional guidance on matters of mine exploration, exploitation, health, safety, mine waste disposal and environmental control of pollution arising from mining activities.
- Formulate and provide technical guidelines, performance standards for mining, mineral processing, metallurgical operations and advise Government accordingly to ensure the international competitiveness of the mining sector.

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- Regulate mining and the mineral industry through issuing of relevant mining permits or licences.
- Receive applications for reconnaissance, prospecting and mining licences for both large and small-scale operations.
- Collate monthly mineral production returns from the mining industry.
- Collate monthly returns on the acquisition, storage and use of explosives.
- Control the manufacture, transportation, storage, usage, disposal/destruction, sale, import and export of explosives.
- Provide for the control of production, processing, possession, purchase, sale and conveyance of diamonds.
- Provide secretarial services for the Minerals Management Board; and
- Promote optimum minerals development by encouraging value addition or downstream development and metallurgical processing.

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REFERENCES

African Union (2009), "African Mining Vision", http://www.africaminingvision.org/

Agricola, Georgius (1556), "De Re Metallica", Translated from 1st Latin Edition by By Herbert Clark Hoover and Lou Henry Hoover (1950)

Bhagwat, S. B and Ipe. C. (2000), "Economic Benefits of Detailed Geologic Mapping to Kentucky", Illinois State Geological Survey Special Report 3, Illinois, USA

Buxton, A. (2013), "Responding to the Challenge of Artisanal and Small-Scale Mining - How can knowledge networks help?", International Institute for Environment and Development, London, UK

Department of Mineral Resources (2011), "Nurturing Junior Miners of the Future: A Strategic Framework to Facilitate the Growth of the Small-Scale Mining Sector in South Africa", Pretoria, South Africa

Drysdall, A.R. (1971), "The Geology of the Big Concession. Section on Economic Geology"

Hentschel, Thomas, Hruschka, Felix and Priester, Michael (2003), "Artisanal and Small-Scale Mining - Challenges and Opportunities", International Institute for Environment and Development and WBCSD, Russell Press Ltd, Nottingham, UK

Hoadley, M. and Limpitlaw, D. (2004), "The artisanal and small-scale mining sector and sustainable livelihood", Paper presented at the Mintek Small-Scale Mining Conference, Johannesburg, 9 September 2004

Ledwaba, P.F. (2017a), "Preliminary Study on Artisanal and Small Scale Mining in South Africa", Open Society Foundation for South Africa, The Centre of Sustainability in Mining and Industry, Johannesburg

Ledwaba, P.F. (2017b), "The Status of Artisanal and Small Scale Mining Sector in South Africa - Tracking Progress", The Centre of Sustainability in Mining and Metallurgy

Lisle, R.J. (2004), "Geological Structures and Maps - A PRACTICAL GUIDE", Third Edition, Elsevier Butterworth-Heinemann Linacre House, Jordan Hill, Oxford OX2 8DP 200 Wheeler Road, Burlington MA 01803, USA

Marjoribanks, R. (2010), "Geological Methods in Mineral Exploration and Mining", Springer, ISBN: 978-3-540-74370-5, 238 p.

Matenga, C. R. (2008), "Rapid Assessment of Child Labour in Non-Traditional Mining Sector in Zambi", ILO

Mkubukeli, Z. and Tengeh R.K. (2015), "Small Scale Mining in South Africa: An Assessment of the Success Factors and Support Structures for Entreprene", Environmental Economics, Volume 6, Issue 4

Mutemeri, N., Sellick N. and Mtegha H. (2010), "What is the Status of Small Scale Mining in South Africa", Discussion Document for the MQA SSM Colloquium, The Centre of Sustainability in Mining and Industry, Johannesburg

Mwaipopo, R., Mutagwaba, W., Nyange, D., Fisher, E. (2004), "Increasing the Contribution of Artisanal and Small-Scale Mining to Poverty Reduction in Tanzania", DFID Research Paper, Unpublished

Njue, L.M. (2010), "Geological Field Mapping Presented at Short Course V on Exploration for Geothermal Resources", organized by UNU-GTP, GDC and KenGen, at Lake Bogoria and Lake Naivasha, Kenya, Oct. 29 – Nov. 19, 2010.

Ruzvidzo, T. (2015), "African Women in Artisanal and Small Scale Mining", Special Report, NewAfricanWoman Magazine February/March 2015 Edition

United Nations (2015), "Getting Started with the Sustainable Development Goals: A Guide for Stakeholders", A Global Initiative for the United Nations, Sustainable Development Solutions Network

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APPENDIX A
- ASM LICENSE FORMS AND CERTIFICATES

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APPLICATION FOR A MINING RIGHT FORM

Form I
(Regulation 7)
(To be completed in triplicate)



REPUBLIC OF ZAMBIA

The Mines and Minerals Development Act, 2015 **(Act No. 11 of 2015)**

The Mines and Minerals Development (General) Regulations, 2016

APPLICATION FOR A MINING RIGHT							
		Shaded fields for official use only		**Licence Code**			
				Date and Time			
Information Required		***Information Provided***					√
1	Type of Mining Right	Exploration		Mining			
2	Scale of operation	Large scale		Large-Scale			
		Small-Scale		Small scale			
				Artisanal			
3	Minerals	Non-Radioactive		Radioactive			
4	(a) Name(s) of applicant(s)						
	(b) Type of applicant (Artisanal mining only)	Individual		Co-operative			
5	(a) Date of Birth (dd/mm/yyyy) (b) Nationality (c) Identity Card (National Registration Card) No. or Passport No. – Attach certified copies						
6	Applicant's physical and postal addresses Tel: Mobile No.: Fax: Email:						
7	(a) Company/Cooperative Registration No. (Attach certified copies of registration certificate)						

