INVESTIGATING THE TECHNICAL, FINANCIAL AND REGULATORY CHALLENGES IN THE ZAMBIAN GEMSTONE MINING SECTOR: A CASE STUDY OF GEMCANTON INVESTMENT HOLDINGS LIMITED

By

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DECLARATION

I Muketekelwa Mashikinyi hereby declare that this thesis is my own work. To the best of my knowledge this work has not been submitted for a degree in any other institution of higher learning. The thesis contains no materials previously published or produced by other parties, except where due acknowledgement is made in the text.

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ABSTRACT

In Zambia, copper mining has largely overshadowed the exploitation of other potential minerals. Recent developments have shown that, gemstone mining, namely emeralds and amethysts have begun to assume a significant role. In the past two decades, Zambia has become one of the major gemstone producing country accounting for approximately 40% of the world's emerald production. With the strong and ever increasing demand of gemstone on the world market, sourcing of gemstones has become one of the industry's biggest challenge. In Zambia, there are over 500 gemstone licences, of which majority has not advanced technologically due to several factors such as technical mining and geological factors; lack of finances; regulatory and instructional frameworks and others, hindering its development. Consequently, this limitation has an effect on the social development of the gemstone sector and the national economy at large.

The main objective of this study was to investigate the technical, financial, regulatory and other challenges affecting the gemstone mining sector in Zambia. A case study of Gemcanton mine (formally, Grizzly Mining Ltd) was used for the investigation. The data was collected through administration of questionnaires, interviews, observation and available data from various sources.

The results from the study have shown that the prevailing technical challenges within the study area include: extreme difficult in defining the orebody (resource/reserve estimation); the presences of induced cracks in gemstones; lack of appropriate mining equipment; lack of geological and mining skills in most of the mines; limited area for mine development and expansion as well as dumping areas; and poor occupational safety standards. In terms of financial context, the challenges that were observed are: lack of start-up capital; lack of working capital; lack of credit facilities; Lack of collateral; lack of marketing; lack of financial statements by gemstone miner; lack of business and management skills; and price fluctuations. The regulatory structures revealed challenges such as difficulties in land accessibility, poor infrastructure in the mining sites in terms of roads and electricity, lack of marketing strategies for gemstones in Zambia, smuggling of gemstones and legal recognition.

Therefore, it can be concluded that there are quite a number of factors affecting the growth of gemstone mining in Zambia with the most prevailing being in association high geological risks aforementioned above. Furthermore, lack of start-up capital appears to be another key challenge being faced by gemstone sector. In view of the notable challenges encountered in the gemstone sector, this study recommends that there is need to review the mineral resource policy established in 2013 in line with the seventh national development plan on exploitation of gemstones and industrial minerals in Zambia.

DEDICATIONS

I dedicate this work to my parents, Mr Mashikinyi Bestone Muketekelwa and Mrs Josephine Mwansakombe for their excellent parental guidance throughout my life. I will always be indebted to them.

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ACRONYMS

Abbreviation	Description
ADT	Articulated Dump Trucks
ASM	Artisanal and Small-Scale Mining
AZ	Alteration Zone
CEE	Citizens Economic Empowerment
EBZ	Export Board of Zambia
ESMAZ	Emerald and Semi-Precious Stones Mining Association of Zambia
FNB	First National Bank
FNDP	Fifth National Development Plan
GDP	Gross Domestic Product
GIS	Geographic Information System
GML	Gemstone Mining Licence
ICT	Information and Communications Technology
ILO	International Labour Organisation
KM	Kilometres
MDC	Mining Development Corporation
MMD	Ministry of Mines and Mineral Development
MSD	Mine Safety Department
MSRF	Mining Sector Revolving Fund
NRERA	Ndola Rural Emerald Restricted Area
PESTEL	Political, Economic, Social, Technological, Environmental and Legal
PF	Patriotic Front
ROM	Run of Mine
SNDP	Seventh National Development Plan
SMEs	Small and Micro Enterprises
SSM	Small Scale Miner
SWOT	Strengths Weakness Opportunities and Threats
TMS	Talc Magnetite Schist
UCS	Uniaxial Compressive Strength
UK	United Kingdom

