Implementation of the African Mineral and Energy Resources Classification and Management System (AMREC) Pilot Project in Uganda

Executive Summary

The existence of mineral resources provides a potential foundation for socio-economic development in Uganda, but only given the right circumstances. Sufficient and reliable geological information and geospatial datasets in part determine the ability for such resources to be developed effectively and sustainably. The purpose of this pilot project report is to critically assess the accessibility and uptake of existing data and policy information relevant to the mineral resource industry in Uganda.

Using a theoretical idealized system for mineral development best practice for comparison, known as the African Mineral and Energy Resources Classification and Management System (AMREC), we report on the current status of mineral resource development in Uganda.
Five key areas known as critical controlling factors for resource progression were considered as pillars of sustainable resource development, these include:

1.) Project milestones and decision gates
– What process does the development of a mineral resource follow and why?

2.) Value addition and resource beneficiation
– What is done to the raw resource to enhance its economic value as a sellable product?

3.) Economic diversification
– What other business operations including infrastructure are enabled by the presence of a mineral project in terms of linkages?

4.) Comprehensive resource recovery
– How efficient is the recovery of a given mineral in relation to the possibility of other minerals co-existing?

5.) Zero waste concept
– Are modern waste management strategies engaged to convert waste into useful by-products?

These five key considerations act as both assessments of potential resource development pathways and controlling factors to their ability to provide for the needs of mining communities in Uganda. Where barriers to these considerations are encountered, rational, evidence-based policy justifications and amendment suggestions are obtained. We report on the degree of implementation of AMREC within the confines of the five controlling factors across four Ugandan case study sites encompassing Artisanal and Small Scale Mining (ASM) of three primary mineral commodities: gold, tin and salt.

We explore the disparity between the existence of geological data and regulatory frameworks and their uptake and implementation across ASM operations. ASM is the dominant producer of raw minerals in Uganda's mining sector, but it largely exists without current mining sector legal frameworks. The process of formalizing the ASM sector to enable it to operate within the mainstream economy has already begun in Uganda, but it is complex, with each commodity and region subject to different developmental considerations, barriers and opportunities.

Comparison of the AMREC key considerations to existing operations in the project case study sites reveal mixed results. Small and Medium Enterprises (SMEs) tend to demonstrate a comprehensive management of the implementation of project milestones and decision gates, enabling a clearer assessment of the long-term sustainability of their operations. ASMs operate on a more unstructured, unpredictable basis, with no clear development pathway for each resource, with value addition limited to basic cleaning and sediment washing activities. Lack of access to technology, skills training and financial assistance is reported as the main barrier to diversification.

Interview outcomes demonstrate that miners understand the importance and impact of maximizing the economic value of mined mineral resources but are limited by the circumstances in which they operate. Mineral substrates that can be used as aggregates in construction enable easy value-addition and some adherence to zero waste concepts, but many simply create waste piles that pose the potential for environmental harm through pollution and socio-economic harm through rendering the land unfit for other uses, such as agriculture.

In summary, we report that ASM operations in Uganda remain subject to a complex series of interconnected barriers. Lack of access to technology, relevant skills training, financial support and access to legitimate resource purchasing limit the ability for value-addition. Informal mining practices limit efficiency, further adding to the economic limitations of ASM mineral production.

This AMREC pilot assessment seeks to add to the body of evidence that demonstrates that policy interventions made in support of the formalization of ASM as a means of sustainable development, that remove the barriers currently impacting the sector through careful analysis of where and why those barriers exist, can enact lasting impacts.

Lake Katwe Salt Mining Site, where artisanal and small scale mining operations produce salt in largely separate, individually-owned salt pans.

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1 Introduction

1.1 Mineral Sector in Uganda

In a global market in which a variety of mineral resources are subject to increasing demand, Uganda's mineral resources present significant potential to contribute to high economic growth (Uganda Vision 2040) and subsequent development of mining areas through the revitalizing of the local economy.

Employment creation, new start-up businesses, enhanced tax revenue collection and set-up of associated mineral processing industries can reasonably be anticipated from the effective management of ASM as an official recognized and regulated sector of the Ugandan economy (MEMD 2019).

As recognized in the Mining and Minerals Policy for Uganda 2018, the geological environment of Uganda is host to a wide range and variety of economic mineral deposits and geological resources including: gold, asbestos, graphite granite, mica, dimension stones, construction materials, copper, lead, zinc, cobalt, nickel, iron ore (haematite), tin, tungsten, beryl, columbite, tantalite, lithium, bismuth, kyanite, kaolin, with potential for nickel and Platinum Group of Elements (PGE), chromites, magnetite, tantalite, nickel, platinum, copper, zinc, niobium (pyrochlore), vanadium, baddeleyite (zirconium oxide mineral), Rare Earth Elements (REE), radioactive elements (uranium, thorium), marble /limestone, diopside (garnet marble), apatite, asbestos, graphite, musovite, talc, serpentinite, gemstone, salt and gypsum including bentonite and diatomite clays; iron (magnetite), niobium, base metals, phosphates and vermiculite. This is an indication of the country's mineral resource potential with estimates of about 80% of the land cover endowed with rare earth minerals thus providing opportunity to develop a strong mining industry. Government will continuously carry out geological explorations in the various parts of the country to assess the viability of the various mineral potentials.

Despite clear indications of resource wealth, development investment in the Ugandan minerals sector has been varied. Detailed geological and geophysical mapping and geochemical sampling is required to obtain accurate reserves estimates. Investment levels from individuals, private companies and the government are determined by the levels of uncertainty surrounding the economic potential of a given reserve. A decrease in geological uncertainty makes for a more attractive investment. Stable investment strategies enable more effective integration with strategies for sustainable socio-economic development.

A crucial factor in enabling socio-economic development at source is centered around the key consideration of value-addition. A large proportion of minerals mined in Uganda are exported in raw form, fetching a comparatively low price by volume when compared to processed minerals and their derivative end products. In essence, the percentage of overall profit made during the entire life cycle of a mineral from mine to end product (e.g. raw cassiterite from a tin mine to a battery for an electronic device) increases dramatically through the various processing steps that can occur to add value to a resource. The percentage of profit represented by the sale of raw minerals is largely negligible.

Policy can play a role in preventing this revenue loss, for example through the restriction of the export of raw materials, however it must be carefully considered and backed by empirical evidence to avoid undermining the ability of mining operations to sell their products at all.
Over the past twenty years the level of regulation of a number of mineral commodities, particularly industrial minerals, has increased from a level of near zero regulation to an environment in which governmental recognition of revenue loss is driving policy creation and amendment.

Given the complex nature of the social, economic and geological environments in which ASM occurs, zero waste targets and adherence to the UN Sustainable Economic Goals are undermined by the need to focus on short term economic gains rather than long term economic planning of the development of sustainable operations with the potential to diversify over time.

Where ASM miners cannot keep pace with regulation changes, they are denied the ability to operate sustainably, both in terms of economics and the environment.

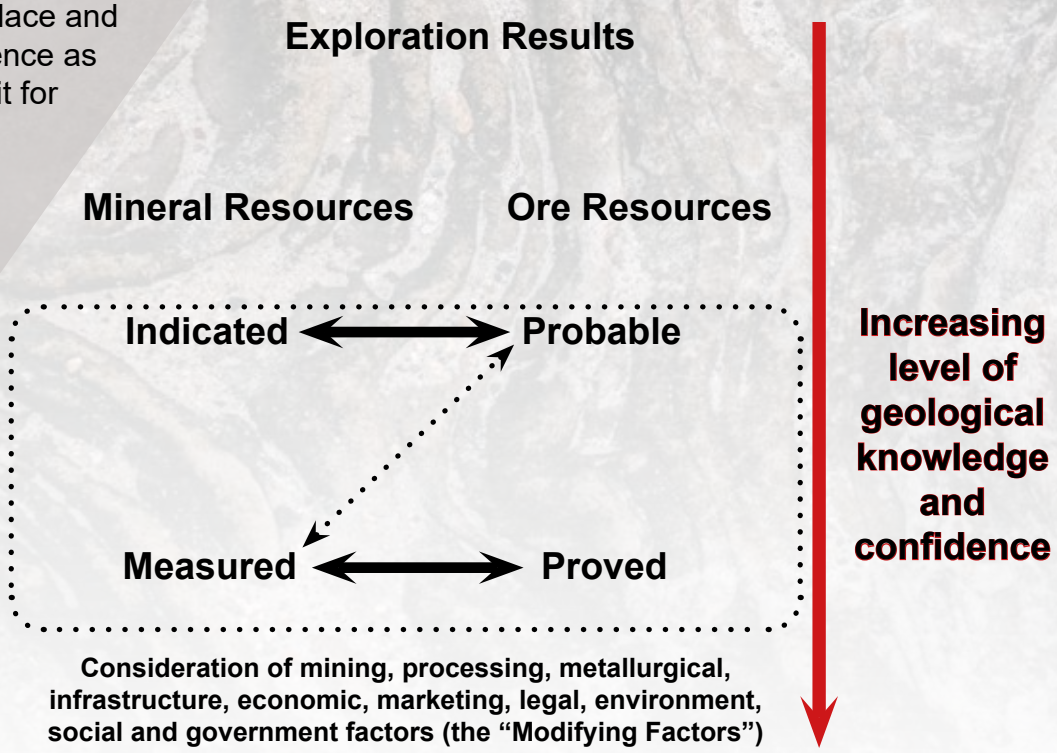
External forces are also driving policy change, as more resource end users demand full traceability of minerals from source to product to ensure that they are mined responsibly. This has, for example, been reflected in the enactment of the EU Conflict Minerals Regulation 2021, which covers the trade in gold, tin, tungsten and tantalum, demanding full traceability to ensure that the mining of any minerals imported into the EU are not a source of income for armed groups or criminals.

Finally, the lack of comprehensive geological and geospatial datasets limits investment in the Ugandan mining sector. Resource reserve uncertainty is too high for many companies and investors to justify the capital expenditure of properly assessing the economic potential of a given area. Long term development plans cannot be formed on a basis of chance finds. Where geological data can be processed to enable a greater understanding of the subsurface, a more accurate assessment of the location and size of a mineral resource can be made.

Internationally, there are minimum standards for the level of geological mapping and sampling carried out when assessing the resource potential of an area for investment. Where these standards fall short, international investment is restricted because of a lack of confidence in the safety of the investment.

Much of Uganda is subject to the existence of a level of geological and geophysical mapping that can infer the potential for an economic resource, but detailed, reliable data is required to indicate the probability of success, to measure the mineral reserve in place and finally to prove its existence as an economic resource fit for development.

The figure below demonstrates the general relationship between exploration results, mineral resources and ore reserves - modified from the JORC Code 2012 Edition, Australian Institute of Mining and Metallurgy.



1.2 The AMREC Framework

The African Mineral and Energy Resources Classification and Management System (AMREC) is a continental system of theorized processes for the effective management of Africa's mineral and energy resources. The AMREC was developed based on the United Nations Framework Classification for Resources (UNFC) Principles, Generic Specifications, and Guidelines and is aligned to the Africa Mining Vision (AMV) and the UN Sustainable Development Goals (SDGs). The UNFC is a resource project-based and principles-based classification system for defining the environmental-socio-economic viability and technical feasibility of projects that seek to develop resources. It provides a consistent framework to describe the level of confidence of the future quantities of a given resource to be produced by the project.

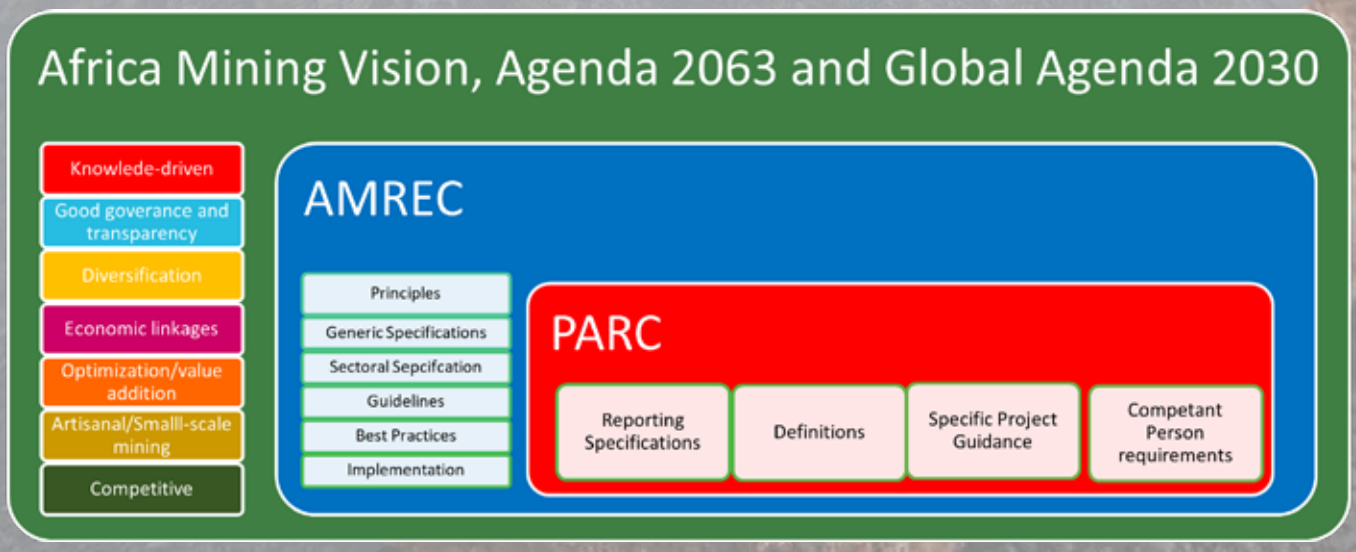
Anchored on regional, national, or local needs, the AMREC provides the specifications and guidelines required for sustainable development of Africa's mineral and energy resources encompassing the use of the Pan African Reporting Code (Figure 1). The objective of the AMREC is to provide comprehensive guidance on sustainable energy and mineral resource management in Africa with four key functions:

I. **Regional Africa resource management:** To enable and support coherent and consistent regional resource classification and management policies and associated regulations at a continental level with the aim of delivering the African Union Agenda 2063 and the Africa Mining Vision.

II. **National resource management**: To assist the development and implementation of sustainable resource management policies and regulations at a national level.

III. **Company internal business process innovation**: To enable companies (both large and small scale artisanal) to develop and adopt business processes and practices that are sustainable, profitable, socially inclusive, environmentally responsible, and resilient.

IV. **Financial reporting**: To enable companies to report resource assets and raise finances from appropriate financial institutions in a manner consistent with international standards and best practices.



AMREC in the context of AMV and Global Agenda 2030

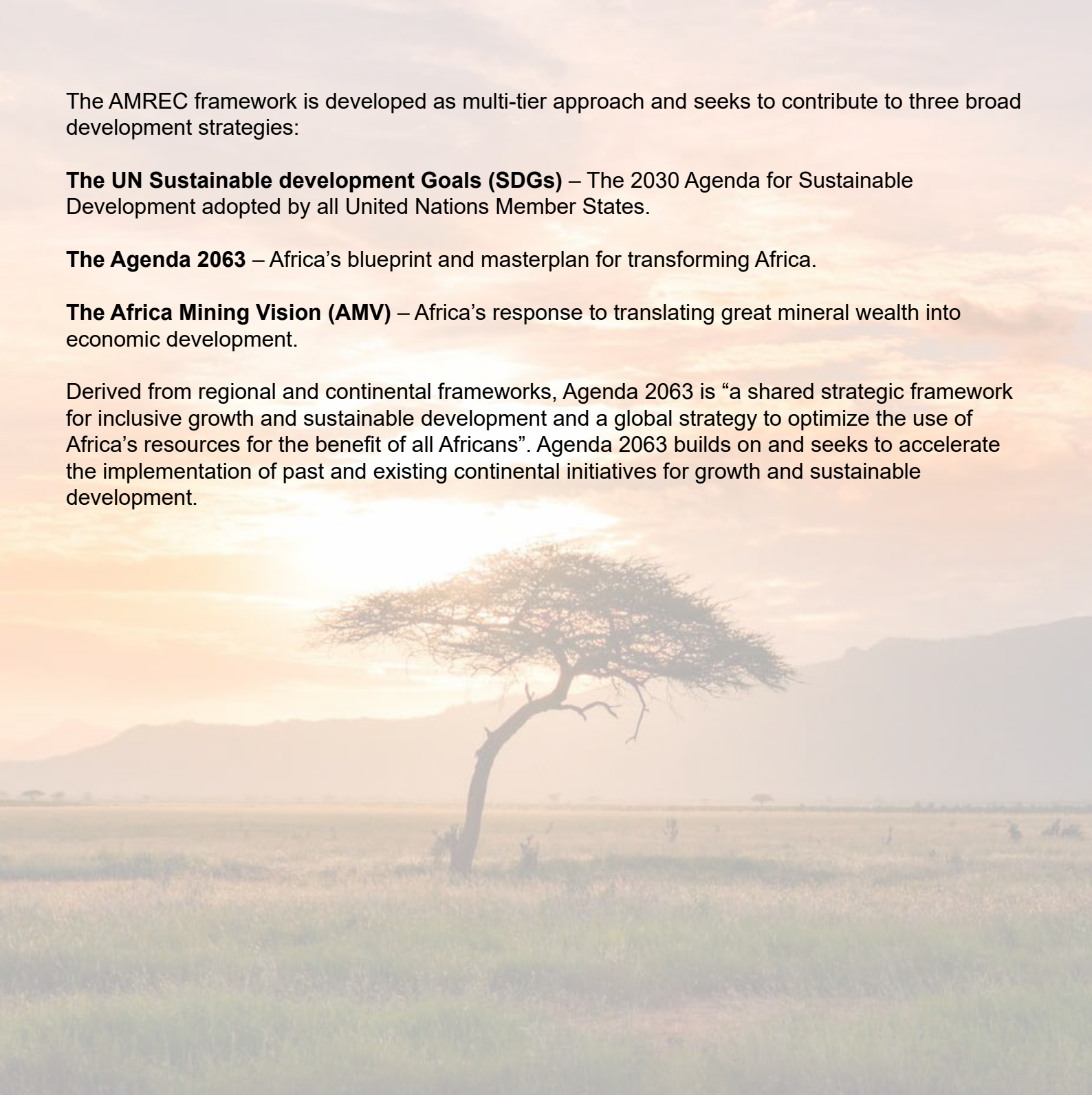
The AMREC framework is developed as multi-tier approach and seeks to contribute to three broad development strategies:

The UN Sustainable development Goals (SDGs) – The 2030 Agenda for Sustainable Development adopted by all United Nations Member States.

The Agenda 2063 – Africa's blueprint and masterplan for transforming Africa.

The Africa Mining Vision (AMV) – Africa's response to translating great mineral wealth into economic development.

Derived from regional and continental frameworks, Agenda 2063 is "a shared strategic framework for inclusive growth and sustainable development and a global strategy to optimize the use of Africa's resources for the benefit of all Africans". Agenda 2063 builds on and seeks to accelerate the implementation of past and existing continental initiatives for growth and sustainable development.