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	(b) Shareholders (Attach certified copies of identity cards and companies Form 2 issued under the Companies Act Cap. 388)	Shareholder	Shares held	Nationality	NRC/Passport No.
	(c) Directors	Directors	Shares held	Nationality	NRC/Passport No.
	(d) Company Chief Executive Officer	Name		Nationality	
	(e) Company Secretary	Name		Nationality	

8	Current Mining Rights or licences in Zambia, if any, by applicant	Mining Right/Licence No.	Location	Area (km^2)
		(a)	(a)	(a)
		(b)	(b)	(b)
		(c)	(c)	(c)
		(d)	(d)	(d)
		(e)	(e)	(e)
		(f)	(f)	(f)
9	Previously held mining rights in Zambia, if any, by applicant	Mining Right/Licence No.	Location	Area (km^2)
		(a)	(a)	(a)
		(b)	(b)	(b)
		(c)	(c)	(c)
		(d)	(d)	(d)
		(e)	(e)	(e)
		(f)	(f)	(f)
10	Currently held mining rights or licences in Zambia, if any, by subsidiary companies	Mining Right/Licence No.	Location	Area (km^2)
		(a)	(a)	(a)
		(b)	(b)	(b)
		(c)	(c)	(c)
		(d)	(d)	(d)
		(e)	(e)	(e)
		(f)	(f)	(f)
11	Currently held mining rights or licences in other countries by applicant	Mining Right/Licence No.	Location	Area (km^2)
		(a)	(a)	(a)
		(b)	(b)	(b)
		(c)	(c)	(c)
		(d)	(d)	(d)
		(e)	(e)	(e)
		(f)	(f)	(f)
12	(a) Has the applicant been convicted of an offence involving fraud or dishonesty or of an offence under the Mines and Minerals Development Act, No. 11 of 2015, or any other law within or outside Zambia? If yes, specify details: …… Nature of offence: …… Date of Conviction: ……			
	(b) Have you been declared bankrupt, or if a company, have you been in liquidation? If yes, specify details ……			
13	Has the applicant ever applied for a mining right or licence in Zambia? If yes, please give details …… ……			
	Mining right or licence applied for	Location	Area km^2	Date of application

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	Status of application			☐ Grant		☐ Rejection				☐ Pending							
14	Area applied for (all coordinates in exact multiples of 6 seconds, latitude/longitude format, Degree-minute-Second format, Arc 1950)																
	(a) Location			Province				District									
				Locality													
	(b) Size (in sq. km)																
	Exploration (activity) area not exceeding 2000 km^2 as follows: (i) Large-scale (ii) Small-scale			121 – 59,880 cadastre units 3 – 300 cadastre units													
	Mining (activity) (i) Large-scale (ii) Small-scale (iii) Artisanal			121 – 7,485 cadastre units 3 – 120 cadastre units Not exceeding 2 cadastre units													
	(c) Coordinates (use additional sheet to indicate coordinates if required)			Latitudes (S)						Longitudes (E)							
				D	D	M	M	S	S	D	D	M	M	S	S		
		Corner	1														
		Corner	2														
		Corner	3														
		Corner	4														
		Corner	5														
		Corner	6														
		Corner	7														
		Corner	8														
		Corner	9														
		Corner	10														
		Corner	11														
		Corner	12														
15	**Appendices**																
	(a) Exploration Licence																
	Appendix No. 1			Proposed programme of exploration operations (should include an estimate of the investment commitment in the approved format)													
	Appendix No. 2			Proposals for employment and training of citizens of Zambia													
	Appendix No. 3			Proposals for promotion of local business development													
	Appendix No. 4			Tax clearance certificate issued under Income Tax Act (Cap. 323)													
	Appendix No. 5			Any further information which the Director of Mining Cadastre may require													
	Appendix No. 6			Proof of consent from appropriate authority if activity is in a National Park, Game Management Area													
	(b) Mining Licence - Large Scale																
	Appendix No. 1			A comprehensive statement of the mineral deposits in the area over which the license is sought (should include details of all known minerals proved, estimated or inferred, ore resources and mining conditions)													
	Appendix No. 2			Feasibility study for mining operations (should include a forecast of capital investment, the estimated recovery rate of ore and mineral products, and the proposed treatment and disposal of ore and minerals recovered)													
	Appendix No. 3			Approved Environmental Impact Statement													
	Appendix No. 4			Details of expected infrastructure requirements													
	Appendix No. 5			Proposals for employment and training of citizens of Zambia													
	Appendix No. 6			Proposals for promotion of local business development													
	Appendix No. 7			Tax clearance certificate (issued under Income Tax Act, Cap. 323)													
	Appendix No. 8			Plan of proposed mining area													
	Appendix No. 9			In the case of gemstones, a plan for cutting, polishing and faceting of gemstone in Zambia													
	Appendix No. 10			Any further information which the Director of Mining Cadastre may require													