UN	United Nation
USD	United States of America Dollar
VWF	Vibration White Finger
WHO	World Health Organisation
ZCCM	Zambia Consolidated Copper Mines
ZEMA	Zambia Environmental Management Agency
ZRA	Zambia Revenue Authority

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Zambia's mineral resource base is substantial and its mineral wealth consist of metals, gemstones, industrial minerals, agricultural, building and energy minerals (Zambia Development Agency, 2015) and the economy derives foreign exchange earnings from export of its minerals. A wide range of minerals occurs in the country but the mining industry has been dominated by copper and a few other metals namely lead, zinc, silver, gold and cobalt. Although the predominant position of copper mining in the economy has largely overshadowed the exploitation of other potential mineral resources, in recent years, gemstones, namely emerald and amethyst have begun to assume a significant role. The gemstones of Zambia include emeralds, amethysts, aquamarines, garnets, tourmalines, rose quartz, agate, amazonite, coloured quartz and others.

In the past two decades Zambia, has become a significant gemstone producing country accounting for about 40% of the world's Emerald production (Seifert, 2004). The Emeralds are recovered exclusively from the Kafubu area of the Lufwanwama district on the Copperbelt where they are hosted by Muva-age talc schists intruded by tourmaline- and phlogophite bearing pegmatite bodies. Aquamarine and tourmaline are mined in the Lundazi and Nyimba areas of eastern Zambia, while amethyst is being mined in the Mwakambiko Hills near Lake Kariba. The major deposits of gemstone in Zambia are shown in the Figure 1.1 below.

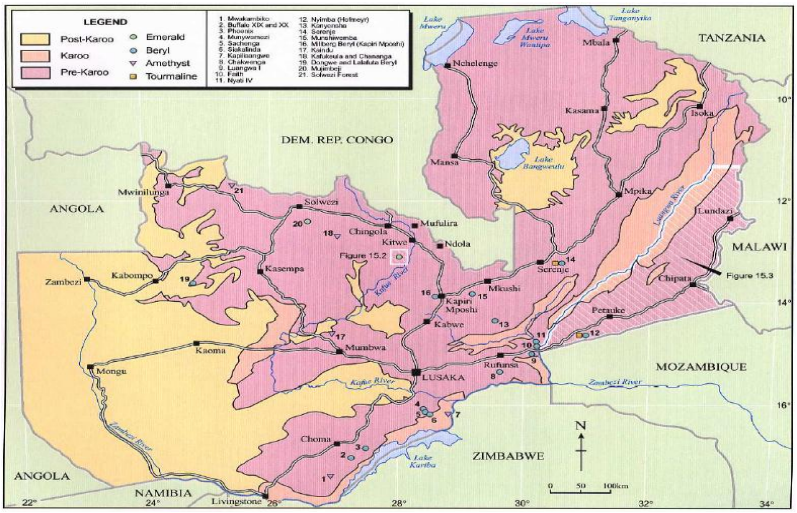


Figure 1.1: Map of Zambia showing major Gemstone Deposits

Gemstone production contributes significantly to Zambia's economy with high quality emeralds being the most important in terms of revenue. Commercial emerald production originates from four main source countries: Colombia, Zambia, Brazil, and Zimbabwe (Geology.com, 2016), with Columbia as the main source seconded by Zambia. The ever-increasing demand for coloured gemstones has made the sourcing of these fine gems one of the industry's biggest challenge (Hall, 2004).