The AMV is more holistic. It advocates thinking outside the "mining box". Explicitly, it is not just a vision of improving mining regimes by ensuring that tax revenues from mining are optimized and directed accordingly – although that is clearly important. Rather, it is a vision of better integrating mining into development policies at local, national, and regional levels.

As a step towards the realization of the AMV, The Geological and Mineral Information System (GMIS) Strategy was developed by the African Mineral Development Centre (AMDC) under the leadership of the African Union Commission and was adopted by the AU policy organs (The Ministerial Specialized Technical Committee on trade, industry and minerals) to facilitate the strengthening of African production, management and dissemination of geological and mineral resource information. An information repository specific to showcasing data required to inform the development of mineral resources is necessary for several important legal, economic, social and environmental applications.

Lack of geological and geospatial information has long been identified as a major constraint upon African nations' ability to maximize the potential of their mineral resources. These information gaps have resulted in countries being disadvantaged in terms of land use planning, development of strategies for mineral exploration and exploitation and development of infrastructure.

The lack of requirement for value addition and beneficiation of mineral resources has seen mineral wealth cashed in by countries other than where the minerals are sourced.

AMREC aims to provide the taxonomy and standardized terminology that can be used by GMIS for consistent update and contribution of geological information to inform decision-making and policy amendments throughout the African mineral value chain.

Implementation of GMIS across the continent requires consistency of approach, terminology and format. The technology to enable a centralized reporting system is already in existence, it is the agreement and demonstration of the importance of the alignment of a resource reporting process that is yet to materialize within Africa.

1.3 Project goals

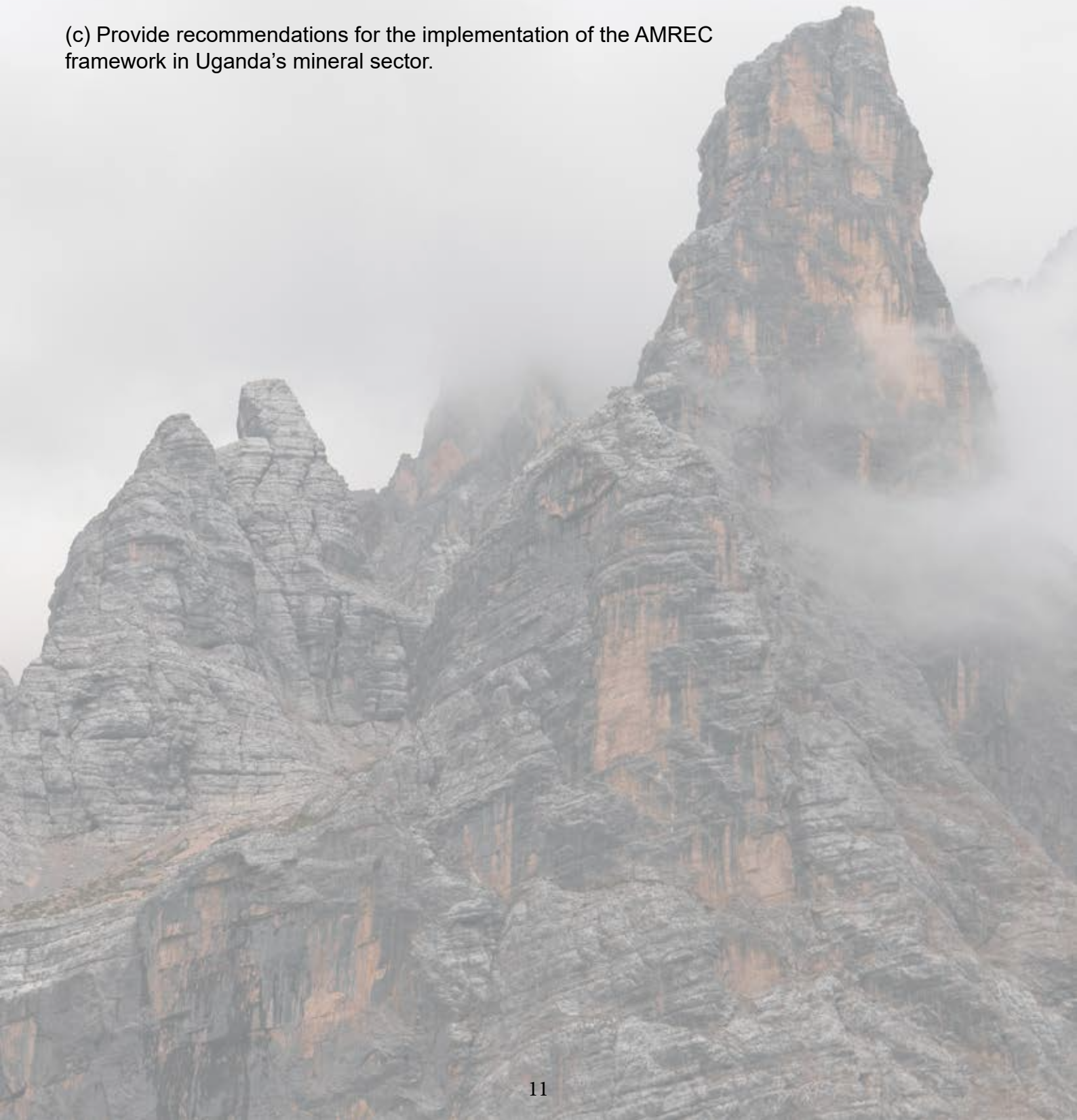
The purpose of this project is broad in scope, as it attempts to collect and collate data representing several aspects of the mineral resource industry. It seeks to assess the sourcing and uptake of existing data while also recording the current implementation of the AMREC framework in Uganda's on-going development of the mineral resource sector.

Within this wide remit it focusses upon three key objectives:

(a) Evaluate the critical controlling factors that determine and govern the management and exploitation of mineral resources in Uganda.

(b) Examine the current challenges faced by the mining sector in Uganda.

(c) Provide recommendations for the implementation of the AMREC framework in Uganda's mineral sector.



1.4 Critical Controlling Factors

The AMREC recommends that resources are classified considering the full project life cycle of a resource by assessing the controlling factors for resource progression. This pilot project has considered the following minerals Gold, Tin and Salt by studying the following five critical controlling factors across its life cycle:

I. Project milestones and decision gates;
II. Value addition and beneficiation;
III. Diversification;
IV. Comprehensive resource recovery; and
V. Zero waste.

1.4.1 Project Milestones and Decision Gates

Adoption of a milestone and decision-gate approach to supporting mining and processing projects can facilitate smooth project planning and operations across the full project life-cycle, including eventual mine closure, decommissioning, and site handover. The methodology aligns with the AMREC criteria, geological knowledge, project feasibility, socio-environmental-economic viability focused on key milestones in a project life. A prerequisite of the successful application of the model is a thorough needs and gap analysis. Based on the conclusions of the gap analysis, capacity-building and resource deployment is targeted to a specific milestone rather than attempting to cover the whole life-cycle at once.

1.4.2 Value-Addition and Beneficiation

The African Mining Vision (AMV) prioritizes down-stream linkages into mineral beneficiation and manufacturing; up-stream linkages into mining capital goods, consumables and services industries; and side-stream linkages into infrastructure (power, logistics, communications, water) and skills and technology development. This implies that value addition is a critical tool in assessing the full economic viability and benefit of a mineral resource. While the existing regulatory space supports and promotes value addition, actualization of this goal is almost absent in Uganda's mining sector. This pilot project analyzes the extent of value addition in Uganda's minerals sector.

1.4.3 Diversification

AMREC strives to achieve a diversified, vibrant, and globally competitive industrialized African economy. The mineral sector constitutes a pivotal foundation for the development of a competitive African infrastructure platform. Put differently, the focus is on a resource sector that optimizes Africa's finite mineral resource endowments and that is diversified, incorporating high value and lower value resources at both commercial and small-scale levels. In this pursuit, it is desirable to analyze all social and economic linkages at a national and regional level before classifying the resources using AMREC principles. In the perspective of the AMREC framework, the inclusion of more development minerals, particularly, sand, clay, rocks, and salt on Uganda's mineral ladder aligns with the government strategy of resource diversification for socio-economic transformation. In this pilot project, we capitalize on this justification to analyze the diversification efforts in Uganda's mining sector.

1.4.4 Comprehensive Resource Recovery

This controlling factor characterizes the methodologies that can maximize returns from mining and processing especially from low-grade, depleted and otherwise non-viable ore bodies. This has both opportunistic and sustainability aspects to consider. On the opportunistic side, the nature of subsurface geology implies potential for a number of different commodities to be commonly collocated, such as uranium, phosphates, rare earths elements, oil, gas, and coal. Managing these resources in an integrated, multi-targeted manner produces higher aggregate recovery rates than a management strategy that targets a single resource. In this pilot project, we utilize this understanding to assess Uganda's mining sector compliance to comprehensive resource recovery principles.

1.4.5 Zero Waste

Consistent with the principles of the waste hierarchy which are increasingly embedded in national and international law, the driving environmental expectation emphasizes that at the end of the mining and mineral processing cycle, there should be zero waste. Applying this constraint constitutes a very significant challenge to the traditional mining and processing narrative, which traditionally focuses on a single mineral for recovery. The volume of tailings, spoil or residues that may be generated in pursuit of the target mineral often, by volume, are vastly out of proportion to the volume of the target mineral itself. The capacity to turn these spoils into economically productive resources encapsulates the zero-waste concept. Where mining 'waste' can be repurposed into a commodity for other purposes, it ceases to be a true waste product.

2 Uganda's Mining policy and Regulatory Framework

A review of relevant literature revealed that the regulatory frameworks that govern Uganda's mining sector span a number of legal and policy documents including: The Mining and Minerals Policy for Uganda 2018; The Mining Act 2003 and the Mining Regulations 2019; the National Environment Act 2019 and other applicable laws. The Ministry of Energy and Mineral Development is currently drafting the Mining and Minerals Bill 2020 to enact the Mining and Minerals Policy 2018 more effectively, and repeal the Mining Act 2013.

For this pilot project, we analyse how these evolving regulatory frameworks support the national mining sector strategic plans, and importantly on the promotion of the five controlling factors under the AMREC.

2.1 The Mining and Minerals Policy for Uganda 2018

The Mining and Minerals Policy for Uganda 2018 was developed as a revision of the Mining Act 2003, with the goal of increased investment in the Ugandan mining industry. Enhanced value addition and the favouring of national participation and investment to enact in-country revenue generation were the key desired outcomes of this policy amendment, aiming for substantial socio-economic transformation and poverty reduction. The policy promotes the concept of enhanced access to geological information and streamlined licencing and permitting processes for potential developers in conjunction with local communities. It recognises the complex nature of ASM, arising conflicts and environmental degradation and seeks to provide frameworks to address existing challenges.

The key issues that the policy was developed to address were:

Legal and Regulatory Framework – improved governance of the mining industry.

Management of ASM – formalising a fragmented and informal industry.

Effective Environmental Management – preventing long term damage for short term profit.

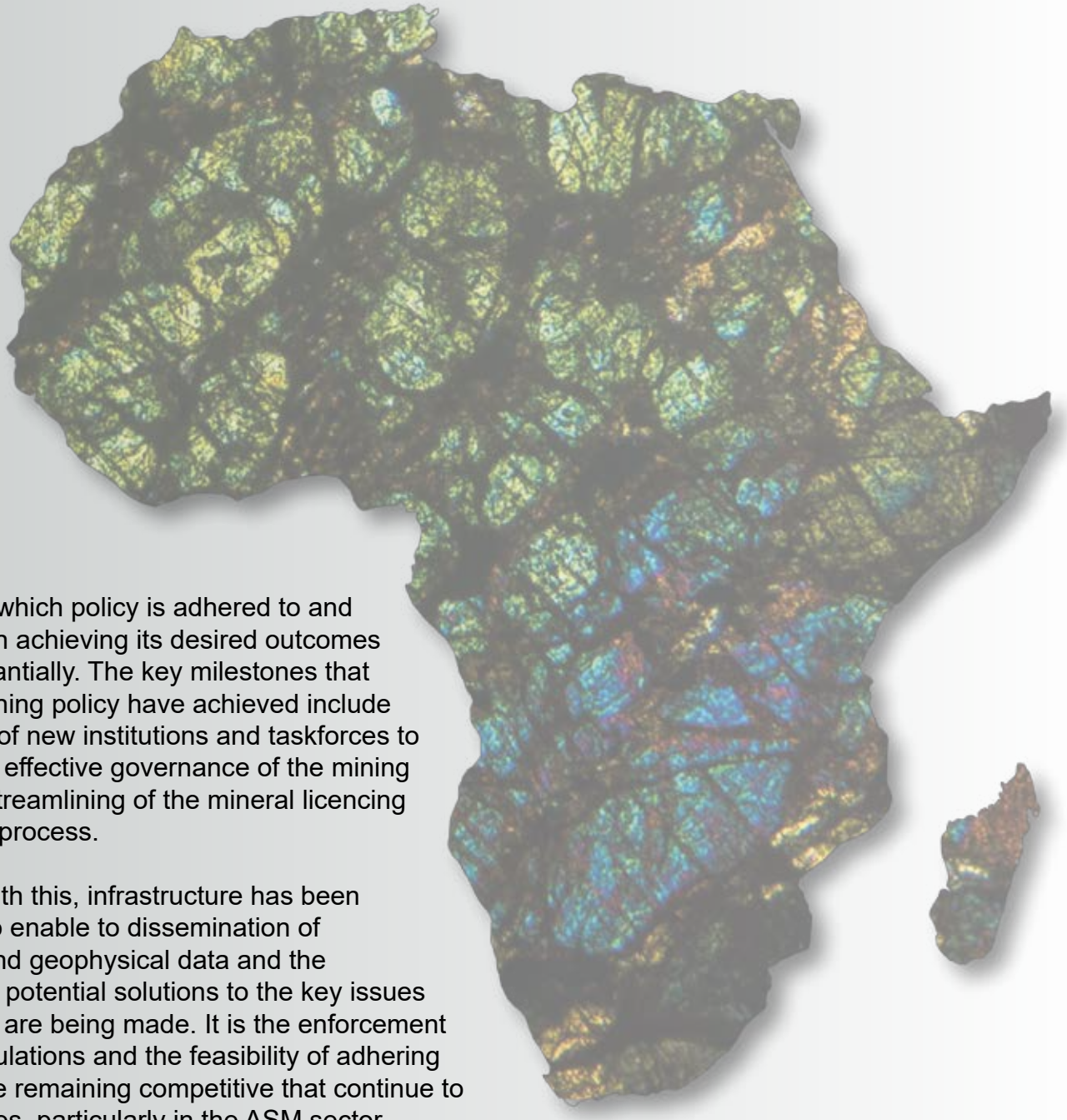
Health and Safety – protection of miners through minimum standards and application of PPE.

Financing – access to credit to enable mining start-ups.

Resource Markets – supporting access to national and international mineral resource markets.

Value Addition – preventing revenue loss through maximising mineral value in-country.

Institutional Capacity – creating and supporting institutions tailored to the governance of the minerals sector.



The level to which policy is adhered to and its success in achieving its desired outcomes varies substantially. The key milestones that Ugandan mining policy have achieved include the creation of new institutions and taskforces to enhance the effective governance of the mining sector and streamlining of the mineral licencing applications process.

In tandem with this, infrastructure has been developed to enable to dissemination of geological and geophysical data and the promotion of potential solutions to the key issues noted above are being made. It is the enforcement of policy regulations and the feasibility of adhering to them while remaining competitive that continue to present issues, particularly in the ASM sector.

Alignment to the AMREC framework is found in four areas:

Value addition and benefication – the policy places a strategic interest in establishing mechanisms for the promotion of investment in activities that seek to process mineral resources beyond their raw state, discouraging the export of low value raw minerals through making it more competitive to add value in-country. The policy recognises the need for training in mining techniques specific to each resource, their different value-addition processes, and pathways for product marketing.

Comprehensive resource recovery - the policy commits to enhanced geodata collection and management as part of a strategy for wider mineral resource feasibility studies. It is important to note that the policy is more outward looking than its predecessor. It targets the strengthening of the legal and regulatory framework in a manner that enables greater alignment with international mining industry fiscal regimes while also promoting linkages between the collection of royalties and mining revenues and the development of regional economies.

Diversification – the policy prioritizes stronger linkages between the mining sector and other sectors of the economy, largely agriculture and linked businesses using mineral resources as a product base. Given the reliance of many mining sites on the provision of reliable electricity and water provision, the policy recognises that mining development is intrinsically linked to the requirement for improved local and regional infrastructure both in terms of technology and logistics.

Zero waste – the policy sets out to promote better HSE practices through the monitoring and compliance enforcement of set minimum environmental standards. Stronger regulation and control of hazardous substances are paired with a greater emphasis on full mine life cycle environmental planning and remediation, in which tailings and waste are managed responsibly, with their use or disposal planned in advance.

It is the **project milestone and decision gates** process that is not explicitly addressed by the policy aims. It demonstrates a continued lack of clarity on the best practices surrounding the process steps to be followed in exploring, developing, operating and decommissioning a mining project, regardless of scale, but particularly in the case of ASM.

2.2 The Mining Act 2003

The Mining Act 2003 is based upon article 244 of the Ugandan Constitution and provides for the procedure for acquisition of mineral rights including prospecting licenses, exploration licenses, retention licenses and mining leases. When compared to the process described in the AMREC framework, uncertainty surrounding the clear provision for set process in the legislation is revealed.

For example, under the Constitution, clay, murram, sand or any stone commonly used for building or similar purposes are not defined as a mineral, but rather building materials, and as such are not subject to the laws governing the mineral sector. Article 244(6) requires parliament to make a law to regulate building substances excluded from the definition of minerals under article 244(5), but the Mining Act 2003 and the Ugandan Constitution do not align in their provisions. There is no clear support of the regulation of building materials.

In addition, ASM has remained largely unregulated and informal under the Mining Act 2003. Its actual contribution to the economy is not accounted for, partly explaining the recorded figure of a less than 1% contribution of the sector to Ugandan GDP. Of crucial importance for future economic contributions of the mineral sector, the provisions of the Mining Act are unclear on value addition and beneficiation of strategic minerals such as iron ore, base metals, precious metals and critical minerals in the global marketplace.

The Mining Act makes few provisions for the practices required to enable the sustainable exploitation of mineral resources and their proper environmental management. Requirements for community engagement, diversification, and zero waste are also lacking.

These limitations highlight some ways in which The Mining Act 2003 has been inadequate in its provision for the sustainable development of mineral resources in Uganda, demonstrating the need for a new evidence-based act that recognizes the complexity of a minerals industry that is typified by informality.

2.3 The Mining and Minerals Bill 2021

The Government has, in principle, overhauled the Mining Act 2003 through the drafting of the Mining and Minerals Bill 2020. This Bill is currently before Cabinet and seeks to put into practice the provisions of the Mining and Minerals Policy for Uganda 2018. The Bill prioritizes strengthening the effective management of mineral resources as a long term foundation for economic growth.