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	(c) Mining Licence - Small-Scale	
	Appendix No. 1	Copy of relevant prospecting permit and prospecting report
	Appendix No. 2	Proposed programme of mining operations (should include forecast of capital investment, the estimated recovery rate of ore and mineral products, and the proposed treatment and disposal of ore and minerals recovered)
	Appendix No. 3	Description of the mineral deposit in area over which the licence is sought
	Appendix No. 4	Statement of duration for which licence is sought (should not exceed ten years)
	Appendix No. 5	Tax Clearance Certificate issued under Income Tax Act (Cap. 323)
	Appendix No. 6	Approved Environmental Project Brief
	Appendix No. 7	Any further information which the Director may require
	(d) Artisanal Mining	
	Appendix No. 1	Environmental Commitment Plan
	Appendix No. 2	Programme of intended mining operations (should include proposals for the proper conservation and use of mineral resources in mining area, in the national interest)
	(e) Radioactive Minerals	
	Appendix No. 1	Plan and description of mine, processing facilities and proposed disposal sites
	Appendix No. 2	Copy of licence issued under the Ionizing Radiation Protection Act, No. 16 of 2005
	Appendix No. 3	Programme to educate persons in the vicinity of the mine or plant on safety, health and the environment in relation to radiation
	Appendix No. 4	Programme to assist authorities outside the mining area in planning and preparing to limit adverse effects of radiation
	Appendix No. 5	Proposed programme for selecting, using and maintenance of personal protective equipment
	Appendix No. 6	Proposed training programme for workers in relation to radiation safety
	Appendix No. 7	Proposed ventilation and dust control methods and associated equipment
	Appendix No. 8	Proposed security measures during mining, processing, storage, transportation (including measures to alert the holder of acts of sabotage
	Appendix No. 9	Storage, transportation and marketing arrangements in conformity with the Nuclear Non-Proliferation Treaty (NPT)
	Appendix No. 10	Any further information which the Director may require
Application Fee		

.....

.....

Applicant/Authorised Representative * Date

.....

Officer

FOR OFFICIAL USE ONLY

Received by: .....

Officer

OFFICAL STAMP

Amount Received: .....

Serial No. of Application: .....

NOTE

1. An application for large-scale or small-scale mining shall only be made by a company.
2. A small-scale mining activity may only be undertaken by a citizen-owned, citizen influenced and citizen empowered company.
3. Artisanal mining shall only be carried out by an individual or a cooperative.
4. *Delete what is not applicable

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APPLICATION FOR RENEWAL OF MINING RIGHT FORM

Form XIII
(Regulation 21 (2) and (3))
(To be completed in triplicate)

REPUBLIC OF ZAMBIA

The Mines and Minerals Development Act, 2015
(Act No. 11 of 2015)

The Mines and Minerals Development (General) Regulations, 2016

APPLICATION FOR RENEWAL OF A MINING RIGHT

		Shaded fields for official use only	**Certificate Code**			
			Date and Time			
Information Required		***Information Provided***				√
1.	Mining Right or Licence No.					
2.	Minerals					
3.	Renewal period					
4.	(a) Name(s) of applicant(s)					
	(b) Type of applicant	Individual	Company	Co-operative	Partnership	
5.	(a) Date of Birth (dd/mm/yyyy)					
	(b) Nationality					
	(c) Identity Card (NRC No.) or Passport No. (attach copies)					
6.	Applicant's Address					
	(a) Tel:					
	(b) Fax:					
	(c) E-mail:					
7.	(a) Company Registration No. (Attach copies of certificate)					
	(b) Shareholders	Shareholder	Shares held	Nationality	NRC/Passport No. (attach copies)	
	(c) Directors	Director	Shares held	Nationality	NRC/Passport No.	
	(d) Company Chief Executive Officer	Name		Nationality		
	(e) Company Secretary	Name		Nationality		
8.	Current Mining Rights held in	Mining Right or Licence		Location	Area (km^2)	

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	Zambia, if any, by applicant	(Type & Licence No.)			
		(a)	(a)	(a)	
		(b)	(b)	(b)	
		(c)	(c)	(c)	
		(d)	(d)	(d)	
		(e)	(e)	(e)	
		(f)	(f)	(f)	
9.	Previously held mining rights in Zambia, if any, by applicant	Mining Right or Licence (Type & Licence No.)	Location	Area (km^2)	
		(a)	(a)	(a)	
		(b)	(b)	(b)	
		(c)	(c)	(c)	
		(d)	(d)	(d)	
		(e)	(e)	(e)	
		(f)	(f)	(f)	
10.	Currently held mining rights or licences in Zambia, if any, by subsidiary companies	Mining right or Licence (Type & Licence No.)	Location	Area (km^2)	
		(a)	(a)	(a)	
		(b)	(b)	(b)	
		(c)	(c)	(c)	
		(d)	(d)	(d)	
		(e)	(e)	(e)	
		(f)	(f)	(f)	
11.	Currently held mining rights or licences in other countries by applicant	Mining right or Licence (Type & Licence No.)	Location	Area (km^2)	
		(a)	(a)	(a)	
		(b)	(b)	(b)	
		(c)	(c)	(c)	
		(d)	(d)	(d)	
		(e)	(e)	(e)	
		(f)	(f)	(f)	
12.	Have you been convicted of an offence involving fraud or dishonesty or of an offence under the Mines and Minerals Development Act, No. 11 of 2015 or any other law within or outside Zambia? If yes specify details:…….. Nature of offence:…… Date of Conviction:…… Sentence:……				
13.	Have you ever applied for a mining right or licence in Zambia? If yes, please give details: …… ……				
	Mining right or licence applied for	Location	Area km^2	Date of application	
14.	Area applied for renewal (all coordinates in exact multiples of 6 seconds, latitude/longitude format, Degree-Minute-Second format, Arc 1950)				
	(a) Location	Province		District	
		Locality			