The Kafubu emerald deposits are situated in the Ndola Rural Emerald Area (NRERA), which is located on the Copperbelt Province in Zambia, covering an area of approximately 700 km^2. Although the emerald fields have been known and exploited since 1928, very little systematic geological investigation and limited production has taken place. In fact, the majority of the emerald deposits have historically and to this day been the preserve of artisanal miners who have not had the capital or cash flow to encourage professional exploration/exploitation of the area.

1.2 Problem Statement

According to Seifert (2004), there are over 500 mining licence areas within the Kafubu area of Zambia's Lufwanyama district of which these resources have not been transformed into wealth to satisfactory manner. The contribution of the gemstone mining sector to the national economy and social development does not meet the expectations of the people. The majority of the license areas have not been developed, due to a number of technical factors such as geological and mining challenges associated with gemstone mining, lack of finances, regulatory and institutional frameworks and other factors. This research focuses on identifying the aforementioned constraints that have affected gemstone mining in Zambia. Gemcanton Mine will be used as a case study to illustrate how these challenging factors have affected the sector. Unemployment and poverty evidences are painful, yet these are some of Zambia's fundamental statistics that cannot be put aside. According to Statistics of Zambia the current unemployment rate is at 25.5% of the workforce, with approximately 10 million people subject to poverty. Addressing the constraints affecting gemstone mining could actually solve the issues of unemployment and poverty as it is believed the mining industry in Zambia is one of the major employer of its citizen. Moreover, other relevant social and environment challenges are considered.

1.3 Research Questions

a) What are the technical and financial constraints affecting gemstone mining?
b) Do miners have the basic technical, business and management skills?
c) What are the causes of lack of funding for the sector?
d) What challenges does the regulatory and institutional framework impose on the gemstone sector development?
e) Are there pieces of legislation that require changes to facilitate sector development?
f) What role has government played in promoting sector development?

1.4 Objectives

1.4.1 Main Objective

The main objective of the research is to investigate the technical, financial, regulatory and other challenges of the gemstone mining sector in Zambia.

1.4.2 Specific Objectives

a) To identify the geological and mining challenges associated with gemstone (emerald) mining
b) To identify the financial, marketing and business capacity challenges associated with gemstone (emerald) industry
c) To review the government regulations and institutional policy on the gemstone mining sector.
d) To highlight possible strategies that can be employed to address the challenges faced in the gemstone industry.

1.5 Significance of the Study

By addressing the technical, financial and regulatory challenges of the gemstone sector, its anticipated that the sector will advance technologically which in turn will bring about economic growth in the country. Additionally, other social and environment factor of the gemstone sector will be investigated so as to advise policy makes come up with ways of reviving the sector.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the available literature on the gemstone mining sector. It begins by providing the background information of mining in Zambia and the followed by information for the gemstone mining sector. It also highlights definitions, challenge, financial institutions, policy and regulations and other relevant information to this research study

2.2 Mining in Zambia

Zambia has a mining history which spans over ninety years including the late 1960's, when Zambia was the world's third largest copper producer, after the United States and the former Soviet Union. Mining was and remains central to the Zambian economy. It has played a key role in the social and economic development of the country (Zambia Development Agency 2015).

Zambia has predominantly been a copper mining country being one of the top two largest copper producers in Africa (Zambia and Congo DRC) and the world's seventh copper producer. In the 1970's, copper production in Zambia reached its peak (700,000 tonnes). Subsequently, falling copper metal prices caused annual production to drop to 200,000 tonnes in the late 1990's. Since the early 2000 following completion of the privatisation of the mining sector, Zambia's mining sector has recovered sharply.

The global commodity market experienced a surge in commodity prices including copper price in the between 2007 and 2010. This development resulted in major investment commitments by large mining companies in Zambia which saw the country's copper production surpassing its peak recorded in 1972 of 700,000 tonnes.