In line with the proposed AMREC framework, emphasis has been placed on ensuring the rational, integrated and safe exploitation and use of mineral resources, recognising the potential for long term damage caused by some existing mineral extraction processes. Stronger regulation is proposed as a means for the transformation of ASM in Uganda, linking it into centralised processes for value addition and beneficiation of minerals produced at all scales. While the bill makes provision for stronger enforcement of minimum HSE standards in the mineral sector, our fieldwork indicates that this remains an on-going challenge to be addressed in practice.

AMREC proposes a system of incentivizing responsible mining practices by demonstrating their ability to create enhanced income, rather than enforcement of poor practice through the application of fines and barriers. This is perhaps one of the most important elements of the application of AMREC to the drafting and implementation of new policy. Policy that enables a framework that is supportive of the development of ASM as a legal and formalized sector of the economy can in turn create an environment in which related societal benefits can be enhanced. These include mechanisms for formalization of ASMs, capacity building for ASM, accessible and affordable financing for ASM, integration of responsible mining practice and environmental protection in mining activities including phased mine closure and waste management strategies, gender equality, equity, and protection of human rights.

Continuity of income and confidence in investment are formed through the provision of legally-ensured mining rights for individuals and communities. The presence of children at the mine site, either as workers or dependents of workers can be vastly reduced through the removal of income uncertainty for mining families.

2.4 The National Environment Act 2019

Mining is in essence the removal of the substrate in some form, which is inherently damaging to the existing landscape and potentially damaging to existing ecosystems and land uses. The environment in which mining operations exist must be fully understood in order to form a baseline from which the impact of mining is quantified and mitigated. Without policy in place to ensure the collection of such baseline information and the submission of development plans for present and future mining operations and remediation activities, operations cannot be considered sustainable.

In Uganda, sustainability must take into account environmental sustainability, particularly given the regular competing land use demands between mining and agriculture, but also economic sustainability. Activities that cannot sustain a community and provide levels of investment that are self-sustaining would also fall under the category of unsustainable. The linkages between the two definitions are valid as an economically unsustainable mining operation would be unlikely to prioritize or even consider remediation activities and the tailoring of processes to protect the environment.

Parliament enacted the National Environment Act 2019 to provide a framework for the creation of regulations specific to the protection of the natural environment in Uganda. These include the National Environment (Strategic Environmental Assessment) Regulations, 2020; the Environment (Environmental and Social Impact Assessment) Regulations, 2020; Environment (Waste Management) Regulations, 2019; which clearly provides for the management of the environment during exploration and mining operations and the management of waste generated from mining activities through a waste management system.

The hierarchical framework set out in the Act and regulations made under the Act provide guidance on:

(a) reduction and recovery at source.

(b) re-use.

(c) recycling.

(d) alternative recovery methods.

(e) treatment.

(f) responsible disposal.

These factors, collectively, form the essential requirements for zero waste under the AMREC aspirations. Our conclusion is that the National Environment Act 2019 is consistent with the AMREC framework and supports sustainable mineral resource development.

3 Methodology

The initial phase of this pilot study has focused on the critical controlling factors that shape and govern the development of mineral resources in Uganda at present. A mixture of quantitative and qualitative data has been combined to give a broad assessment of the perceived and measurable barriers to the development of the mineral resources sector in Uganda (Hall & Howard, 2008). Quantitative data were collected using a series of questionnaires to assess the economic structure of the selected mining sites – Mubende and Busia for Gold, Lake Katwe for Salt, and Kikagati for Tin. Qualitative data were collected using Document Reviews and Key Informant Interviews (KIIs). Thematic content analysis using a deductive approach was employed to summarize both.

3.1 Quantitative Analysis

The foundation of the quantitative analysis is structured around a systematic review of policy and empirical documentation relevant to the mineral resource sector. Relevant documents were assembled and reviewed to provide an overview of the current status of the development of the mineral resource sector with regards to regional and national socioeconomic development and environmental impacts.

The documents reviewed include:

The Uganda Vision 2040.
Third National Development Plan 2020/21 – 2024/25.
The Ministry of Energy and Mineral Development Sector Performance Reports (Various Issues).
The Ministry of Energy and Mineral Development Sector Strategic Plans (Various Issues).
The Mining and Minerals Policy for Uganda 2018.
The Mining Act, 2003.
the Mining Regulations, 2019.
The National Environment Act, 2019.

The above national policy documents were subjected to a content and discourse review. In addition, quantitative data from the case study mining sites has been analyzed to augment the overall review findings.

3.2 Qualitative Analysis

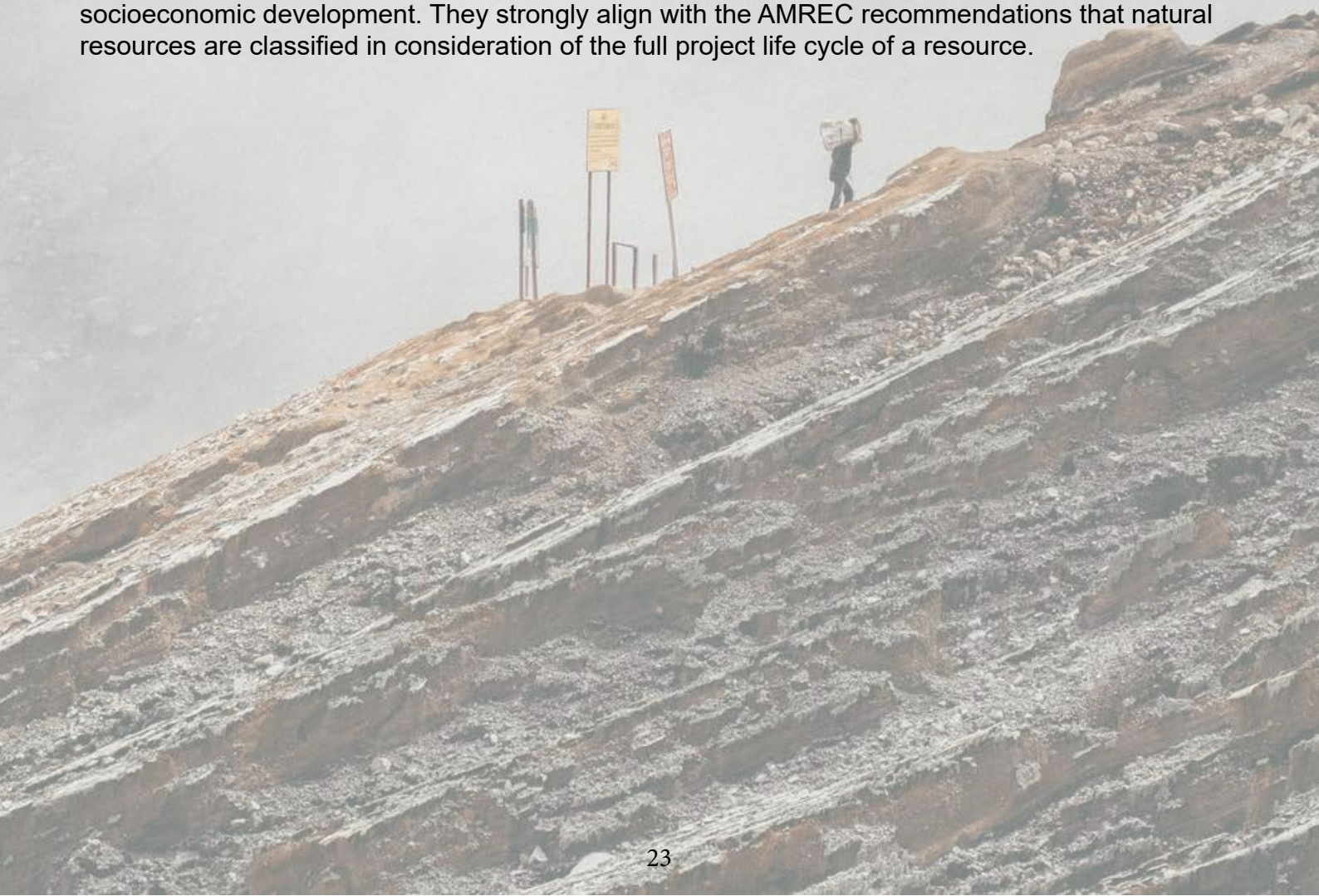
Understanding and analyzing the influences upon the controlling factors that govern the complex workings of the minerals value chain in Uganda requires direct interaction with stakeholders directly employed in and associated with the mineral resource sector. The impact of policy is only one element to consider, particularly in an industry where in practice the majority of operations exist outside of policy governance..

For this purpose, in-depth interviews and field site visits were conducted to case study mining sites and relevant institutions. Interviews were carried out with policy makers and implementers at different levels in the Ministries, Departments and Agencies (MDAs) in the mineral sector, with active Mining Companies and with Artisanal and Small Miners (ASMs) and ASM formalized groups. Non-Governmental Organizations and key stakeholders for the selected case study minerals constituted the Key Informants. These structured interviews and field visits were concentrated on the regulatory, social, environmental, economic, technological, and geological factors that either facilitate and or undermine sustainable mineral resource development in Uganda.

Findings are presented in terms of the five key consideration areas;

- Project milestones and decision gates
- Value addition
- Diversification
- Comprehensive resource recovery
- Zero waste.

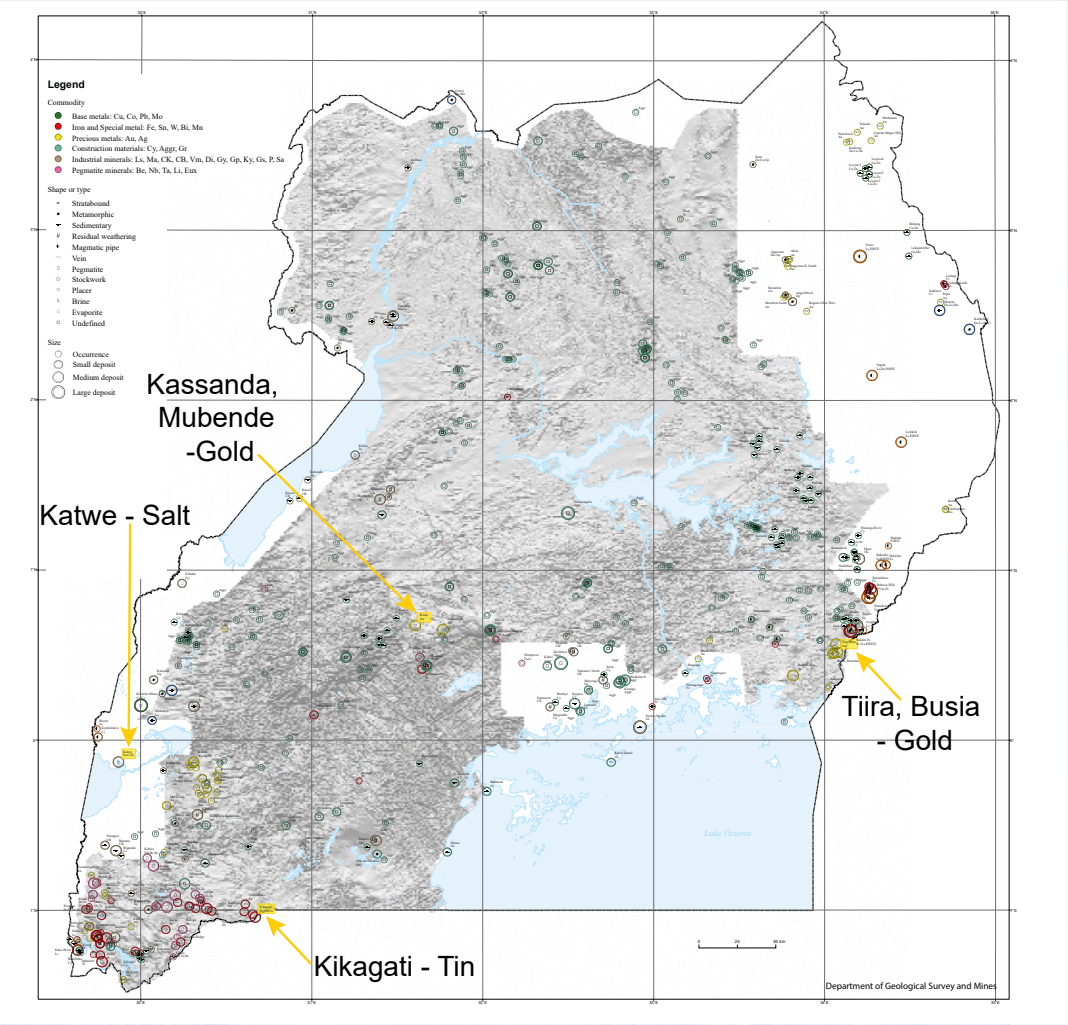
Justification for the choice of these key outcome areas is that they present the strongest contenders for methods to be adopted to enable mineral resources to provide a foundation for socioeconomic development. They strongly align with the AMREC recommendations that natural resources are classified in consideration of the full project life cycle of a resource.



4 Findings

In this section we present the findings from the field sites. The geological and economic context for each site is provided as well as a narrative of experiences and challenges at the mining sites.

4.1 Salt—Lake Katwe, Kasese, Uganda



4.1.1 Geological Background

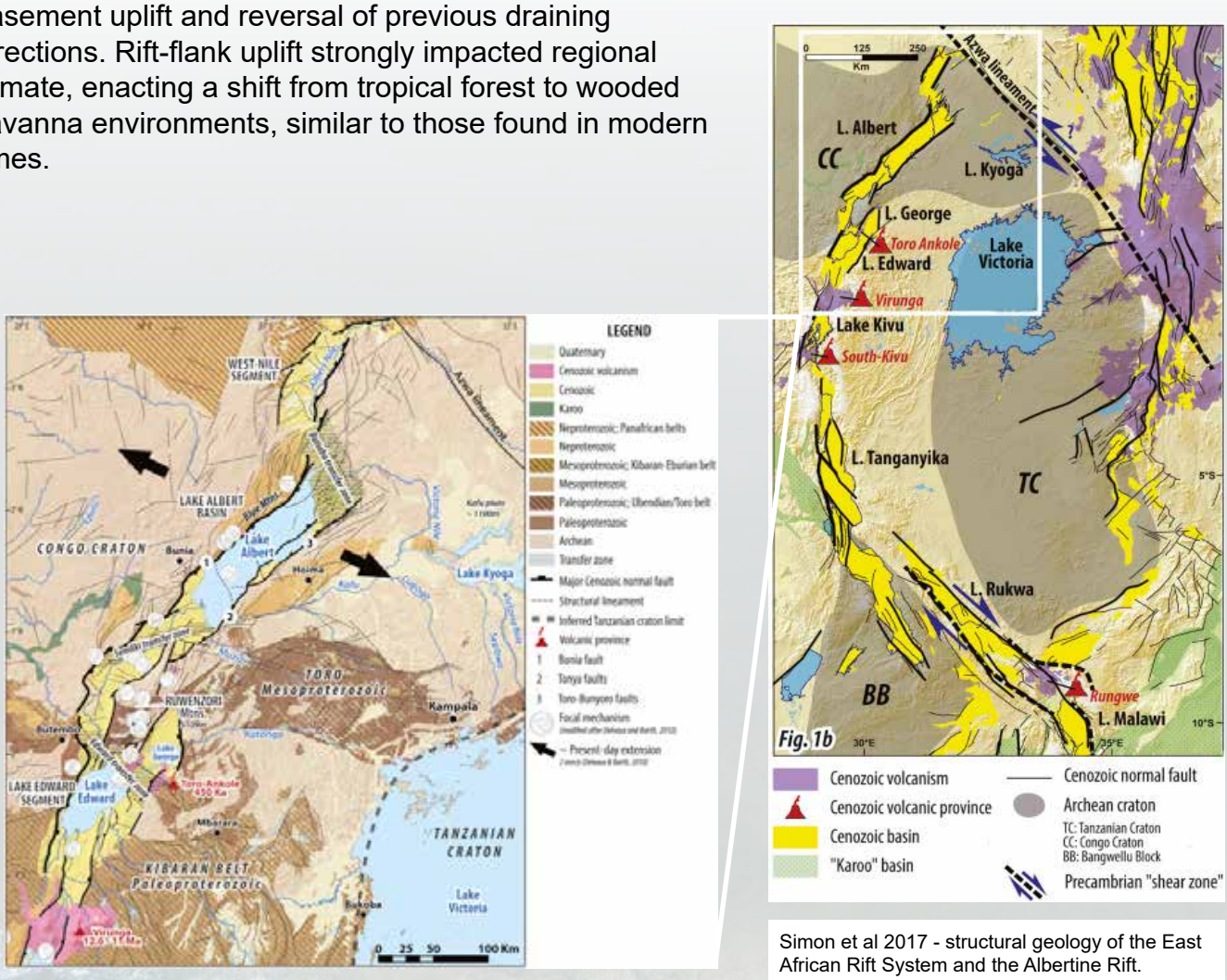
Lake Katwe is situated in a volcanic crater within the Albertine Rift, which represents the western extent of the East African Rift System, an active continental rift. The ~500km long Albertine Rift cuts NE-SW through Archaen and Proterozoic units, with a sediment fill dating to ~12.5Ma, and onset of volcanism dating to ~12Ma. At 2.5km², Lake Katwe is the largest of a series of 8 saline crater lakes within an area known as the Katwe-Kikorongo Volcanic Field.

The Albertine Rift is thought to have undergone three major evolutionary stages.