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	(b) Size (in Sq. Km.) *Exploration licence area- compulsory relinquishment of at least 50% of original area *Large-scale Mining licence area- not exceeding 250km^2 *Small-scale mining licence area - not exceeding 4km^2 *Artisan's mining right area- not exceeding 0.0668km^2														
	(c) Coordinates		Latitudes (S)						Longitudes (E)						
			D	D	M	M	S	S	D	D	M	M	S	S	
		Corner 1													
		Corner 2													
		Corner 3													
		Corner 4													
		Corner 5													
		Corner 6													
		Corner 7													
		Corner 8													
		Corner 9													
15.	**Appendices**														
	(a) Exploration														
	Appendix No. 1	Report on execution of approved programme of exploration operations including results in digital format on work done													
	Appendix No. 2	Approved Environmental Project Brief													
	Appendix No. 3	Proposed programme of exploration operations for renewal period (should include an indication of the investment commitment).													
	Appendix No. 4	Proposals for employment and training of citizens of Zambia.													
	Appendix No. 5	Proposals for promotion of local business development.													
	Appendix No. 6	Tax clearance certificate													
	Appendix No. 7	Any further information which the Mining Licencing Committee may require													
	(b) Large-Scale Mining														
	Appendix No. 1	Report on execution of approved programme of mining operations													
	Appendix No. 2	A latest statement of proved, estimated and inferred mineral deposits in the area over which licence is sought (should include details of all known minerals proved, estimated or inferred, ore resources and mining conditions, expected changes in mining and treatment methods, expected change in mining activities and estimated life of a mine)													
	Appendix No. 3	Proposed programme for exploration and mining operations (should include a forecast of capital investment, the estimated recovery rate of ore and mineral products, and the proposed treatment and disposal of ore and minerals recovered)													
	Appendix No. 4	Approved Environmental Management Plan													
	Appendix No. 5	Details of expected infrastructure requirements													
	Appendix No. 6	Proposals for employment and training of													

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		citizens of Zambia			
	Appendix No. 7	Proposals for promotion of local business development			
	Appendix No. 8	Tax clearance certificate issued under Income Tax Act (Cap. 323)			
	Appendix No. 9	Plan of proposed mining area during renewal period			
	Appendix No. 10	Execution report of plan for cutting, polishing and faceting of gemstones in Zambia during previous tenure; and plan for cutting, polishing and faceting gemstones in Zambia during renewal period			
	Appendix No. 11	Any further information which the Mining Licencing Committee may require			
	(c) Small-Scale Mining				
	Appendix No. 1	Report on the development of a mining area during previous tenure			
	Appendix No. 2	Proposed programme of mining operations (should include forecast of investment, estimated recovery rate of ore and applicants proposal for treatment and disposal of ore)			
	Appendix No. 3	Description of the mineral deposit in area over which licence renewal is sought			
	Appendix No. 4	Statement of duration for which licence is sought (should not exceed ten years)			
	Appendix No. 5	Tax clearance certificate			
	Appendix No. 6	Approved Environmental Management Plan			
	Appendix No. 7	Any further information which the Mining Licencing Committee may require			
	(d) Artisanal Mining (by citizens of Zambia)				
	Appendix No. 1	Report on the development of mining area during previous tenure			
	Appendix No. 2	Approved Environmental Management Plan			
	Appendix No. 3	Programme of intended mining operations (should include proposals for the proper conservation and use of mineral resources in mining area, in national interest)			
	(e) Radioactive Minerals- In addition to requirements at (b) above				
	Appendix No. 1	Plan and description of mine, processing facilities and proposed disposal sites			
	Appendix No. 2	Copy of licence issued under the Ionizing Radiation Protection Act, No. 16 of 2005			
	Appendix No. 3	Programme to educate persons in the vicinity of the mine or plant on safety, health and the environment in relation to radiation			
	Appendix No. 4	Programme to assist authorities outside the mining area in planning and preparing to limit adverse effects of radiation			
	Appendix No. 5	Proposed programme for selecting, using and maintenance of personal protective equipment			
	Appendix No. 6	Proposed training programme for workers in relation to radiation safety			
	Appendix No. 7	Proposed ventilation and dust control methods and associated equipment			
	Appendix No. 8	Proposed security measures during mining, processing, storage, transportation (including measures to alert the holder of acts of sabotage			
	Appendix No. 9	Storage, transportation and marketing arrangements in conformity with the Nuclear Non-Proliferation Treaty (NPT)			

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	Appendix No. 10	Any further information which the Director may require			
Application Fee					

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Applicant Date

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Officer Date

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Officer

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Amount Received: .....

Serial No. of Application: .....