Although the global commodity prices have somehow slowed down due to economic growth stabilisation and in some cases slowdown in mainly Asian economies such as China, Zambia has continued to attract foreign direct investment in the mining sector and this has supported the increase in copper than other metal production. Copper production has increased from 572,793 tonnes in 2008 and raising to over 800,000 tonnes in 2013 and slowed down to below 800,000 tonnes in year 2014. It is however,

projected that copper production will reach 1,500,000 tonnes by the year 2018 on account of new mining projects that are currently under development arising out of earlier investment commitments from investors.

The mining sector has attracted investment in excess of USD 8 billion since the year 2000 creating over 80,000 jobs by the year 2013 up from 27,000 jobs in the year 2000. These employment levels have stabilised around 70,000 during the year 2014 but expected to increase following the commissioning of new mining projects on the Copperbelt Province and North Western Zambia. It is projected that investments in the mining sector will reach approximately USD 15 billion on account of new projects under implementation and/or exploration by the year 2020 if the international average metal prices hold above those recorded in the year 2014 (Zambia Development Agency 2015).

Zambia's endowment of mineral resources is substantial and the mineral wealth includes metals, gemstones, industrial minerals, agricultural, building and energy minerals. Production of metallic minerals dominates the mining sector. Nevertheless, the full potential of these and other known mineral deposits is yet to be realised creating greater exploration opportunities.

2.3 Gemstone Mining in Zambia

In the past two decades, Zambia has become a significant gem-producing country within Africa, with good quality emeralds, aquamarines, amethyst and tourmalines being produced. Zambia is one of the world's most significant sources of fine-quality emerald and has been called the second most important producer by value after Colombia (Suwa, 1994; Giuliani et al., 1998). For years, the mines in the Kafubu area (near the Kafubu River in the Ndola Rural Restricted Area) have produced emeralds of uniform colour and size.

2.3.1 Background

According to Sliwa and Nguluwe (1984), beryl mineralization was first discovered in the Kafubu area (at a locality that later became known as the Miku mine) in 1928 by geologists working for the Rhodesia Congo Border Concession Co. Although initial investigations did not reveal good-quality gems, Rhokana Co. and Rio Tinto Mineral Search of Africa continued small scale exploration work into the 1940s and '50s. In

1966, the claim was passed to Miku Enterprises Ltd., and in 1971 the rights to the Miku area were taken over by Mindeco Ltd., a government-owned company. The region was subsequently mapped and the Miku deposit verified by Zambia's Geological Survey Department (Hickman 1972, 1973).

During the 1970s, when local miners discovered several more deposits, the Kafubu area became a major producer of good-quality emeralds. Due to the significant economic potential and extensive illegal mining, the government established a restricted zone and forcibly removed the population of this sparsely inhabited area.

In 1980, a new government-controlled agency, the Reserved Minerals Corp., took over the major deposits and prospecting rights to the surrounding region (Sliwa and Nguluwe, 1984). Kagem Mining Ltd. (owned 55% by Reserved Minerals and 45% by Hagura, an Indian-Israeli corporation) was authorized to conduct exploration and mining in the Kafubu area. A privatization agreement was signed between Hagura and the Government of Zambia in May 2001, and the transfer of shares was completed by the government.

Outside the Kagem properties, which lie on the north side of the Kafubu River, the emerald area has been subdivided into nearly 500 prospecting plots. However, many of these claims were established without the benefit of a thorough geologic evaluation. Small-scale mining currently takes place on dozens of claims, whereas mechanized activity is mostly concentrated on the Kagem, Grizzly (Gemcanton), Chantete, and Kamakanga properties (Zwaan J.C, 2005).

2.3.2 Geology of the area

Geology plays a key role in determining which actors engage in production. Deeper and more concentrated primary deposits require significant investment to extract, but may deliver greater returns; these tend to be developed by companies. More dispersed and accessible secondary deposits (also commonly referred to as "alluvial deposits") may be mined by citizens using small-scale and artisanal methods (Shortell P, 2017).