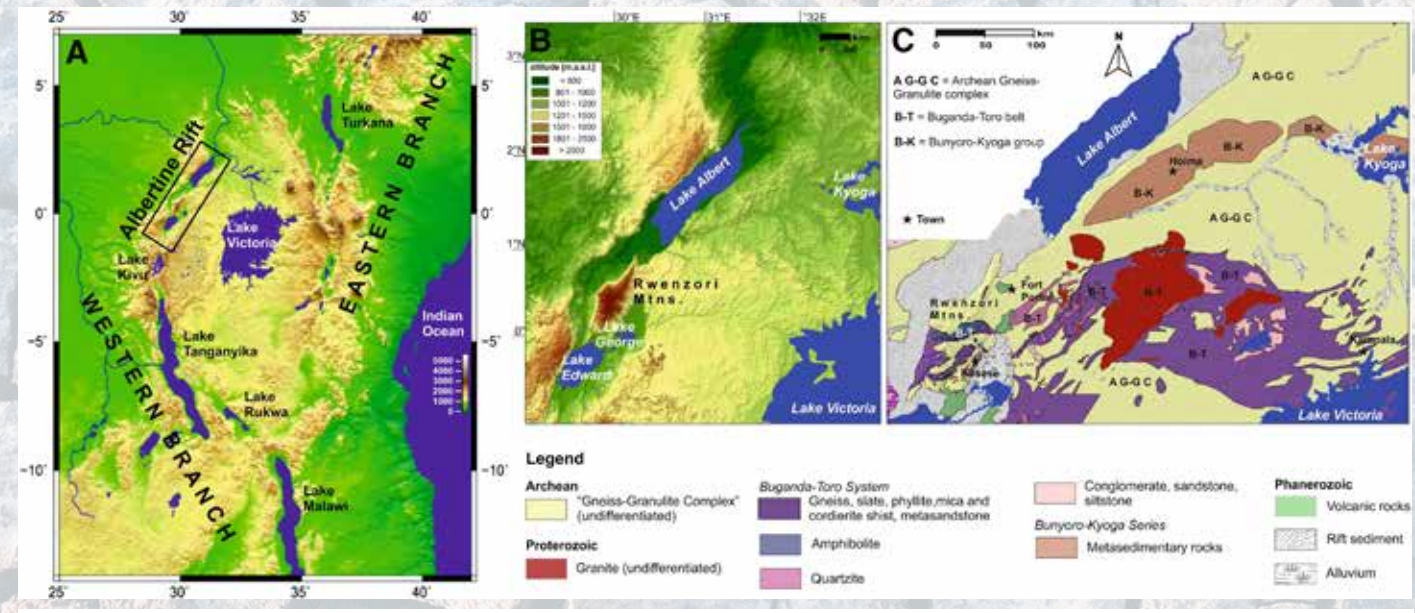
~12.5 - 7 Ma - The Albertine Graben developed as a shallow extensional basin in semi-arid climatic conditions. Sediment infill was largely fluvial, from the proto-Nkusi River, which terminates in Lake Albert.

8 Ma - onset of first major faulting. Graben formation and accelerated subsidence formed extensive lacustrine depositional settings. The climate moved from one dominated by arid conditions to a humid one, supporting semi-tropical conditions.

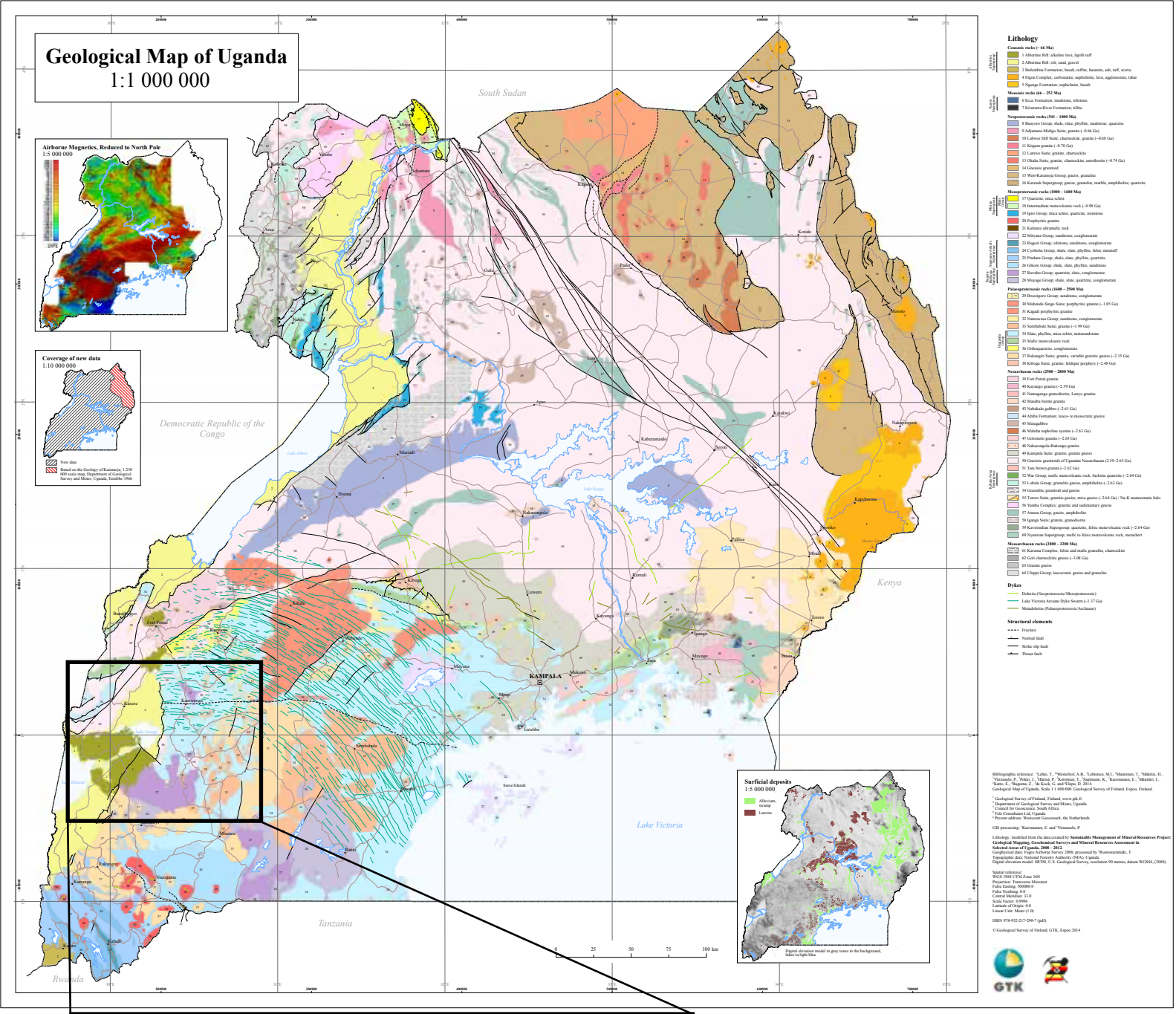
2.3 - 0.012 Ma - exhumation of the Rwenzori block, basement uplift and reversal of previous draining directions. Rift-flank uplift strongly impacted regional climate, enacting a shift from tropical forest to wooded savanna environments, similar to those found in modern times.



Simon et al 2017 - structural geology of the East African Rift System and the Albertine Rift.



Modified after Schneider et al 2016 - A - an overview of the East African Rift System, B - an overview of the Albertine Rift, C - Geology of Western Uganda (modified after Schluter 2008). The location of Lake Katwe is indicated on each map.



a.) Albertine Rift: alkaline lava, lapilli tuff

b.) Albertine Rift: silt, sand, gravel

c.) Gneissic granitoids of Ugandan Neoarchaean (2.59-2.65 Ga)

The lake exists in the remains of an exploded volcanic crater, formed in a series of tuffs, composed mainly of pyroclastics and ultramafic xenoliths. Beneath these are Pleistocene lacustrine and fluvial sediments. It is fed by a series of saline springs, with the lake water level determined by the hydrological balance between water inflow and evaporation, as there is no outflow from the lake.

There are competing hypotheses as to the primary provenance of the salts in Lake Katwe, with the input of highly mineralized spring waters and the leaching of salts from the surrounding tuffs proposed as the source. Recent geochemical studies have demonstrated a high Chloride and Bromine concentration in the Lake Katwe brines as compared to other saline lakes in the wider region. The concentrated brines are highly alkaline and dominated by carbonates (Na+, Cl-, SO 2-4 and HCO-3 + CO23).

Comparisons to historic studies have shown gradual changes in the concentration of the lake brines over the past 40 years, with the total salinity varying based on seasonal factors. The brines are under-saturated, requiring continued replenishment and evaporation cycles to precipitate salts.

A variety of trace metals also occur within the brines, the concentration of which is controlled by several factors, largely related to the chemical weathering of the surrounding bedrock. The chemical composition of the brines varies through the water column, impacting the salt grades due to the presence of mineral salt impurities.

Mining Rights and Production

Salt production in Uganda is focused around the seasonal harvesting of salt from Lake Katwe, a major source of brine, estimated to contain a reserve of over 22 million tonnes of salt. Salt has been mined from Lake Katwe for over 100 years, resulting in a current yield of variable quality precipitated salts. Halite content varies from 55% - 95%, making the quality of produced salts unpredictable. This in turn makes the price paid for the salt production comparatively variable. Different methods are used to mine salt from the lake, depending upon the salt grade to be obtained. To produce higher-grade salts, brine from the lake is channelled into salt pans around the lake perimeter, from which water is evaporated off to leave salt crystals. Once dried, salt is scraped out of the pans.

There are about 15,000 registered salt pans that are actively mined on Lake Katwe. The Lake is owned by the Central Government of Uganda but is operated and managed by Katoboro Town Council, Kasese district. While salt miners own the salt pans through customary and or lease arrangements, they must obtain a mining license from the Ministry of Energy and Mineral Development to operate legally. This license provides confirmation of regulated mining rights and stipulates obligations for responsible management.

To purchase and own a salt pan, the current market price ranges between UGX 8,000,000 (US$ 2,200) to UGX 15,000,000 (US$ 4,200) depending on the surface size.

Three categories of salt, commonly called “grades” are mined.

Grade 1 characterizes salt that has been washed and can be used for human consumption as table salt. Physically, it can be white, pink, or grey depending on the washing mechanism utilized. A 100-kilogram sack of this grade of salt is sold at UGX 60,000 (US$ 17) during peak extraction and UGX 170,000 (US$ 47) during the non-peak (rainy) season.

Grade 2, locally known as “Ekihabule” is largely extracted for livestock consumption. A 100-kilogram sack is sold at UGX 16,000 (US$ 5) and UGX 30,000 (US$ 9) during peak and non-peak extraction periods respectively.

Grade 3, also called “rock salt” from the lake-bed is a mud extract that is used as a fertilizer for agricultural purposes. A 100-kilogram sack of this salt grade is sold at UGX 100,000 (US$ 28). It is noted that this salt is unprocessed, raw, and could feasibly be transformed into higher value products that would sell for a relatively higher price per kilogram.

The Lake Katwe salt pans from above

An average salt pan produces approximately 2 tonnes of salt per week during peak extraction. However, some larger pans can generate up to 10 tonnes of salt output per week during peak extraction. In terms of labour requirements, salt miners work for a maximum of 3 hours per day, earning UGX 45,000 (US$13) per day. Salt pan workers work between 8:00 hours to 13:00 hours. Operation and maintenance costs of a salt pan constitute approximately 60% of total revenue.

Most salt pan owners rely on family labor to minimize operational costs. This practice, we observe, can promote use of child labor—commonly associated with Artisanal and Small-Scale Mining communities. With regards the trading of salt, the local market is dominated by cattle keepers and industrialists. Livestock farmers purchase salt for animal consumption and as an ingredient in feedstocks. Industrialists utilize salt as a preservative and largely for the manufacturing of the fertilizers for agricultural purposes.

4.1.3 Assessment of project against the five controlling factors

Project Milestones and Decision Gates

A fundamental AMREC requirement for sustainable mineral development is that projects need to have a framework that assesses the environmental impacts of mining practices. Survey results from Katwe Salt mining demonstrates a very limited existence of sustainable working practices, effective environmental impact assessments, and feasible mine closure or decommissioning plans. Salt extraction at this site follows unregulated practices. For instance, all miners questioned had neither Environmental Impact Assessments (EIAs) nor knew that it is a requirement by the national mineral policy.

Overmining of salt is depleting the ability for the lake to provide a predictable output for sustainable mineral development. This behavior, we assume, is attributable to two compelling factors; First, the knowledge gaps on the side of the miners relating to sustainable salt extraction, pushed by the economic pressures to maximize short-term gains at the expense of long-term sustainability. Second, the weaknesses in the mineral regulatory frameworks that, until recently, tended to neglect salt mining on the mineral development radar.

Value addition and Beneficiation

This characterizes the difference between the price and the cost of producing or extracting a mineral resource. Importantly, value addition is a critical tool in assessing the full economic viability and benefit of mineral resources in country. Findings from Katwe Salt mining show that value addition is generally lacking. Washing using water is the basic and final process in the value chain between the mine site and end user within Uganda. Extracted raw rock salt, is for instance, packed in sacks and loaded for the market.

Critical to note, and central to beneficiation efforts, is that the mineral resources are exported as unprocessed raw products that naturally fetch lower returns to the mining economy in Uganda. This practice incurs substantial economic losses for the Ugandan government and the miners themselves, and thus, requires a strategy that sets out clear plans for mineral processing beneficiation. The primary hindrance to value addition and beneficiation efforts relates to barriers in accessing capital financial investment. This inhibits the capability of individuals, mining companies, and community trusts to invest in requisite technology for downstream mineral development.

Diversification

The AMREC framework is constructed on the logical notion that the extraction of most minerals depletes a finite resource. This natural resource attribute demands a minerals-driven sustainable development strategy. Diversification encompasses the extension of mining activities to new products, areas, and markets. This growth strategy generally requires new skills, new techniques, and new facilities. The pilot survey results reveal that diversification of the salt mining at Katwe remains limited. While local infrastructure has been developed as a result of the salt mine operations, the ability to seed other linked industries is still limited by financial constraints.
At Katwe, the ability to earn a living from anything other than the mining of salt is severely curtailed. This limited economic diversification is typical of ASM communities, which operate as a subsistence economy out of necessity.

We observe that the barriers to the development of salt mining in Uganda are a consequence of two main factors:

Firstly, the limited attempts at value-addition for almost all salt extraction is a manifestation of an inability to develop the technical skills needed to improve salt production and processing. Minerals are exported in their raw form at low cost out of necessity to make immediate profit. This uncompetitive behavior diminishes the potential gains from downstream linkages within the source region.

Second, in poor communities, unregulated and indiscriminate mining regimes promote resource exploitation practices, which do not integrate other sectors of the economy through desperation and necessity; individuals tend to focus on short term survival over any kind of long-term business growth.

The implication for the AMREC framework is that interventions must prioritize development of infrastructure, boost non-mining economic activities, and adopt economy-wide integrative approaches in mineral resource management, considering the reasons why mining is taking place at all in such localities.

Comprehensive Resource Recovery

The advent of a circular economy implies that waste and the waste repositories in which it resides are becoming targets for resource recovery, both for legacy waste and for future waste creation. Comprehensive resource recovery considers the processes and methodologies that can maximize economic returns from the mining and processing of minerals, especially from low-grade, depleted and other non-fully recovered ore bodies. Findings from the salt mining site provide evidence of an understanding and utilization of comprehensive resource recovery principles. In particular, the extracted brine is thoroughly washed for recovery of potential Grade 1 and Grade 2 salt products. The waste water from this washing process, unlike rain water, is then channeled back to the Salt pans because it still carries some chemical compounds that can facilitate further salt formation.

The barriers to resource recovery at the salt mining site are attributable to the lack of access to suitable and efficient salt extraction technologies. For example, the mining activity is wholly manual, based around use of basic tools and equipment. Hand-held hoes, shovels and scoops are the predominant tools that are used to harvest salt from the salt pans. These extraction approaches are not only inefficient; they increase the economic losses through loss of quantity and value of the final salt output. While the techniques employed in these recovery efforts are basic and relatively inefficient, we can infer that such attempts exemplify an understanding of optimal resource management in ASM communities.

Zero Waste

Modern waste management strategies include the application of cleaner production principles, the use of waste as a raw material, production processes that minimize waste production, and conversion of waste into useful by-products. These mining practices, combined, constitute the aspirations of the AMREC framework. Waste minimization often results in increased mineral productivity. Critical to note is that there is a need to transit to approaches which aim to reduce or eliminate waste production at source. Against these expectations, the survey results indicate that salt mining waste minimization at Lake Katwe is lacking, blamed on ASM practices, characterized by indiscriminate extraction methods. For instance, at the salt pans, brine is indiscriminately deposited on the lake shores, with no established waste management process and no assessment of the environmental impact of such activities.

There are no efforts made to minimize brine volumes removed from the lake and no attempts to reprocess it. Existing processes are restricted to basic waste disposal only. The miners interviewed do not have the requisite knowledge to estimate the impact of non-waste management on the sustainability of salt mining. This observation signals the existence of regulatory and skills gaps in waste management at the mining site.

Challenges

Significant challenges face those attempting to mine salt from Lake Katwe, only some of which can be addressed though policy change.

The factors influencing the ease of extraction of salts from Lake Katwe are strongly climatic, with a natural solar method used to evaporate off water to obtain precipitated salts. Temperatures higher than approximately 27 degrees Celsius are required to obtain sufficient evaporation rates to produce salts. The brine is concentrated in the lake during the dry seasons as evaporation outpaces the renewal of lake waters. However, during rainy seasons, the salt formation process is limited as rainwater dilutes the brines and hinders evaporation in the salt pans. A direct implication is that rainy seasons are associated with reduced harvests of salt, and as such, reduced incomes for miners. Of greater significance when considering the potential for policy change, salt production from Lake Katwe carries serious health risks to salt miners. High concentrations of salt in these waters reportedly causes irreversible skin, body, and reproductive defects, including infertility, and can even lead to death.

One miner who was interviewed as part of the fieldwork reported “if that water drops in your ears, you can die”. The health risks are known, but the ability to avoid them is limited by the need to maintain an income. The health risks posed in particular to female miners limit their ability to rely on the lake as a source of income. Exposure to the lake brines is linked to severe reproductive health issues, which in practice means that women tend only to be able to work in areas of the lake with shallow water depths, below knee depth. Dehydration, inhalation of poisonous gases and the risk of laceration by salt crystals and rocks add to these dangers.
While salt miners have improvised rudimentary protective measures through necessity, and developed rules to reduce the most pressing health risks (e.g. restricting access to deeper water by female miners), the methods adopted have only a limited impact and cannot be considered to adhere to the notion of decent work typified by safe practices, as aspired to by the UN Sustainable Development Goals.

Lack of access to suitable technologies also impede the efficiency and productivity of salt mining activities at Lake Katwe, where most mining activity is wholly manual, based around use of basic tools and equipment.

Hand-held hoes, shovels and scoops are the predominant tools that are used to harvest salt from the salt pans, creating a labor-intensive process in an already harsh environment. Rock salt from the pans is then stacked in sacks, which are physically carried on the heads or backs of miners to storage facilities nearby. The ability to add value to the raw salts is limited, as is the ability for miners to plan any long-term changes to their working patterns.

A consistent fear of eviction from the lake was reported during field interviews. “Big investors” are viewed as a potential source of displacement of existing miners, bringing in money as a means of access to land ownership without any compensatory measures in place for those displaced or negatively impacted. The local community blames this on unsupportive political interference and weak implementation of regulatory frameworks.

Most salt miners own a designated number of salt pans, either purchased historically or inherited through customary acquisitions from their parents or family. While these carry ownership rights, there is no stipulation in Ugandan law that prevents their displacement by forced purchase by what are deemed to be “predatory” buyers. Interviews conducted during fieldwork revealed a frustration at the government for ignoring repeated pleas to formalize the ownership status of the Lake Katwe salt plans. Miners cannot be expected to even attempt to invest in long term strategies for sustainable operations if their ability to predict future land access is uncertain.

Miners reported the applications process for a mining licence in Uganda to be highly bureaucratic, involving significant delays and costs that were beyond their affordability. This clearly demonstrates existing policy gaps and highlights the potential for the adoption of the AMREC framework in forming recommendations specific to a mineral resource that receives far less attention than those with a more global supply chain, such as a gold and tin.