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APPLICATION FOR CONSENT TO TRANSFER MINING RIGHT FORM

Form XVI
(Regulation 29 (1))
(To be completed in triplicate)

REPUBLIC OF ZAMBIA

The Mines and Minerals Development Act, 2015 **(Act No. 11 of 2015)**

The Mines and Minerals Development (General) Regulations, 2016

APPLICATION FOR CONSENT TO TRANSFER A MINING RIGHT, MINERAL PROCESSING LICENCE, OR REGISTER TRANSFER OF SHARES IN, OR TRANSFER CONTROL OF, COMPANY HOLDING MINING RIGHT OR MINERAL PROCESSING LICENCE

		Shaded fields for official use only	**Certificate Code**			
			Date and Time			
Information Required		***Information Provided***				√
1.	Mining Right or Licence No.					
2.	Current Holder					
3.	Name of proposed assignee					
4.	(a) Name(s) of applicant(s)					
	(b) Type of applicant	Individual	Company	Co-operative	Partnership	
5.	(a) Date of Birth (dd/mm/yyyy)					
	(b) Nationality					
	(c) Identity Card (NRC No.) or Passport No. (attach copies))					
6.	Applicant's Address					
	(a) Tel:					
	(b) Fax:					
	(c) E-mail:					
7.	(a) Company Registration No. (Attach copies of certificate of registration issued under the Companies Act, Cap. 388)					
	(b) Current shareholders (Attach copies of certificate of registration issued under the Companies Act, Cap. 388)	Shareholder	Shares held	Nationality	NRC/Passport No. (attach copies)	
	(c) Directors	Director	Shares held	Nationality	NRC/Passport No.	

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	(d) Company Chief Executive Officer	Name		Nationality		
	(e) Company Secretary	Name		Nationality		
8.	**Appendices**					
	Appendix No. 1	Minutes of company board meeting				
	Appendix No. 2	Resolution of the company's board meeting				
	Appendix No. 3	Reasons for transferring or assigning mining right, mineral processing licence, share or shares or control of company which holds a mining right or mineral processing licence				
	Appendix No. 4	Application form for a mining right completed by proposed assignee				
	Appendix No. 5	Tax clearance certificate by holder of mining right or mineral processing licence				
Application Fee						

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Applicant Date

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Officer Date

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Officer

Amount Received: .....

Serial No. of Application: .....

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APPLICATION FOR ABANDONMENT FORM

Form XVII
(Regulation 31)
(To be completed in triplicate)

REPUBLIC OF ZAMBIA

The Mines and Minerals Development Act, 2015
(Act No. 11 of 2015)

The Mines and Minerals Development (General) Regulations, 2016

APPLICATION FOR ABANDONMENT CERTIFICATE

		Shaded fields for official use only	**Certificate Code**		
			Date and Time		
Information Required		***Information Provided***			√
1.	Mining right or Licence No.				
2.	Minerals				
3.	(a) Proposed abandonment date				
	(b) Name(s) of applicant(s)				
	(c) Type of applicant	Individual	Company	Co-operative	Partnership
4.	(a) Date of Birth (dd/mm/yyyy)				
	(b) Nationality				
	(c) Identity Card (NRC No. or Passport No.)- (attach copies)				
5.	Applicant's Address				
	(a) Tel:				
	(b) Fax:				
	(c) E-mail:				
6.	(a) Company Registration No. (Attach copies of certificate of registration issued under the Companies Act.)				
	(b) Shareholders	Shareholder	Shares held	Nationality	NRC/Passport No. (attach copies)
	(c) Directors	Director	Shares held	Nationality	NRC/Passport No.
	(d) Company Chief Executive Officer	Name		Nationality	
	(e) Company Secretary	Name		Nationality	
7.	**Area applied for abandonment** (all coordinates in exact multiples of 6 seconds, latitude/longitude format, Degree-				

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	Minute-Second format, Arc 1950)														
	(a) Location		Province					District							
			Locality												
	(b) Original size (in Sq.km)														
	(c) Proposed abandonment area (in Sq. km) (d) Proposed date of abandonment														
	(e) Coordinates		Latitudes (S)						Longitudes (E)						
			D	D	M	M	S	S	D	D	M	M	S	S	
	Corner	1													
	Corner	2													
	Corner	3													
	Corner	4													
	Corner	5													
	Corner	6													
	Corner	7													
	Corner	8													
	Corner	9													
	Corner	10													
	Corner	11													
	Corner	12													
15.	**Appendices**														
	Appendix No. 1	Board Resolution													
	Appendix No. 2	Report on execution of programme of operation.													
	Appendix No. 3	A copy of Closure Certificate granted by Director Mines Safety													
	Appendix No. 4	The receipt of payment of the application fees													
	Appendix No. 5	Company registration details													
Application Fee															

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Applicant Date

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Officer Date

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Officer

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Amount Received: .....

Serial No. of Application: .....

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EXPLORATION LICENCE TEMPLATE

Form XVIII
(Regulation 17(1))

REPUBLIC OF ZAMBIA
The Mines and Minerals Development Act, 2015
(Act No. 11 of 2015)

The Mines and Minerals Development (General) Regulations, 2016

LICENCE NO.……

EXPLORATION LICENCE
(*Section 23 of the Mines and Minerals Development Act, No. 11 of 2015*)

Holder's name ……
Address……

The Exploration area shall be the area described in the Schedule and annexed hereto and bordered …… on the Plan.

The licence relates to the following minerals ……
……
The licence relates to the following level of operation ……
……
The licence is granted for a period of …… commencing on the ……..
day of ……., 20……
The conditions of grant of the licence are as shown in the Annexures attached hereto.