Regional Geology. The region encompassing the Zambian Copperbelt and the Kafubu area comprises a complex assemblage of geologic units that evolved during three successive orogenies of mostly Proterozoic age. The emerald deposits are hosted by metamorphic rocks of the Muva Supergroup (Daly & Unrug, 1983) that overlay

the basement granite gneisses along a structural unconformity. The Muva rocks consist of quartzites, mica schists, and metabasites. Emerald mineralization is hosted by the metabasites, which consist of talc-chlorite-actinolite ± magnetite schists (Hickman 1973; Sliwa & Nguluwe, 1984). These schists are thought to represent metamorphosed volcanic rocks that were dominated by komatiites i.e., highly magnesian ultramafic rocks (Seifert et al., 2004b). Their high chromium content provides a necessary component for emerald mineralization.

In the Kafubu area, thick layers (up to 200 m) of the metabasite are intercalated in the mica schist– quartzite sequence. Deposition of the Muva Supergroup is dated to ~1,700 million years. Subsequent folding and metamorphism, which also involved the basement granite gneisses, took place during the Irumide orogeny ~1,010 million years (De Waele et al., 2002). Importantly, with the exception of the Kafubu area, the metabasites are unknown in other portions of the 1,000-km-long Irumide belt of north eastern Zambia (Daly & Unrug, 1983; De Waele & Mapani, 2002).

The basement granite gneisses and the Muva Supergroup were later buried under sediments of the Katanga Supergroup during the Neoproterozoic era (i.e., 570–900 million years). The entire crustal domain then underwent folding, thrusting, and metamorphism during the Pan-African orogeny, culminating at ~530 million years (John et al., 2004). This tectonic event produced the most observable deformation and metamorphic features in the Muva rocks of the Kafubu area (Hickman, 1973).

During late stages of the Pan-African orogeny, rare-element pegmatites and some beryllium-rich granites intruded various crustal units in central, eastern, and possibly also north western parts of Zambia (Cosi et al., 1992; Parkin, 2000). In the Kafubu area, field studies at numerous mines and exploration pits indicate the existence of a major field of beryllium-bearing pegmatites and hydrothermal veins that is nearly 20 km long.

This field overlaps major horizons of metabasites that are enriched in chromium, resulting in emerald mineralization over a large area. Potassium-argon dating of muscovite from a pegmatite and an associated quartz-tourmaline vein gave cooling ages of 447–452 million years (Seifert et al., 2004). This corresponds to the approximate time of emerald mineralization, when the rocks cooled below 350 ±

50°C (which is the approximate temperature at which muscovite becomes “closed” to argon loss; (Viana et al., 2003).

Local Geology. Emerald miners in the Kafubu area use a local geologic vernacular that is summarized in the Gems and Gemology Data Depository (www.gia.edu/gemsandgemology). Knowledge of this terminology is critical to understanding their observations of the geology and emerald mineralization. The emerald mineralization is directly related to the metasomatic alteration of the chromium bearing metabasites by beryllium -bearing fluids derived from hydrothermal veins (Coats et al., 2001; Seifert et al., 2004). For the most part, economic quantities of emerald are restricted to the phlogopite reaction zones (typically 0.5–3 m wide) between quartz-tourmaline veins and metabasite. These reaction zones locally contain aggregates of emerald, of which a minor proportion is gem quality. Only rarely are good stones found in the quartz-tourmaline veins, or very exceptionally in less altered, partially phlogopitized host rocks.