The ability for the realization of value addition to raw salt is also restrained by the lack of regulation of middlemen in the form of purchasers of raw salt products at the lake. The salt miners receive between 5%-10% of the commercial value of the salt from the direct buyers, who then take the salt to the wider market for limited value addition. The lack of regulation of this particular process has served to restrict the salt miners with regards their ability to become more economically progressive. The more links in the chain between the miners and the open market, the lesser the resource value received by them, and the more restricted their ability to invest in more sustainable practices becomes.

Sustainability of the resource itself is also a growing issue that requires regulation to prevent long term loss. Overmining and over-extraction of salt is depleting the ability for the lake to provide a predictable output, with the chemical composition of the brines altering over time as more and more of the dissolved salts are removed through mining. This has largely been blamed on the rapidly growing population around Lake Katwe as well as the widespread poverty that forces people to turn to the lake for an income simply to survive

Low value addition could exacerbate this behavior as the monetary flows into the region around Katwe are kept artificially low if the resource price at source remains uncompetitive.

The combination of these factors has exerted severe pressure on Lake Katwe as a geological resource, as a habitat and a provider of income to a community with few other employment options. There is an urgent need to better understand the geological setting of Lake Katwe with regards its ability to continue to provide salts from the brine if the usage rate continues to increase. This is combined with the potential for climate change to alter the pattern and intensity of rains, threatening to decrease salt yields and quality further.

Finally, competition from regional producers of salt, particularly Kenya and Tanzania, threatens the already insecure Ugandan salt market. Imported salt from Tanzania and Kenya is considered of superior quality and is heavily preferred by industry in Uganda compared to the unprocessed Ugandan Salt. International imports of salt from India also threaten the ability of the salt from Lake Katwe to ever be more than a lower value, regional product with a niche market.

Uganda imports approximately UGX 94.7 billion ($25 million US) worth of salt annually, approximately 90% of overall consumption, while the market for Ugandan salt remains a minor sector of the market. This raises the question as to whether policies to promote resource nationalism for salt in Uganda could promote unsustainable levels of production at Lake Katwe that would be damaging to the whole industry in the long run.

The outcome of this study supports policies that focus strongly upon promoting enhanced value-addition of salt produced at Lake Katwe, rather than those which seek to alter the market availability of salt in Uganda to artificially raise the price of raw salt.

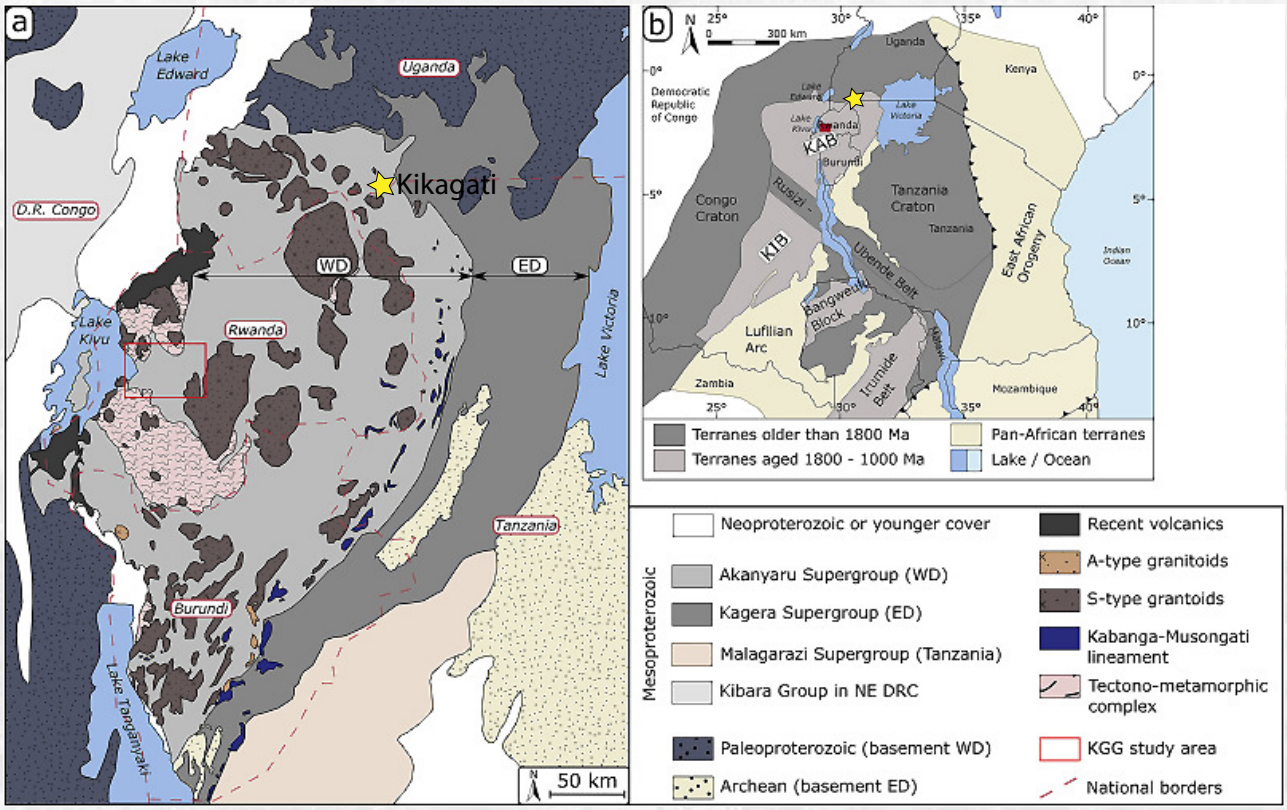
4.2 Tin— Kikagati, Insingiro, Uganda

4.2.1 Geological Background

Located in Southern Uganda on the border with Tanzania, Kikagati tin mines encompass a series of mine sites along a NW-SE trending ridge. Tin occurs as coarse-grained irregular nuggets of cassiterite associated with quartz-muscovite veins within quartzites altered by the nearby intruded Ibanda granite. The quartz veins at Kikagati are brecciated, having undergone structural reactivation, with cassiterite best developed on the margins of these brecciated veins. Alongside tin, occurrences of Beryl have also been reported at Kikagati within the tin-bearing mineralised veins, with a BeO content of 13.65% according to laboratory reports. Occurrences of Lead and Copper have also been reported. The mineralised veins occur within 70-100m thick quartzites banded by graphitic phyllites. The quartzites dip ~40°NE, with a NE-SW strike. The mineralised quartz-muscovite veins trend NNW-SSE and dip ~45°SW to ~70°SW. The Kikagati mine site extends over a 3km x 0.5km area as a system of pits, tunnels and mines. The bedding unit containing the veins is 3km long, 100m wide and hypothesised to extend up to 1km down dip into the hillside, creating a stacked system of veins with a density of 14-22% by volume of the host unit.

Tin occurrences in Uganda occur in association with hydrothermal alteration of country rocks, pegmatitic intrusions and alluvial deposits, largely within SW Uganda in the Mid Proterozoic rocks of the Northern reaches of the Karagwe-Ankolean fold and thrust belt, a structurally complex succession of argillaceous rocks composed mainly of siltstones, shales, conglomerates and sandstones, deposited between 1420 Ma and 986 Ma in intracratonic basins. These sediments were punctuated by a series of igneous intrusions, creating varying degrees of metamorphism of the surrounding country rock and the development of hydrothermal systems. Tin ore, cassiterite (SnO_2), is confined to the shales and sandstones within the succession, where hydrothermal veins occur in proximity to granite batholiths emplaced between 998 and 957 Ma.

Many of the granitic intrusions in SW Uganda are known as ‘arena granites’, emplaced in anticlinal cores where erosion of central granite domes has led to the formation of basinal depressions bounded by circular ridges of surrounding sediments and metasediments. The roof zones of buried granitic bodies are commonly intruded by pegmatites and mineralised hydrothermal veins. The area in which this vein mineralisation occurs in SW Uganda is known generally as the Karagwe Tinfield.

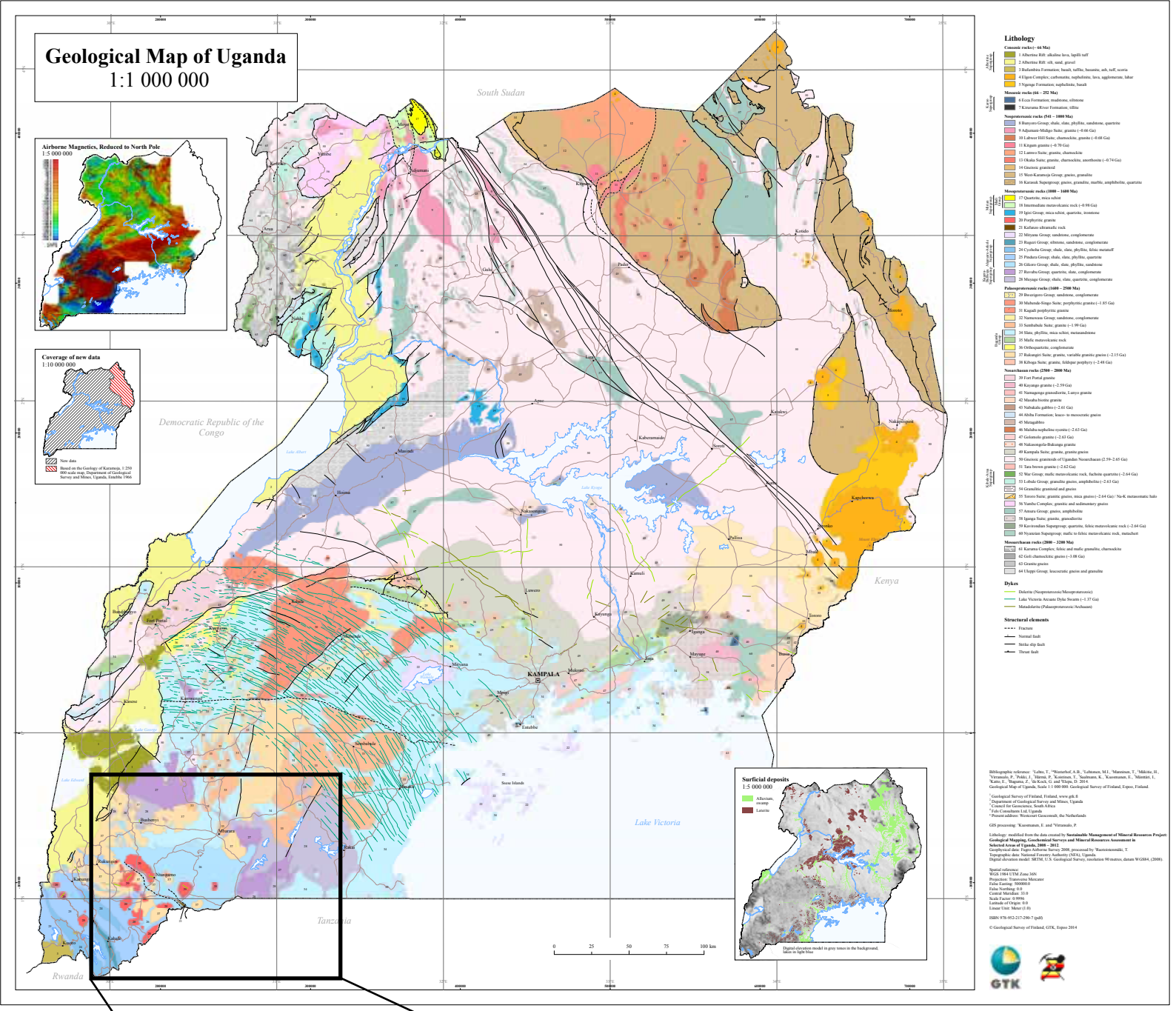


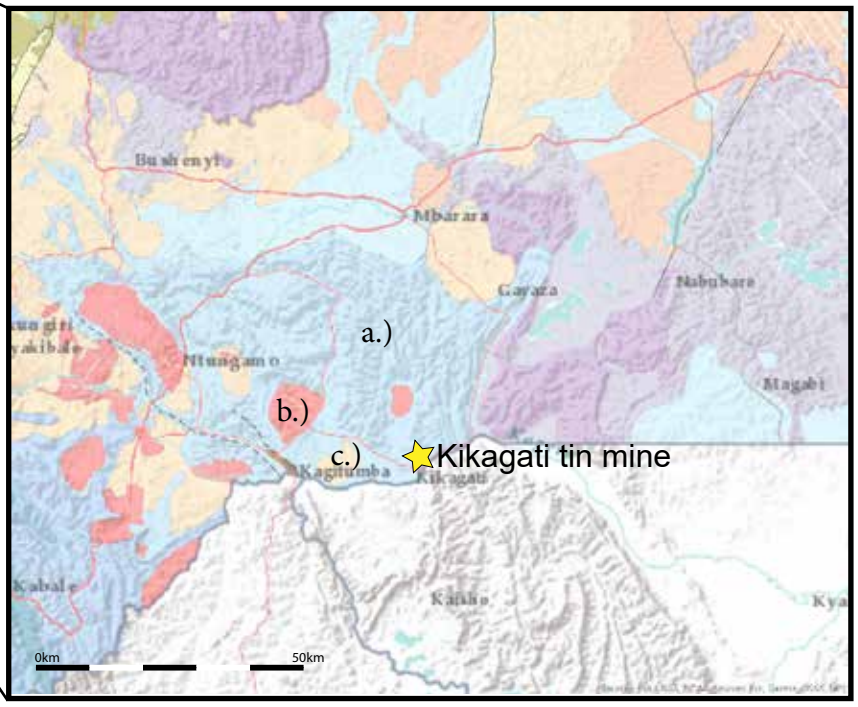
Geological setting of the Karagwe-Ankole Belt, modified from Van Daele et al (2020). The location of Kikagati tin mine is highlighted. WD = Western Domain, ED = Eastern Domain, KIB = Kibaran Belt, KAB = Karagwe-Ankole Belt

The Karagwe-Ankolean fold belt (KAB) represents the Northernmost extension of a series of orogenic fold belts in Central Africa, running from Burundi in the South to SW Uganda at its Northern end. There remains a lack of detailed structural analysis of the KAB in SW Uganda, largely due to limited outcrop exposure and regionally correlatable stratigraphy. The focus of detailed geological studies have been situated largely in Tanzania and Rwanda in recent years, with published Ugandan detailed geological field mapping campaigns largely dating to the 1960s. Recent airborne geophysical surveying in Uganda has provided data crucial in identifying the location of intruded granites at depth, enabling exploration of their associated mineralised roof zones while also enabling a greater understanding of the geological evolution of the region.

Data from Uganda has been combined with previous studies based largely in Rwanda and Burundi to begin to unpick the tectonic history of the region. A phase of crustal extension and basin development was followed by the emplacement of the North Kibaran Igneous Province, thought to relate to a mantle thermal anomaly.

It is later, smaller scale igneous events that caused the mineralisation associated with the tin occurrences in SW Uganda, following on from a period of basin inversion, folding and thrusting. Recent geochronological data indicated that post-compressional crustal relaxation gave rise to the emplacement of ‘post-Kibaran tin granites’ and associated pegmatites and quartz veins. It is these igneous intrusions into the surrounding sediments of the Gikoro Group that have provided the formation and geological setting of the project case study site for the mining of tin.





a.) Gikoro Group; shale, slate, phyllite, sandstone

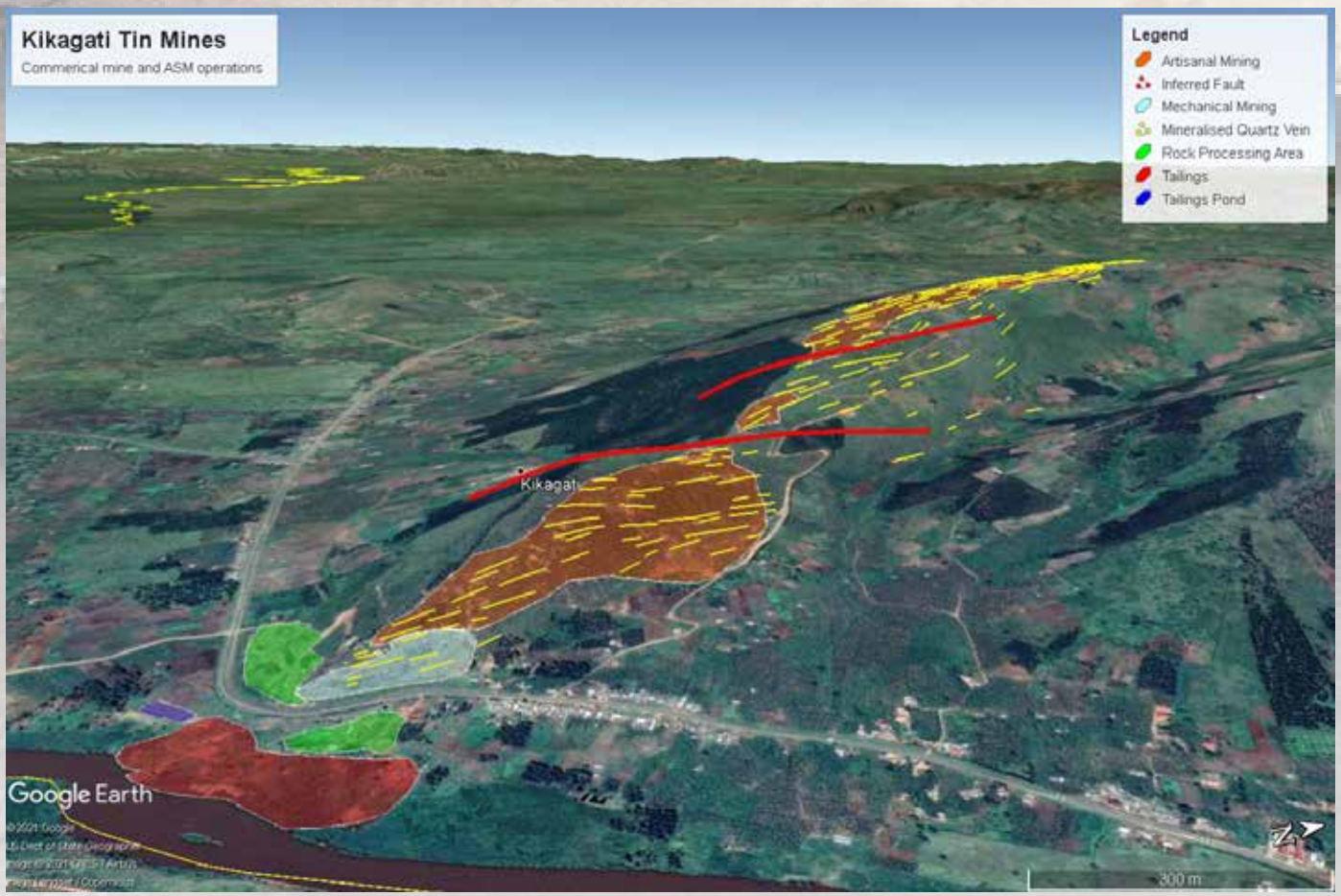
b.) Porphyritic granite

c.) Rukungiri Suite; granite, variable granitic gneiss

4.2.2 Mining Rights and Production

Tin is reported to have been mined at Kikagati since 1925, with upwards of 300 tonnes of cassiterite produced per annum during the first 20 years of mining operations. In 2019/2020 Kikagati mine was reported to have produced tin exports valued at UGX 586,977,224 ($163,000 US), resulting in royalties payments of UGX 29,348,849 ($8100 US). The site is considered to be in an underdeveloped state by the Ministry of Energy and Mineral Development. The present-day Kikagati site is a small to medium scale enterprise currently operated commercially by African Panther Resources as well as being a site with significant ASM activity, where ASM miners sell cassiterite concentrates to the site licence holder. The site has been operated by a number of different mining companies, with the economic potential of the mine governed by resource uncertainty, global tin prices and trade links to smelting facilities.