Issued at …… this …… day of ……..……..

……
Director of Mining Cadastre

ENDORSEMENT OF REGISTRATION

This Exploration Licence has this …… day of ……., 20……..
been registered in the Register.

……
Director of Mining Cadastre

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MINING LICENCE TEMPLATE

Form XIX
(Regulation 17(1))

REPUBLIC OF ZAMBIA

The Mines and Minerals Development Act, 2015
(Act No. 11 of 2015)

The Mines and Minerals Development (General) Regulations, 2016

LICENCE NO. ……..

MINING LICENCE
(*Section 32 of the Mines and Minerals Development Act, No. 11 of 2015*)

Holder's name ……
Address……

The mining areas shall be the area described in the Schedule and annexed hereto and bordered …… on the Plan.

The licence relates to the following minerals ……
……..

The licence relates to the following level of mining operations ……
……

The licence is granted for a period of …… commencing on the ……
day of ……., 20……

The conditions of grant of the right are as shown in the Annexures attached hereto.

Issued at …… this …… day of ……..……

……
Director of Mining Cadastre

ENDORSEMENT OF REGISTRATION

This Mining Licence has this …… day of ……, 20……
been registered in the Register.

……
Director of Mining Cadastre

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CERTIFICATE OF ABANDOMENT TEMPLATE

Form XXVIII
(Regulation 32)

REPUBLIC OF ZAMBIA

The Mines and Minerals Development Act, 2015
(Act No. 11 of 2015)

The Mines and Minerals Development (General) Regulations, 2016

CERTIFICATE NO. ……...

CERTIFICATE OF ABANDONMENT

(*Section 70 of the Mines and Minerals Development Act, No. 11 of 2015*)

Holder's name ……

Address……

The abandoned area shall be the area described in the Schedule and annexed hereto and bordered …… on the Plan.

The area abandoned was in respect of the following minerals ……

The abandonment certificate takes effect commencing on the …… day of ……, 20…… and I hereby impose the attached conditions of abandonment.

Issued at …… this …… day of ……..……

……
Director of Mining Cadastre

ENDORSEMENT OF REGISTRATION

This Certificate of Abandonment has this ……. day of ……., 20…….. been registered in the Register.

……
Director of Mining Cadastre

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FEE AND AREA SIZE SCHEDULE

SECOND SCHEDULE

(Regulations 7 (1), 8 (1), 8 (2), 8 (4), 9, 10, 11, 15 (3), 18 (1) and 57)

PRESCRIBED FEES, AREA CHARGES AND MAXIMUM AREAS FEES

TYPE OF MINING RIGHT OR APPLICATION	FEE UNITS
(1) Exploration Licence	
(a) Small-scale	3000
(b) Large-scale	10000
(2) Mining Licence	
(a) Artisanal	3000
(b) Small-scale	15000
(c) Large-scale	160000
(3) Transfer of Exploration Licence	
(a) Small-scale	15000
(b) Large-scale	160000
(4) Transfer of Mining Licence	
(a) Small-scale	15000
(b) Large-scale	160000
(5) Alteration of Exploration Licence	
(a) Small-scale	2500
(b) Large-scale	3000
(6) Alteration of Mining Licence	
(a) Artisanal	500
(b) Small-scale	2500
(c) Large-scale	3000

Note: 1 Fee 0.33

NON-MINING

Unit = ZMW

RIGHTS/OTHER CATEGORIES

LICENCE, CERTIFICATE OR PERMIT	FEE UNITS
Mineral Processing Licence	160000
Renewal of Mineral Processing Licence	160000
Transfer of Mineral Processing Licence	160000
Alteration of Mineral Processing Licence	3000
Mineral Trading Permit	7000
Renewal of Mineral Trading Permit	7000
Gold panning certificate	500
Mineral Import Permit	3500
Mineral Export Permit	750
Application for consent to acquire, store, transport or export radioactive minerals	3500
Mineral Analysis Certificate	750
Valuation Certificate	1000
Inspection of documents	2000
Replacement of licence, permit or certificate	3000

Note: 1 Fee Unit = ZMW 0.33

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AREA CHARGES (FEE UNITS)

TYPE OF LICENCE	Year 1 – 4	Year 5 - 7	Year 8 -10	Year 11 and later years where applicable
Exploration Licence (per hectare per year)				
(a) Small-scale	2	5	-	
(b) Large-scale	4	12	16	
Mining Licence (per hectare per year)				
(a) Artisanal Mining	14	14	14	14
(b) Small-scale mining	28	28	28	28
(c) Large Scale Mining	56	56	56	56
Mineral Processing Licence (per hectare per year)	56	56	56	56
Excess exploration ground	22	22	22	22

Note: 1 Unit = ZMW 0.33

PRESCRIBED MAXIMUM AREAS

TYPE OF MINING RIGHT OR LICENCE	MAXIMUM AREA		
	Square Kilometers	hectares	Cadastre units
Exploration Licence			
(a) Small-scale	10	1000	3000
(b) Large-scale	2000	200000	59880
Mining Licence			
(a) Artisanal	0.0668	6.68	2
(b) Small-scale	4	400	120
(c) Large scale	250	25000	7485