The most recent large investor in the Kikagati mines, Carnavale Resources, abandoned plans for further development of the site in 2019 due to a 25% fall in tin prices over the previous year and drilling results which highlighted the sporadic nature of cassiterite occurrences at the site. Interviews carried out during fieldwork revealed that a key factor in the withdrawal of investment from the Australian stock-market listed company was due to the geological uncertainty faced at the site.



The ability to sufficiently estimate the recoverable reserves of tin at Kikagati is not at a level that meet the requirements of an international investor such as Carnavale, who must meet the minimum standards for public reporting of mineral exploration results in Australia. This is known as the JORC Code, the Australian Code for reporting exploration results, mineral resources and ore reserves.

The geological controls on the economic feasibility of the site as a large-scale commercial venture are countered by the potential for such sporadic mineral occurrences to sustainably support smaller scale ASM ventures, particularly with investment in geological training to enable detailed mapping of mineralised veins by miners. The tunnels dug into the hillside by ASM miners are estimated to be up to 30m deep. Reports of dangerous working practices in unstable pits by ASM miners also highlights a need for training in safe excavation methods and mining HSE.

During historic exploration of the area grades of 0.38% (0.5-1.4kg/m^3) of cassiterite were reported, fetching UGX 8000 – 25,000 ($2-7 US) per KG. Recent drilling campaigns by Carnavale Resources (2084m of drill core obtained) reported a higher grade average of 1.23%, encompassing the main Kikagati site and a new site 2km to the West. This new discovery further highlights the importance of a greater understanding of the local and regional geological setting if small-scale tin mining is to provide a sustainable means by which to provide economic development of the area.

Kikagati tin mine provided one of two case studies for the testing of a new mine site inspection manual and mine site inspection template in development by the Ministry of Energy and Mineral Development as part of the 2020 sector performance review, in advance of the development of a new Ugandan Mining Act to be put to parliament in 2021.

4.2.3 Assessment of project against the five controlling factors

Project Milestones and Decision Gates

Sustainable mineral resource development is built on the practices that optimize resource extraction and production, minimize environmental damage, and promote inclusive dialogue and cooperation with local communities. We utilize these principles to assess the understanding and practical existence of this mining project. Evidence shows that the project understands and implements the tenets of Project Milestones and Decision Gates. As a requirement, the project was approved by the Ministry of Energy and Mineral Development upon satisfactory presentation of resource extraction plans, Environmental Impact Assessment (EIA), and a project decommissioning strategy. The Tin Mining Company—African Panther Resources Uganda Limited – has elaborate plans and structures that satisfy the requirements of a functioning system regarding sustainable development and community enhancement.

Further, there is evidence of a positive socio-economic impact of tin mining in the area. Mining profits have enabled the construction of a piped water system that serves the entire community with safe drinking water. The company runs a focused employment program where the Kikagati community youth are given priority to work in the tin mines. This is despite the financial uncertainties brought about by the lack of geological data required to inform accurate tin reserve estimates. Fieldwork uncovered clear plans for further economic development of the locality should investment or direct mining profit enable such. The linkages between the resource development and access by the community to enhanced living standards and work opportunities will be used as a direct example and case study for the recommendation of the formation of policy that would promote similar ventures elsewhere in Uganda.

Value-Addition and Beneficiation

The Africa Mining Vision (AMV) prioritizes down-stream linkages into mineral beneficiation and value-addition through the manufacturing of products from mineral resources produced in the region. It highlights parallel linkages into mining capital goods, consumables and service industries, as well as direct consequential investment into infrastructure (power, logistics, communications, water etc.) and skills and technology development. The overall financial gain/loss difference between the economic output of a resource without value-addition at source and one with value addition linkages can be considered to be a measurement of the value of investment required to bridge the gap.

While the existing regulatory space supports and promotes value addition, realization of this goal is limited at the Kikagati tin mining site. Fieldwork observed that separation of tin from mined rubble is the highest notable value addition attained within the region. The extracted tin is exported as an unprocessed raw material to external markets for value addition. Interviews with the project manager revealed that the justification for minimal value addition was that tin smelting requires huge electricity resource access, which in Uganda, is both expensive and unreliable. This electricity infrastructure barrier restricts the company's value addition efforts to extraction and clean-up for export. At the same time, this barrier presents the AMREC framework an opportunity to tangibly demonstrate the impact of what is lost over the life cycle of a mineral resource by understanding and mapping out the potential theoretical financial gain in country of differing levels of value addition.

Diversification

Linkages between the minerals industry and other economic and social sectors is one of the fundamental pillars of the AMREC framework. However, these linkages are insufficiently developed, reflecting the industry's over-reliance on extracting and exporting minerals with limited value addition to overseas markets. Management of a trans-national sector requires careful and thorough analysis of all relevant social and economic linkages at a local, national and regional level before classifying the resources using the AMREC framework and its key considerations. In the case of Uganda, the separate treatment of industrial minerals, stone for construction and precious metals is seen to add complexity to policy stipulations governing the mineral resource sector without basing these policy differentiations on a framework for their effective management. In Uganda, resource projects are assessed on whether they are practicing diversification but the barriers to implementing such diversification are not addressed.

Findings from the tin mining site demonstrates that resource diversification efforts remains limited. Tin mining, for instance, is restricted to exploration and extraction of tin only. We note two critical barriers to this controlling factor: First, Tin exploration, like for most minerals with a high bulk volume to mineral product ratio and sporadic occurrence, carries significant economic and logistical challenges. While geological data can provide suggestive indications of potential mineral occurrence, actual extraction and recovery of tin is associated with uncertain outcomes in terms of total volumes of rock mined. At the Kikagati mining complex, rare, nugget-like tin ore occurs within the quartz veins, known locally as reefs, requiring a high degree of excavation for potentially low volumes of tin recovery.

The ore occurrence is highly sporadic, with large volumes of vein material containing no ore, or small amounts of low-grade ore. Such high levels of uncertainty with regards reserves in place across the mine site make for a challenging investment case. During interviews the African Panther Resources mine manager reported that 20,000m of exploration drill core might not encounter any potential tin deposits. This does not make for an attractive investment for financial providers or companies who need to demonstrate high likelihood of future profit. Second, tin extraction is highly electricity intensive – to extract the tin effectively a series of grinding machines are required. However, electricity supply in Uganda is intermittent, unreliable and costly. Alternative power sources require additional financial resources which can constrain project finances further.

Comprehensive Resource Recovery

A primary controlling factor under the AMREC framework is that a mineral resources project should satisfy the tenets of comprehensive resource recovery. On economic enhancement, the geology of Uganda is such that where one economic resource exists, they are often found alongside other elements of monetary worth. The issue is that different recovery processes and scales may be required for each resource. Managing separate resources at one site requires an integrated development plan and a systems approach that considers a hierarchy of resource recovery. Given the changing global landscape of mineral demand and commodity price, this hierarchy can be expected to change over time, with implications for site management and development plans. In this pilot project, we utilize these considerations to assess the alignment of Uganda's mining industry to comprehensive resource recovery principles. Results from the tin mining site provide evidence of an understanding and utilization of comprehensive resource recovery principles. At the Kikagati tin mining site, rocks are crushed and separated using a water system to harvest the tin concentrate. In addition to tin, iron is also harvested during the separation process. Importantly, the non-mineralised rocks are washed and separated into aggregates of gravel and sand that are utilized in the construction of roads and buildings. Currently, these aggregates are in high demand at the on-going construction works of the Kikagati mini-hydro power plant, a short distance away from the mine. Comprehensive resource recovery, in our assessment, under present circumstances, emerges as the best performing controlling factor at Kikagati tin mining site.

Zero Waste

Consistent with the principles of the waste hierarchy, in which waste management options are ranked according to their most appropriate deployment, the use of natural resources affords access to management strategies that mean in essence that at the end of mining operations, there should be zero waste. In reality, such theoretical constraints constitute a significant challenge to traditional mining and processing techniques, particularly those which operate to exploit a single mineral. The volume of tailings, spoil or residues that may be generated in pursuit of the target mineral can, by volume, be vastly out of proportion with the volumes of the total target mineral produced. The capacity to turn these spoils into economically productive resources encapsulates the zero-waste principles.

The mining practices at the tin mining site demonstrate a solid understanding of the concept of zero waste. In particular, the only waste output at the tin mining facility is muddy water, which drains into the River Kagera. Part of this "wastewater" is also re-used for repeated phases in the ore separation process. In addition, in response to the challenges of geological uncertainty, the company's management strategy is focused around the key considerations of comprehensive resource recovery and zero waste as a business strategy. The processed waste rock from tin exploration is stockpiled as coarse gravel and as sand. Though characterized as "waste" in tin production, these "waste" rocks are donated to the local community and they have a monetary worth when sold as aggregates. That said, there are reasonable concerns surrounding its practicability and enforceability. Just as a hierarchy exists for the appropriateness of different waste management strategies, one also exists for the relative importance of mitigating the myriad impacts brought about by mining activities in Uganda.

While in theory best practice should always be aspired to when creating any management system, practicality must also feature when policy governs the jurisdiction and enforcement of operations in developing economies. For zero waste strategies to enhance rather than reduce the profitable operations of resource extraction, specific technical skills and wider sector awareness must be employed. Companies with broad linkages to the wider community, associated infrastructure and the global resource market may be seen to require a social license to operate, placing a higher value on zero waste principles.

Challenges

Tin exploration, as for most minerals with a high bulk volume to mineral product ratio and sporadic occurrence, carries significant economic and logistical challenges. While geological data can provide suggestive indications of potential mineral occurrence, actual extraction and recovery of tin is associated with uncertain outcomes in terms of total volumes of rock mined.

As previously highlighted, high demands are placed on local electricity supplies by tin mining operations, with the costs of such supply requiring offsetting by exploration success. This cannot be easily predicted in such complex geology.

The economic output of tin mining at source is enhanced where ore extraction can be combined with processing, to concentrate the tin to a level where it can be sold directly to smelting companies. In general, large volumes of processed tin are required by these companies if purchasing directly, meaning that individual small or medium sized mining enterprises remain uncompetitive if producing from a single mining site, without access to regional purchasing hubs.

African Panther Resources aspire to develop the community fund from aggregate sales into ventures able to support the local community. If the tin mining at Kikagati proves profitable in the long term, the future plan is to create further value-addition through the set-up of a brick processing plant, taking the waste material from the mine and creating higher value construction materials from it. The focus is upon how mining can contribute to linked sustainable businesses within the vicinity of the mine. The challenge in bridging the gap between aspirations and reality is investment and access to capital.

The potential for mining operations to diversify into providing materials for linked businesses depends upon whether a market exists for the mining by-products. The groundmass in which the tin occurs is geologically very different to that which is mined for other mineral resources. Blanket policies supporting or requiring value-addition when dealing with mining waste products would not be suitable for all mine sites, but access to education and financial support where such operations are deemed viable could be transformative.

Within the scope of the AMREC framework, our output recommendations for policy focus upon greater provision for access to financial support specifically for viable business plans that use mining waste as a base product. The reasoning behind this is that if centrally-regulated, it would enhance integration between commercial mining enterprises, ASM miners and mining communities as well as enabling economic gain from what would otherwise be left as waste. Central to the success of such a system would be the ability for mining operations to be able to make long term assessments of the economic viability of sites, requiring greater access to detailed geological data.

4.3 Gold—Kassanda, Mubende, Uganda

4.3.1 Geological Background

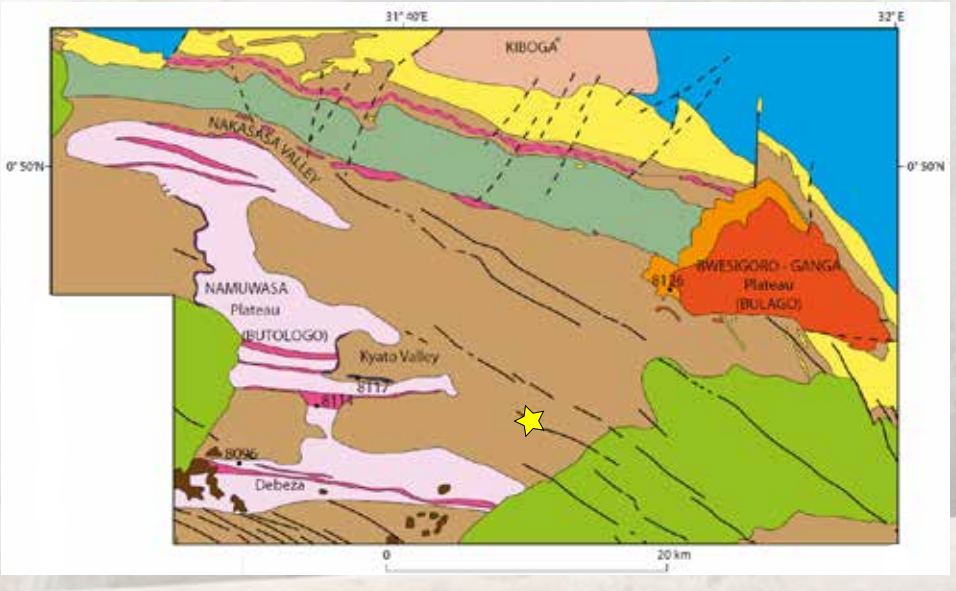
The gold at Kassanda occurs as orogenic deposits, formed during a period of compressional deformation and deposited from hydrothermal fluids derived from the metamorphism of existing sediments. Gold occurs in a variably metamorphosed calcareous sedimentary sequence called the Buganda Group. The Buganda Group comprises sediments ranging from basal conglomerates, to siltstones, shales and sandstones.

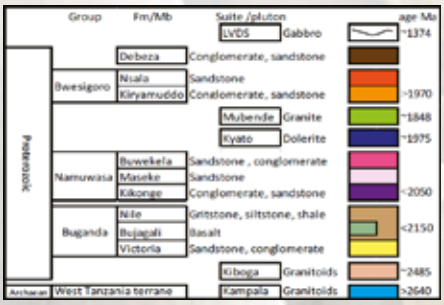
The regional metamorphism of this sedimentary sequence is associated with the E-W trending Rwenzori fold belt, with localised contact metamorphism associated with later granitic intrusions of the Mubende-Singo suite. Most parts of these granites are covered with swamps and dense vegetation, making the mapping of the boundary between the granite and the surrounding sedimentary rocks uncertain.

Alluvial gold is found in association with the weathered and eroded granite, while the Buganda sediments and meta-sediments occur in several structurally discrete belts, each with its own stratigraphy and complex structural arrangement.

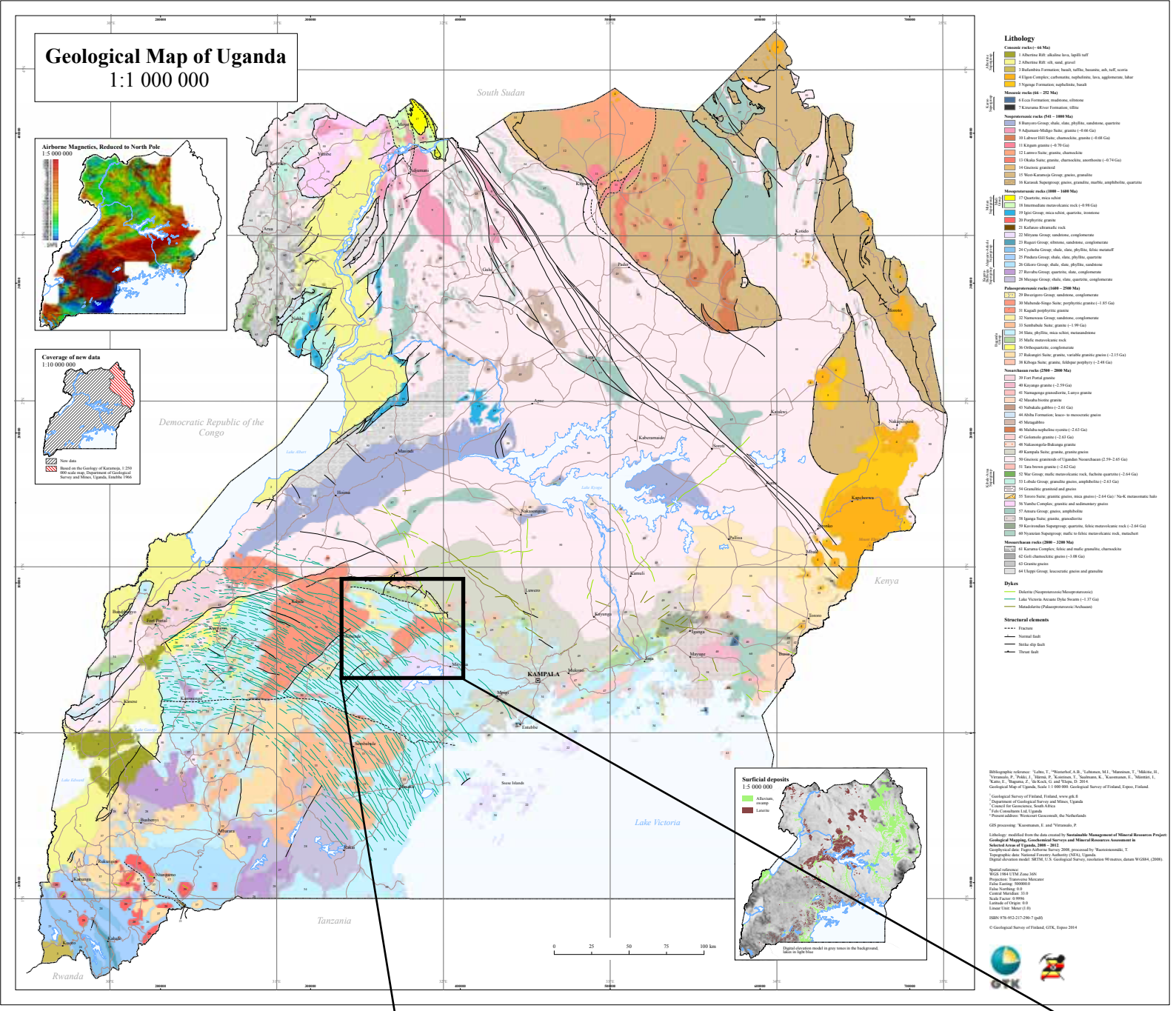
In the area around Kassanda, primary gold occurs in thin quartz veins in areas of higher-grade metamorphism along shear zones within the Buganda Group, with alluvial gold associated with the erosion of these features. The shear zone related quartz veins are heavily oxidised and subject to significant weathering. Regional mapping indicates that the extent of the shear zones are likely to be controlled by the stresses associated with a major shear zone to the South. Gold has been eroded from this shear zone and redeposited in the area as alluvial gold contained largely within gravels.