Note: 1 Cadastre Unit = 3.34 hectares

MINIMUM ANNUAL EXPLORATION EXPENDITURE PER HECTARE

Type of licence	Fee Units per hectare per year									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Exploration licence	40	40	40	40	120	120	120	160	160	160

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CONDITIONS OF GRANT OF MINING RIGHTS

THIRD SCHEDULE
(Regulation 17 (3))

CONDITIONS OF LICENCES, CERTIFICATES, PERMITS AND AUTHORISATIONS

A. CONDITIONS OF GRANT OF A MINING LICENCE - LARGE-SCALE MINING

1. The holder shall-

(a) develop the mining area in accordance with the approved programme of mining operations;
(b) execute the environmental management plan;
(c) implement the local business development programme;
(d) employ and train Zambians in accordance with the approved program;
(e) demarcate the mining area and keep it demarcated;
(f) pay mineral royalty in accordance with the Mines and Minerals Development Act, No. 11 of 2015 and the Income Tax Act, Cap. 323;
(g) maintain at the holder's office complete and accurate technical and financial records of the mining operations;
(h) permit authorised officers, at any time, to inspect all records, mining and mineral processing operations;
(i) submit statutory reports and any other information concerning the mining or mineral processing operations;
(j) submit a copy of the annual audited financial statements within three months of the end of each financial year;
(k) submit reports on external supplies of ore, concentrates, tailings, slimes or any other mineral fed to the plant;
(l) provide current information on recovery from ores, mineral products, production costs and sales;
(m) conduct operations only upon meeting the requirements of the Environmental Management Act No. 12 of 2011;
(n) contribute to the Environmental Protection Fund as required under the Mines and Minerals Development Act, 2015;
(o) obtain appropriate insurance for all phases of the mining operations;
(p) give preference to Zambia products and services;
(q) submit a Pegging Certificate for approval within one hundred and eighty days of grant of licence; and
(r) comply with the provisions of the Mines and Minerals Development Act, No. 11 of 2015 and other relevant laws of Zambia.

2. Illegal mining and trade is not permitted in the licensed area.

3. The holder shall not enter into an agreement or transfer of the licence without the prior consent of the Minister.

4. The holder shall be liable for harm or damage caused by the mining or mineral processing operations and shall compensate a person to whom harm or damage is caused.

5. The holder shall not exercise a right under the licence without the prior consent of the legal occupiers of the land or local chiefs.

6. Other terms and conditions are as follows:
……
……
……..

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B. CONDITIONS OF GRANT OF AN EXPLORATION LICENCE – LARGE-SCALE EXPLORATION

1. The holder shall-

(a) pay the relevant taxes under the Income Tax Act, Cap. 323;
(b) promote local business development;
(c) execute the environmental management plan;
(d) employ and train Zambians;
(e) execute the programme of prospecting;
(f) commence the exploration operations within one hundred and eighty days of grant of the licence;
(g) give notification of any discovered minerals or commercial deposits within thirty days of the discovery;
(h) give preference to Zambian products and services;
(i) permanently preserve or make safe any water boreholes and surrender water rights on expiry of licence;
(j) surrender to Government the drill cores and other mineral samples;
(k) remove, within sixty days of the expiry, cancellation or termination of the exploration licence, any camp, temporary buildings or machinery and repair or make good any damage as required under the Mines and Minerals Development Act, No. 11 of 2015;
(l) keep and preserve such records as the Minister may prescribe in relation to the environment;
(m) submit reports to the Director of Geological Survey, Director of Mines and Director of Mines Safety in both hard and electronic copies;
(n) keep full and accurate records of the prospecting operations, at the holder's office;
(o) obtain appropriate insurance for all phases of its operations;
(p) submit a Pegging Certificate for approval within one hundred and eighty days of grant of the licence; and
(q) comply with the provisions of the Mines and Minerals Development Act, No. 11 of 2015 and other relevant laws of Zambia.

2. The holder shall –
(a) expend on exploration operations each year, not less than the minimum annual exploration expenditure set out in the Second Schedule, failing which the holder commits an offence and is liable, on conviction, to a fine –
(i) equal to the difference between the minimum annual exploration expenditure and the amount actually expended on exploration operations in that year if less than five hundred thousand penalty units; or
(ii) of five hundred thousand penalty units if the difference between the minimum annual exploration operations in that year exceeds the equivalent of five hundred thousand penalty units; and
(b) submit annual exploration expenditure statements accompanied by copies of relevant transaction documents to the Director of Geological Survey.

3. The holder shall be liable for harm or damage caused by the exploration operations and shall compensate a person to whom harm or damage is caused.

4. The holder shall not exercise a right under the licence without the prior consent of the legal occupiers of the land or local chiefs.

5. Other terms and conditions are as follows:
……
……
……

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C. CONDITIONS OF GRANT OF AN EXPLORATION LICENCE – SMALL-SCALE EXPLORATION

1. The holder shall-

(a) pay the relevant taxes under the Income Tax Act, Cap. 323;
(b) execute the Environmental Project Brief;
(c) execute the programme of prospecting operations;
(d) commence the prospecting operations within one hundred and eighty days of the grant;
(e) give notification of discovered minerals or commercial deposits within thirty days of the discovery;
(f) give preference to Zambian products and services;
(g) permanently preserve or make safe any water boreholes and water rights on expiry of the licence;
(h) surrender to Government, without compensation, drill cores and other mineral samples;
(i) remove, within sixty days of expiry or termination of the exploration licence, any camp, temporary buildings or machinery, and repair or make good any damage as specified by the Director of Geological Survey;
(j) keep and preserve such records as the Minister may prescribe in relation to the environment;
(k) submit reports to the Director of Geological Survey, Director of Mines or Director of Mines Safety in both hard and electronic copies;
(l) keep full and accurate records, at the holder's office, of the prospecting operations;
(m) obtain appropriate insurance for phases of its operations;
(n) submit a Pegging Certificate for approval within one hundred and eighty days of grant of permit; and
(o) comply with the provisions of the Mines and Minerals Development Act,No. 11 of 2015 and other relevant laws of Zambia.