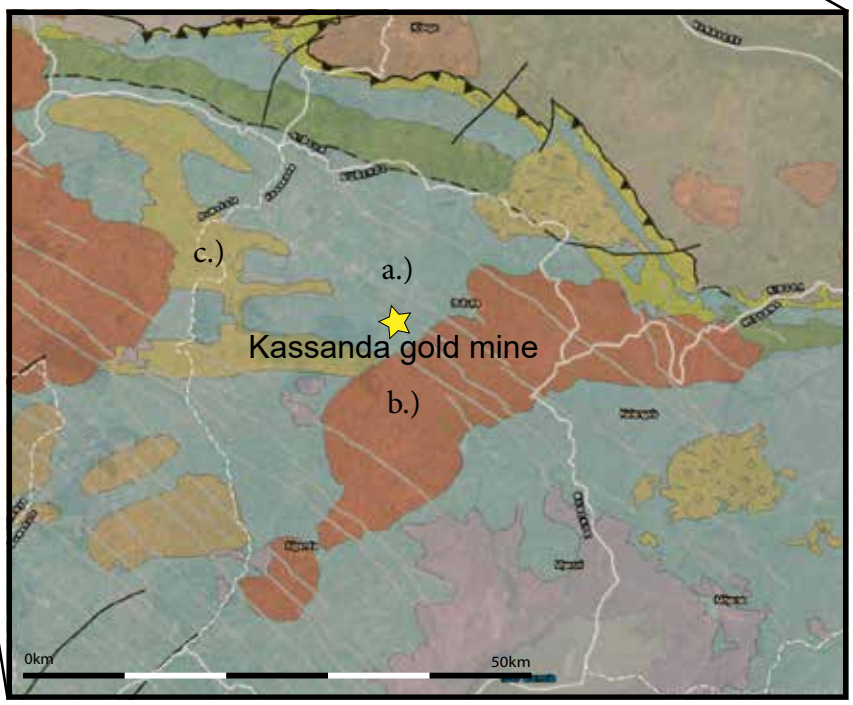
On a regional scale, it is thought that the whole roof zones surrounding the Mubende and Singo granite batholiths are potentially prospective for gold occurrences. The widespread zones of vein quartz alteration within discrete shear zones are thought to be related to mineralisation events.





Simplefied map showing the geology surrounding the Kassanda gold mine, modified after Kock and Natukunda 2014. Note the NW-SE trending fault zone on which the mine is located, with gold occurence associated with the fault deformation.





a.) Buganda Group –
Slate, phyllite, mica schist, metasandstone

b.) Mubende-Singo Suite;
porphryritic granite

c.) Namuwasa Group;
sandstone, conglomerate

4.3.2 Mining Rights and Production

Managed by Mubende United Minerals Assembly (MUMA), an association of members seeking to manage and consolidate mining outputs for community development, the gold mines located in the Kassanda-Kagaba Hills are typified by widespread but well-organized ASM activity. The mines are licensed by the government of Uganda and were the first mines to be licensed for the activities of Artisanal Small-Scale Miners (ASMs) in Uganda. The gold is currently dug from a pit approximately 150-300 ft in depth, following a vent-like vein as miners dig down to reach the gold along its length.

In addition to the creation of jobs, the gold mining in this region has been responsible for the development of local infrastructure, access roads and transport links. A specialized police security force also operates locally.

The provision of PPE and safety procedures at the mine site sets the Kassanda mine apart as unusual when compared to most other ASM ventures. Protective covers are used at the mine site to provide a barrier between the miners and the prevailing weather conditions, an oxygen supply is provided to miners in the pits and maintained sets of steps and ladders are provided to assist with pit access.

4.3.3 Assessment of project against the five controlling factors

The Gold mining project in Kassanda was assessed against the five controlling factors of AMREC. The assessment is based on a visit to the mines by the project team and responses to the project questionnaire provided by members of Mubende Miners Association and Mubende United Miners Assembly. The associations are comprised of more than 150 miners with at least 80% being men engaged in Artisanal and Small-Scale mining activities. The mining activity takes place every day with gold production in the order of grams/day.

Project Milestones and Decision Gates

The results of the survey show that most of the gold miners at Kassanda have a fair understanding of the concept of sustainable development and that they possess valid mining licenses as a first step to a managed development process. The gold mining projects in Kassanda were subject to a feasibility study prior to commencement, including the approval of an environmental impact assessment report by the National Environment Management Authority. This suggests that the early planning of the mining activity was done with an awareness of sustainable development. The survey however shows that there is no mine closure or remediation plan developed by the miners as part of that assessment. This may be attributed to the fact that such a plan is not a pre-requisite for the awarding of mining licenses by the government.

Value Addition and Beneficiation

The survey results show that most of the ASMs are aware of value addition and beneficiation concepts but have no organizational policy on value addition. This may be attributed to the fact that the mining licences they hold, as indicated by the miners, do not require them as a condition to add value to the raw mined gold. The miners use both imported and locally made tools to extract and process the gold, with mineral buyers able to purchase gold directly on site. This business model limits the opportunity for value addition and beneficiation. When asked about this significant barrier to value addition, the miners did not have a clear response and instead pointed to the fact that any change to the current model requires additional investment, for which available funds are lacking. They indicated that they are willing to add value in future, dependent upon availability of funding and technology, but currently have no plans to develop value addition practices.

Diversification

The concept of diversification is not well understood by the miners, with none of them practicing or promoting diversification as envisaged in models for sustainable development. Gold mining is the primary economic focus, with no effort made to identify and develop other economic linkages into other sectors of the economy both locally and regionally. When asked whether the livelihood of the people in the mining area has improved because of the mining activities, the respondents were positive, citing creation of jobs which increased household income for families around the mines. Some of the infrastructure developments that exist in the area include the construction of roads, water boreholes, energy sources and community clinics.

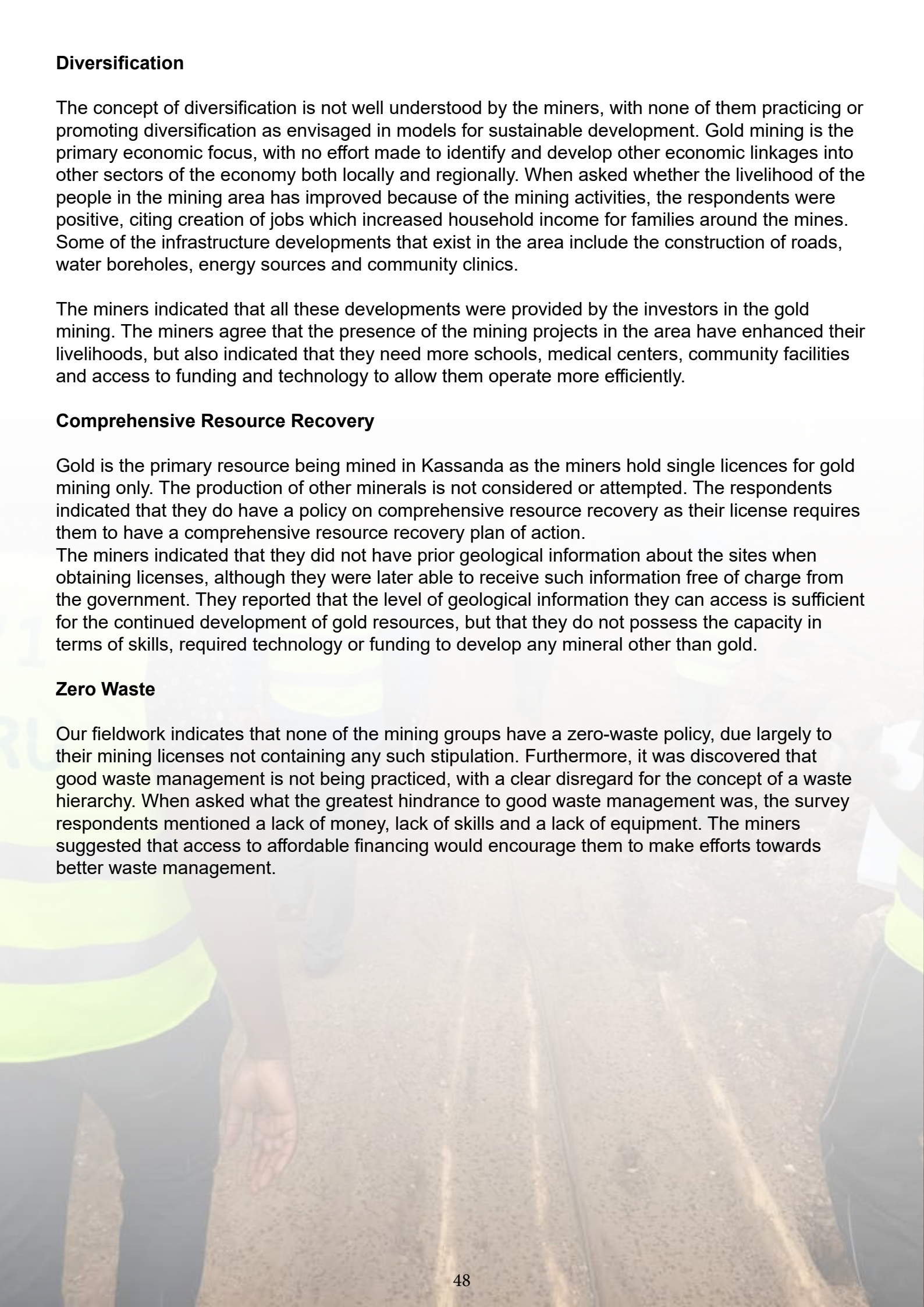
The miners indicated that all these developments were provided by the investors in the gold mining. The miners agree that the presence of the mining projects in the area have enhanced their livelihoods, but also indicated that they need more schools, medical centers, community facilities and access to funding and technology to allow them operate more efficiently.

Comprehensive Resource Recovery

Gold is the primary resource being mined in Kassanda as the miners hold single licences for gold mining only. The production of other minerals is not considered or attempted. The respondents indicated that they do have a policy on comprehensive resource recovery as their license requires them to have a comprehensive resource recovery plan of action.
The miners indicated that they did not have prior geological information about the sites when obtaining licenses, although they were later able to receive such information free of charge from the government. They reported that the level of geological information they can access is sufficient for the continued development of gold resources, but that they do not possess the capacity in terms of skills, required technology or funding to develop any mineral other than gold.

Zero Waste

Our fieldwork indicates that none of the mining groups have a zero-waste policy, due largely to their mining licenses not containing any such stipulation. Furthermore, it was discovered that good waste management is not being practiced, with a clear disregard for the concept of a waste hierarchy. When asked what the greatest hindrance to good waste management was, the survey respondents mentioned a lack of money, lack of skills and a lack of equipment. The miners suggested that access to affordable financing would encourage them to make efforts towards better waste management.



Challenges

Despite the advanced levels of organisation and HSE provision at this particular mine site, the mining methods themselves remain highly labour-intensive, with the miners facing technological challenges that could be overcome with access to more advanced tools and machinery. Gold extraction is carried out using basic manual tools such as hand-held hoes, forks, axes and shovels. Using these rudimentary tools, the miners are typically employed to dig and excavate the vein to access the gold deposits. Such basic equipment is associated with inefficient production and challenging working conditions. The choice of where to extract rock in the search for entrained gold is largely presumptive, rather than a decision based on geological data and detailed mapping. A substantial degree of intensive physical effort is based on little more than luck.

The extracted rock is stored in sacks before being taken to the processing centre, where it is crushed into powder. The powder is then filtered and sieved using water to check for gold occurrence. If gold is found, it is harvested and sold in its raw form, with no value-addition processes followed beyond the manual separation of raw gold from sediment. No evidence was observed of any kind of formal skills training with regards to understanding the local geology, advanced mining techniques or processing of gold into products that would enable local value-addition.

While the Kassanda mine is an important case study for aligning to the aspirations of the AMREC framework in some aspects, particularly with regards the efforts to provide a safer working environment for the miners and the security offered by the provision of a governmental licence for land tenure, there are opportunities for socioeconomic development currently being missed.

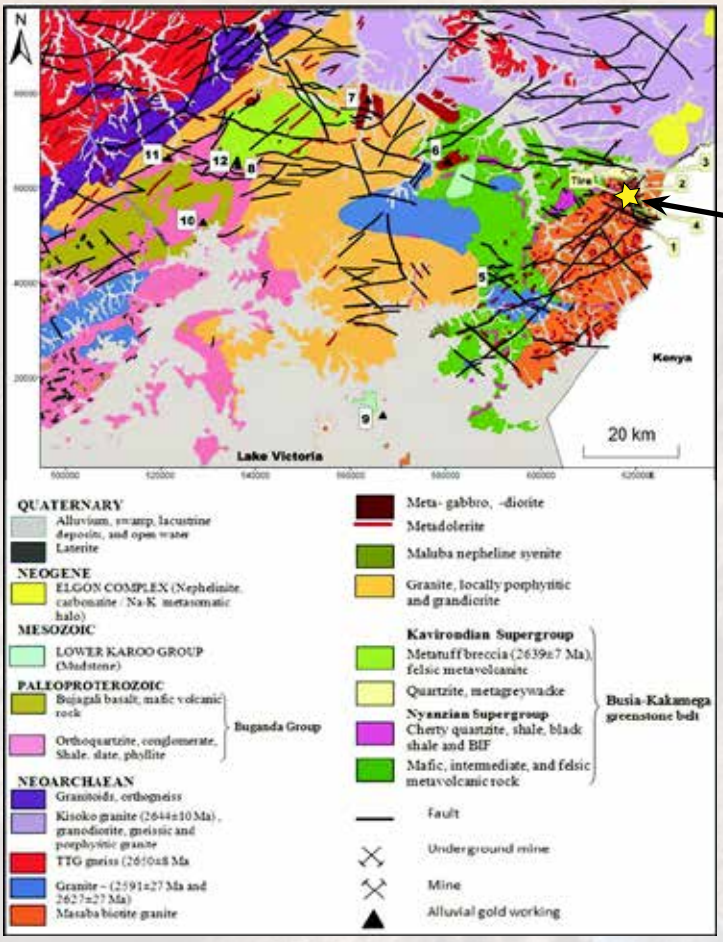
4.4 Gold— Tiira, Busia, Uganda

4.4.1 Geological Background

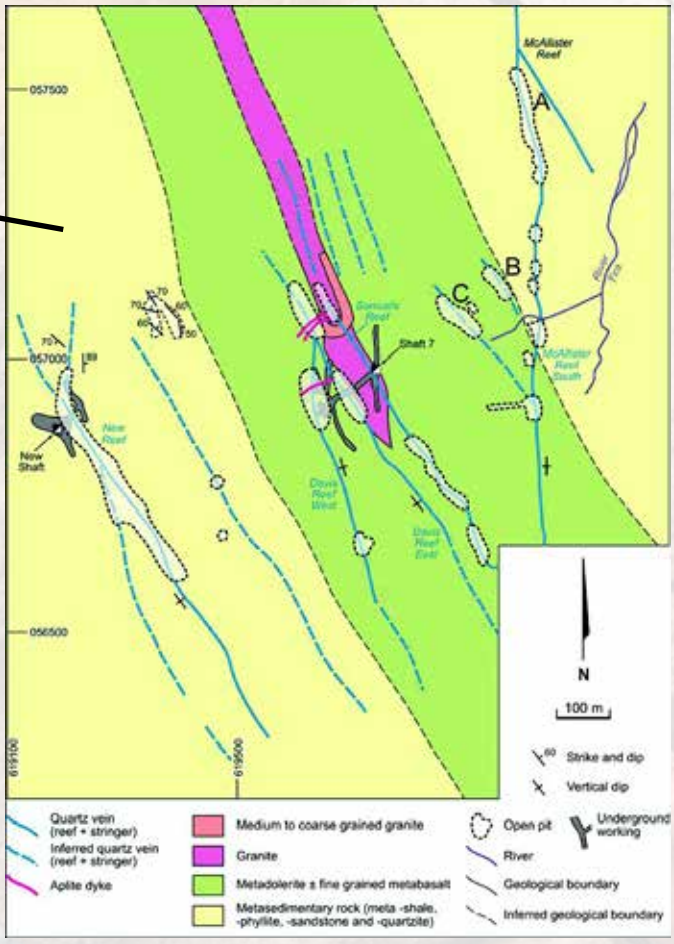
Gold at Tiira occurs in ancient Neoarchean rocks within the Busia-Kakamega granite-greenstone belt, part of the Tanzania Craton, an area covering Northern Tanzania, Western Kenya and SE Uganda. The craton is composed of high-grade metamorphic rocks and granitic bodies. At Tiira, gold is found in the Nyanzian Supergroup suite of rocks, which is formed largely of metabasalts and felsic to intermediate volcanic rocks and low-grade metasediments. These have been thermally metamorphosed in proximity to large granitic intrusions. The area is subject to a complex geological history, with a series of separate igneous intrusive events, volcanic eruptions and associated metamorphism.

The occurrence of gold-bearing rocks at Tiira are structurally-controlled, with gold occurring in epigenetic quartz veins in highly deformed shear zones associated with steep faults, most of which trend NE-SW. The veins are hosted within carbonate-altered mafic metavolcanic rocks that occur in close proximity to metasedimentary rocks, largely shales, phyllites and quartzites. The shear zones contain quartz veins up to 2m wide, with associated smaller veinlets known as stringer veins. The gold content along the veins is sporadic, with their occurrence subject to significant structural complexity as a result of intense faulting and fracturing.

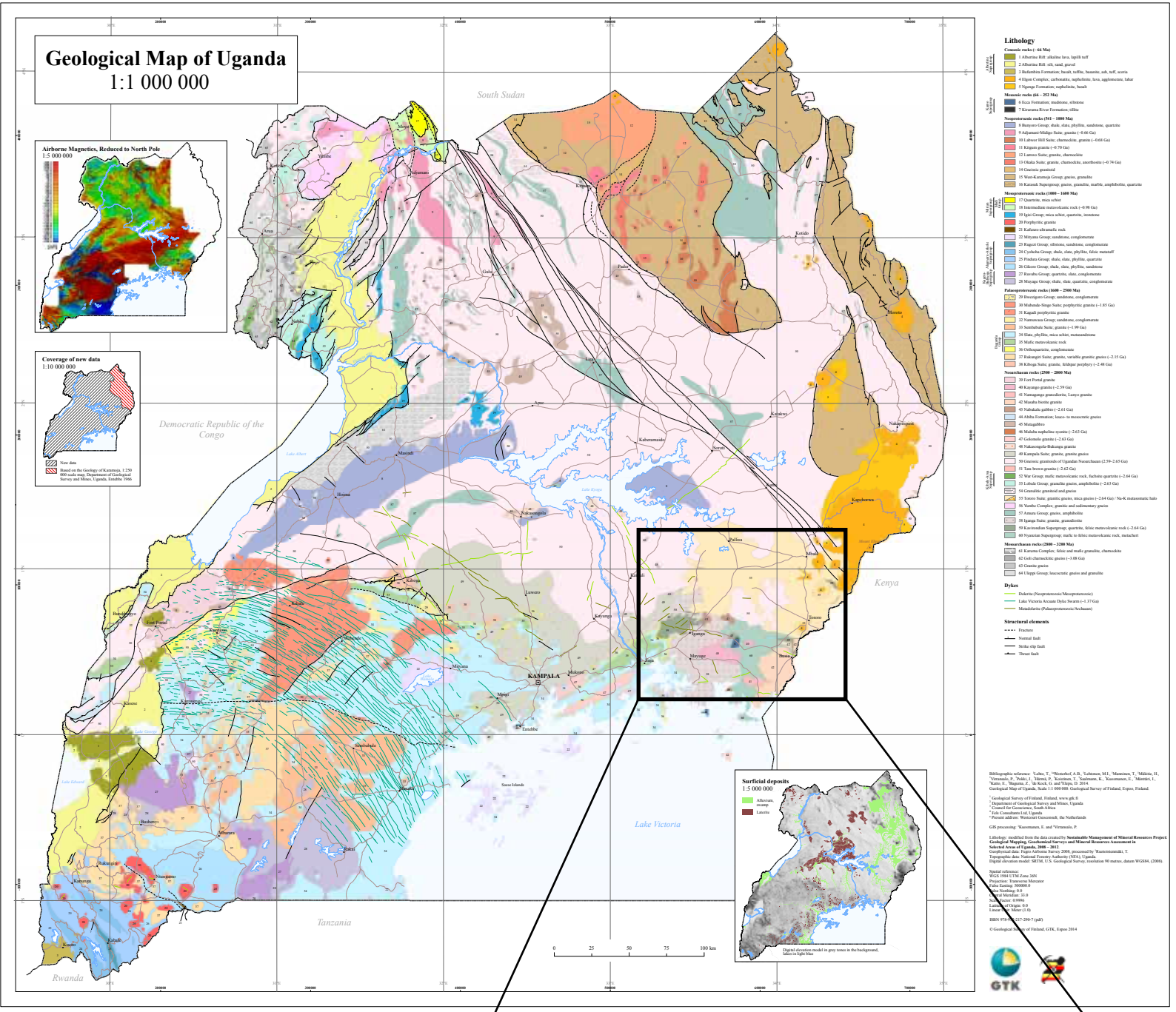
Gold is reported to have been mined at Tiira since the 1930s, with numerous associated alluvial gold ASM operations having been developed in the region since. The mine at Tiira was closed from the 1950s to the 1990s as it was deemed unprofitable.

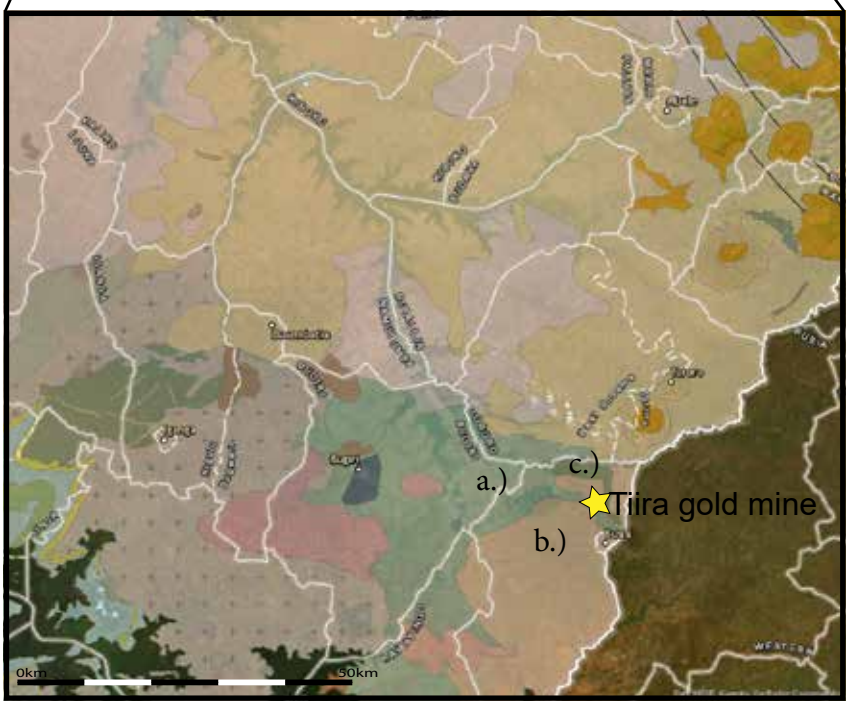


Geological map of the Busia gold district (modified after Nyakecho & Hagemann 2014)



Geological map of the Tiira mine site (modified after Nyakecho & Hagemann 2014)





a.) Nyanzian Supergroup; mafic to felsic metavolcanic rock, metachert

b.) Masaba biotite granite

c.) Kavirondian Supergroup; quartzite, felsic metavolcanic rock

Mining Rights and Production

In a similar process to that seen at Kassanda, sacks of mined rock are taken to milling stations where the gold-bearing rock is crushed and dry-milled into a fine powder in a metal ball mill. The powder is then mixed with water and washed in a large tub to separate out the gold from the powdered rock. Mercury is added to the tub as this amalgamates with the gold, making the process of separating it out from the rock quicker and easier. The final amalgam of gold and mercury is then heated over a fire, which evaporates off much of the mercury, leaving a small fraction of mercury and the concentrated gold. The mine produces approximately 3kg of gold per month.

4.4.3 Assessment of project against the five controlling factors

The gold mining project in Tiira was assessed against the five controlling factors of AMREC. The assessment is based on a visit to the mines by the project team and the responses to the project questionnaire provided by six respondents. The respondents were mainly members of Tiira Landlords and Artisanal Miners Association and Tiira Small Scale Mining Association.
As the names suggest, the associations bring together mainly Artisanal and Small Scale miners in development activities involving over 400 miners with men constituting over 70% while women constitute the rest with few minors. The mining activity takes place every day with gold production in the order of grams/day.

Project Milestones and Decision Gates

The results of the survey show that most of the gold miners at Tiira have a fair understanding of the concept of sustainable development and possess valid mining licenses as a first step to the sustainable development of local mineral resources. Our fieldwork uncovered that while the gold mining project in Tiira underwent a general feasibility study, less than 50% of the sites have approved environmental impact assessments. This may be attributed to some of the miners being unaware of the need to carry out EIA or they may be ignoring the requirement. The survey also shows that there is no mine closure or remediation plan put in place by the miners, which may be attributed to the fact that such a plan is not a pre-requisite for the award of a mining license. All survey respondents agreed that it was difficult to obtain a mining license from the government.

Value Addition and Beneficiation

Value addition is a common term, with the survey results indicating that most of the ASMs are aware of it, but have no associated policy. It was not clear whether the mining licences held by the ASMs have a condition for value addition as conflicting responses were given as to whether or not value addition is a requirement of the mining license. It was noted that the ASMs mainly rely on regional gold buyers operating directly on site, this process limits the opportunity for value addition which denies the miners its potential benefits. Amalgamation of the raw gold is the peak of its processing on site. When asked about the greatest barrier to value addition and beneficiation, the respondents mentioned lack of skills, lack of financial resources and machinery and lack of technology to facilitate value addition. They advocate for setting up value addition centers regionally to train and build the experience and capacity of miners but this also necessitates the provision of financial support together with conducive policies and laws that will promote value addition as being widely obtainable.

Diversification

The concept of diversification is largely understood by the miners. However, most of them do not practice or promote diversification as their sole economic activity and skills focus is the mining of gold. Some practice subsistence farming and have small businesses on the side. The miners questioned do agree that the mining projects in the area have somewhat improved the livelihood of the people as they have been able to build their houses, jobs have been created and improved infrastructure like roads have brought a few services like clinics closer to the people. They are also able to educate their children, something they would not be able to do without the mining activities. They attribute the improvement in livelihoods to both government and the investor influence. When asked what they want the authorities to do to improve the lives of the community further, the miners mentioned rural electrification, vocational institutions and financial support to add value to their gold and to open up new markets for their gold.

Comprehensive Resource Recovery

As with the other sites visited, gold is the primary resource being mined in Tiira with less attention being paid to any other minerals as the miners hold single licenses for gold mining only. The fieldwork respondents indicated that they don't have a policy on comprehensive resource recovery even though the license they hold requires them to have a comprehensive resource recovery plan of action. Even though the miners had obtained prior geological information about the sites, the information was not readily available in the public domain as they had to pay for access to be granted by government. A few respondents did indicate that they obtained some geological information free of charge from a private source. When asked what process they would follow upon discovering a mineral resource other than gold, the respondents indicated that they would notify the government, but in most cases, the miners do not possess the technical or financial capacity to detect and develop the discovery of a new mineral resource.

Zero Waste

Half of the survey respondents indicated that their mining license requires them to have a zero-waste policy but none of them actually have one. It was clear that none of the sites were practicing good waste management, with no concept of a waste hierarchy. None of the sites were making efforts to prevent waste build-up. The only re-use strategy for the waste is to sell the rocks as construction materials and murram for making roads. There are no efforts made to recycle or treat the mining waste. The biggest challenge in applying the concept of zero waste, as indicated by the respondents, include lack of skills, technology and finance. A common theme across all of the fieldwork sites. The miners suggest that with the provision of targeted funding and sensitization together with relevant training, the ASMs would make efforts toward the attainment of a zero-waste aspiration.

5 Conclusions

Minerals constitute the building blocks of almost all products, from bricks to the components for complex electronics, they empower society and fund modern economies. Through the creation of jobs, both directly and indirectly, the receipt of tax revenues and the collection of foreign exchange earnings, the mineral resource economy can be a primary driver of economic development as well as a force to stimulate regional and global cooperation. Where one nation has a resource another wants, if managed correctly, with integrity, it can develop a relationship of mutual benefit. Uganda's complex geological history from ancient Archaen terranes to modern tectonic processes has left a legacy of substantial reserves of lucrative minerals such as gold, platinum, tin, tungsten and tantalum, among many others. Quality building materials such as marble and granite are also found in abundance.

The Uganda Mining Sector Performance Report 2020 reported a 1:50,000 scale coverage of geological maps in Uganda for 26% of the country, up from 18% in 2018, with 1:100,00 coverage standing at 78%, up from 52% respectively. Geochemical mapping covers 38% of the country, while airborne geophysical mapping covers 80% of the country's land area. This has however correlated with a decline in mineral revenues over that same period. The declared value of Ugandan mineral production was UGX 158.754Bn ($44.6m US) for 2018, UGX 154.5Bn ($43.3m US) for 2019 and UGX 141.8Bn ($39.8m US) for 2020. This raises the question as to whether a lack of accessibility to geological data for Uganda is impacting upon the development of the minerals sector. Regional geological mapping is carried out by the Ugandan government, with the data not easily obtained in the public domain.

Added to this, a quantifiable reflection of whether the Mining Act 2003 remains fit for purpose was in the surveying of license holders in Uganda by the government in 2020. The survey found that an average of only 20% of the mineral rights reviewed were compliant with the terms of the Mining Act 2003. If enforcement action serves to potentially outlaw up to 80% of licensed mining operations, then clearly a different approach is required.

There are over 726 Artisanal and Small-Scale Mining entities in Uganda, and the government has initiated the process of biometric registration of all ASMs in the country. To enhance regulatory and production efficiency in Uganda's mining sector, several initiatives have been implemented. These include an online Mining Cadastre and Registry System (MCRS) for the streamlining of license applications and renewals, an airborne Geophysical Survey of Karamoja to add to existing geophysical data, and a Regional Mineral Certification System (RCM) to certify and track minerals sourced in Uganda. While these represent positive steps in the formalizing of the sector, they fall short in addressing the reasons why mineral extraction processes, particularly through ASM, do not adhere to current policy governing the mining sector. Investment in ASM communities needs to be proportional to the potential revenue that could enter the local and national economy if their operations were supported in aligning to the AMREC framework.

Steps are being taken within Uganda to promote mineral investment, including developments such as the revamping of mineral laboratories and the training of staff who work within them, acquisition of new geoscientific data for the exploration and development of several mineral resources and the development of geothermal resources. There are strong indications that support exists for a progressive mining regime in Uganda at policy level, but compelling gaps that threaten to undermine attempts to formalize the ASM sector remain.

Most mineral production and associated employment in Uganda is widely attributed to the ASM sector (Barreto et al., 2018). The ASM sector's economic contributions to the national and local economy are poorly quantified, poorly understood and highly informal. The lack of value-addition to almost all produced resources only compounds the difficulties faced during attempts to place a monetary value on Ugandan raw mineral resources mined to date. Performing a reasonable comparison between this unknown figure and one that could feasibly be attained through the process of local value-addition is made even more complex.

The AMREC framework seeks to enable the process by which a relative value is placed on Uganda's resources, not just in terms of foreign exchange and economic derivatives, but also the value of land itself for a diversified economy, as a community asset and as a natural habitat. In a sector that serves to provide an income for some of the poorest communities in the region, it can be counterintuitive to attempt to prioritize long term development and environmental goals if they are not considered in tandem with the needs of the community and the reasons why mining is taking place to begin with.

Financial capital to enable a realization of fair earnings and access to skills development that can allow individuals and companies to make informed development decisions is almost impossible to access if a relative monetary value cannot be placed on both the resource, its potential and the worth of the environment from which it is derived. Mineral resource policy is currently becoming more and more aligned to placing a value on specific minerals, but their potential value through value-addition and associated diversification and the value of the environment as a community asset is still largely lacking. The challenges of financial constraints at a local and national level were raised during interviews with the salt and gold miners. Inadequate energy provision, infrastructure and supervision of the minerals sector were identified as all linking into the larger issue of a lack of access to capital.

6 Recommendations

An assessment of the divergence between existing policy and the AMREC framework has identified the following recommendations as part of a move to seek to enhance investment in the Ugandan minerals sector:

I. Enhance the provision of geological and geospatial data: Sustainable mineral resource development and use starts with the availability of consistent, reliable and accessible geological data. Such data is particularly crucial in attracting commercial investment, focussing exploration efforts and in assessing the economic viability of identified resources. It is vital that any existing data be accessible for those who cannot access high levels of start-up capital, such as ASM miners. There exists a sense that geological data has a monetary worth, cost money to procure, and so should be sold at a high price. Our express recommendation is that the true worth of geological data is only realised when it is easily and freely accessible, enabling a maximum number of people to interpret it and use these interpretations as the basis of investment decisions.

I. Formalize the Artisanal and Small Scale Mining (ASM) sector. Uganda's mineral extraction sector is dominated by ASM mining practices. While ASM in principle makes a substantial contribution to the economic growth of the regions in which it exists, its potential to underpin viable, sustainable businesses is undermined by the mining techniques that typify it. Highly labour intensive, potentially unsafe working practices need to be transitioned into operations that are properly planned. Formalizing implies mainstreaming the ASM operations in the national mineral resource registry and providing an enabling regulatory environment. This process aligns, strongly with the AMREC framework, particularly the promotion of project milestones and decision gates throughout the development of a mineral resource. Formalisation must view ASM primarily as a means to provide economic stability to impoverished communities, the development of which can lead to economic development at a national level.

III. Increase the Skills and Technical Capacity of workers within the ASM sector through targeted campaigns. Skills capacity building is critically needed to improve the extraction, processing and trading methods employed by miners. A greater awareness of the environmental impact assessment process is also required within Uganda's mining sector. Training of miners is required throughout the entire mining value chain. Practical demonstration institutions, ideally based at working mine sites and regional training centers could reduce existing skills gaps and consequently enhance value addition and diversification targets.

IV. In order to promote sustainable working practices, effective environmental impact assessments are needed. Miners need to understand why they are needed and how they make provisions for long term land management. There is need to make the requirement for a feasible mine closure or decommissioning plan and environmental and social impact assessment a pre-requisite for granting mineral rights. This should be in addition to training the miners in how to comply with the requirements of the National Environment Act, 2019 and regulations made under that Act. The biggest challenge to applying the concept of zero waste for instance, was indicated by the respondents as including a lack of skills, a lack of finance and a lack of applicable technology. The miners suggest that with the provision of targeted funding and sensitization together with relevant training, the ASMs would make efforts toward attainment of zero-waste aspirations as its significant as being of long term benefit to themselves and their community would be understood.

V. Prioritise efforts to promote the process of value-addition. A pervasive and fundamental challenge to Uganda's mining sector is the lack of value addition to raw minerals. Their value within Uganda is anomalously low when compared to their value in the global marketplace. Deliberate action is required to raise the value and competitiveness of Ugandan mineral resources. For instance, as a requirement, export of raw minerals should be deliberately discouraged not through export bans, but by establishing mineral processing plants and industries that use Ugandan minerals as a base product within Uganda. Many of the survey respondents mentioned a lack of skills, a lack of financial resources and a lack of machinery or technology to facilitate value addition. They advocate for setting up value addition centers regionally to train and build the capacity of miners but also the provision of financial support together with conducive policies and laws that will promote value addition. This was the main hindrance to investment in requisite technology for downstream mineral development. In addition to this, some processes such as tin smelting, require significant electrical supplies, which in Uganda is both expensive and unreliable. This operating resource barrier restricts the company's value addition efforts to extraction and clean-up only prior to export. There exists a need to include a condition in the mineral rights granting process requiring value addition and beneficiation.

VI. Prioritise the development of infrastructure aimed at boosting non-mining economic activities and adopting economy-wide integrated approaches in mineral resource management. This is paramount in promoting diversification in the minerals sector.

VII. Establish a center at the Makerere University Business School (MUBS) to build upon this pilot project and continue to undertake research into the capacity of the Ugandan minerals sector to provide net benefits to the Ugandan people, especially in relation to principles highlighted by the AMREC framework. The principles are formed to signpost the way along a process for which resource wealth can be realised as social and economic development.

VIII. There is need to broaden the pilot project to cover other minerals and mining sites. A recommendation is made to continue the collaboration with MUBS and Heriot-Watt University by applying this same process demonstrated in this study to other African Countries.

IX. Promote pathways to facilitate access to financing. The lack of access to financing is a major impediment for many ASMs and mining companies in efforts to add value, increase investment and improve mining methods. Access to affordable financing will enable the miners to adopt the use of modern technologies and it will encourage them to make efforts towards comprehensive resource recovery and good waste management strategies, enabling long term sustainability.

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