2. The holder shall be liable for harm or damage caused by the prospecting operations and shall compensate a person to whom harm or damage is caused.

3. The holder shall not exercise a right under the licence without the prior consent of the legal occupiers of the land or local chiefs.

4. Other terms and conditions are as follows:
……
……
……

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D. CONDITIONS OF GRANT OF MINING LICENCE - SMALL-SCALE MINING

1. A holder shall-

   (a) develop the mining area in accordance with the approved programme of mining operation;
   (b) execute the environmental management plan;
   (c) demarcate the mining area and keep it demarcated;
   (d) pay mineral royalty in accordance with the Mines and Minerals Development Act, No. 11 of 2015 and the Income Tax Act, Cap. 323;
   (e) maintain at the holder's office, complete and accurate technical and financial records of mining operations;
   (f) permit authorised officers, at any time, to inspect all records, mining or mineral processing operations;
   (g) submit statutory reports, records and other information concerning mining operations;
   (h) submit copies of annual audited financial statements within three months of the end of each financial year;
   (i) submit reports on external supplies of ore, concentrates, tailings slimes or other mineral fed to the plant;
   (j) provide current information on recovery from ores, mineral products, production costs and sales;
   (k) conduct operations only upon meeting the requirements under the Environmental Management Act, No. 12 of 2011;
   (l) contribute to the Environmental Protection Fund as required under the Mines and Minerals Development Act, No. 11 of 2015;
   (m) obtain appropriate insurance for phases of its operations;
   (n) submit a Pegging Certificate for approval within one hundred and eighty days of grant of licence; and
   (o) comply with the provisions of the Mines and Minerals Development Act, 2015 and other relevant laws of Zambia.

2. Illegal mining and trade are not permitted in the mining area.

3. The holder shall not enter into an agreements or transfer the licence without the prior consent of the Minister.

4. The holder shall be liable for harm or damage caused by the mineral processing or mining operations and shall compensate a person to whom harm or damage is caused.

5. The holder shall not exercise a right under the licence without the prior consent of the legal occupiers of the land or local chiefs.

6. Other terms and conditions are as follows:

   .....
   .....

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E. CONDITIONS OF GRANT OF A MINERAL PROCESSING LICENCE

1. The holder shall-

(a) pay taxes under the Income Tax Act, Cap. 323;
(b) pay mineral royalty;
(c) commence operations within three years of the grant;
(d) execute the approved programme of mineral processing operations;
(e) expend not less than the approved amount on mineral processing operations;
(f) submit reports on source of ore, concentrates, tailing, slimes or other mineral fed to the plant;
(g) submit statutory reports and other information concerning the operation;
(h) execute the environmental management plan;
(i) provide current information on recovery from ores, mineral products, production costs and sales;
(j) conduct operations only upon meeting the requirements of the Environmental Management Act, No. 12 of 2011;
(k) contribute to the Environmental Protection Fund as required under the Mines and Minerals Development Act, No. 11 of 2015;
(l) obtain appropriate insurance for all phases of its operations;
(m) submit a Pegging Certificate for approval within one hundred and eighty days of grant of licence; and
(n) comply with the provisions of the Mines and Minerals Development Act, No. 11 of 2015 and other relevant laws of Zambia

2. The holder shall not enter into an agreement or transfer the licence without the prior consent of the Minister.

3. The holder shall be liable for harm or damage caused by the mineral processing operations and shall compensate a person to whom harm or damage is caused.

4. The holder shall not exercise a right under the licence without the prior consent of the legal occupiers of the land or local chiefs.

5. Other terms and conditions are as follows:
……
……
……

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F. CONDITIONS OF GRANT OF MINING LICENCE – ARTISANAL MINING

1. The holder shall-

(a) submit statutory reports and other information concerning the operation;
(b) pay mineral royalty and other charges in accordance with the Mines and Minerals Development Act, No. 11 of 2015;
(c) execute the environmental project brief;
(d) maintain production and financial records at the holder's office;
(e) provide current information on recovery from ores, mineral products, production costs and sales;
(f) conduct operations only upon meeting the requirements of the Environmental Management Act, No. 12 of 2011;
(g) contribute to the Environmental Protection Fund as required under the Mines and Minerals Development Act, No. 11 of 2015;
(h) submit a Pegging Certificate for approval within one hundred and eighty days of grant of the right; and
(i) comply with the provisions of the Mines and Minerals Development Act, 2015 and other relevant laws of Zambia.

2. The holder shall be liable for harm or damage caused by the mineral processing operations and shall compensate a person to whom harm or damage is caused.

3. The holder shall not exercise a right under the licence without the prior consent of the legal occupiers of the land or local chiefs.

4. Other terms and conditions are as follows:
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