Localized phlogopite reaction zones in the metabasites also were caused by emplacement of simple quartz-feldspar pegmatites, which are typically 2–10 m thick and steeply dipping. Field observations indicate that these pegmatites were emplaced shortly after the quartz-tourmaline veins. Since fluids from the pegmatite system contained some Be, minor emerald mineralization occurs locally in the phlogopite alteration zones associated with these pegmatites, too. The best emerald mineralization is found in phlogopite schist near intersections between the quartz-tourmaline veins and the pegmatites—particularly at the intersection between steeply dipping pegmatites and flat-lying veins. The abundance of quartz-tourmaline veins with associated phlogopite reaction zones in the Kafubu area suggests a “regional” influx of hydrothermal fluids containing Silicon, Baron, Potassium, Fluorine, and other elements (Seifert et al., 2004). The Be-bearing fluids that altered the metabasites, causing emerald mineralization, are most likely related to a hidden granitic source. Information from a fluid inclusion study (Seifert et al., 2004) is consistent with the results of the regional geology described above, which indicates emerald mineralization occurred at temperatures of 360–390°C and pressures of 400–450 MPa.

2.3.3 Exploration

About 2% of the Kafubu area is currently being mined (i.e., 5 km^2), and exploration activities are limited mostly to the immediate surroundings of known deposits. The

nearly omnipresent cover of residual soil (2–10 m thick) is a serious obstacle to prospecting.

Exploration methods range from “witchcraft” and “gut feel” to the use of advanced geophysical methods, core drilling, and geologic mapping. Gemcanton has highly qualified geologists who carefully monitor exploration and mining activities. Smaller companies rely on local consultants who provide geologic interpretation and basic geophysical surveying. Local miners, many of whom have decades of experience working the area, also are an important resource. These miners are experts at locating emeralds through careful field observations (e.g., quartz-rich soil uplifted in tree roots).

The basic geological controls are known (Sliwa, 1982; Sliwa & Nguluwe, 1984). The emeralds occur as euhedral crystals, mostly found in alteration zones (biotite/phlogopite-tourmaline-schists) adjacent to the quartz-beryl-tourmaline pegmatites, which cut the talc-chlorite-magnetite schists. The pegmatite bodies commonly have been intruded along contacts between biotite-schist and talc-schist units. Typically, they are 0.5–5m in thickness and extend along strike for tens of metres as irregular pods and veins. Individual groups of branching veins can be traced for strike lengths in excess of 5km.

The target ore geology at Kafubu is favourable for magnetic surveying. This rather simple geophysical technique has been used in the area for years, and remains the main tool for emerald prospecting. A magnetic survey measures variations in the earth’s magnetic field intensity over an area of interest (Cook, 1997).

In addition to magnetic surveying, radiometry (Cook, 1997) is often used at Kafubu. With this method, a gamma ray spectrometer measures Uranium, thorium and potassium anomalies to distinguish different rocks on the basis of their mineralogy; it may also reveal geologic contacts and major fault structures. Combinations of magnetic highs and radiometric highs indicate a very favourable geologic setting, and such geophysical anomalies are tested by digging pits to verify the presumed occurrence of metabasites and hydrothermal veins. When favourable conditions are encountered, local geologic indicators may point toward areas with high potential for emerald mineralization. Although expensive and time consuming, oriented drilling exploration programs may reveal important new emerald accumulations.

So far, emerald mineralization has been mined to maximum depth of 100m. However, structural and lithologic criteria suggest that mineralization continues to deeper levels. Field surveys and laboratory analyses (Seifert et al., 2004), as well as a study of the structural geology (Tembo et al., 2000), have demonstrated that the potential for substantial reserves and new emerald occurrences in the Kafubu area remains very high.

2.3.4 Mining

The Kafubu Emerald mining area (or Ndola Rural Restricted Area) has been subdivided into several hundred small concessions at around 100 hectares each. Most of these concessions are located in areas with unpromising geology. However, some are in favourable areas, and a few of these have been amalgamated into larger entities such as the one operated by Gemcanton mine. All the Kafubu emerald deposits are worked by open-pit mining. Because of abundant water during the rainy season (November to March), underground work is not considered an option; the groundwater level is too high for sinking shafts, as it would be too expensive to pump water continuously (Gemfields, 2016).

Mining is done by removing the overburden rock with bulldozers, excavators, and large dump trucks. At all the big pits, the miners drill a series of holes, so that explosives can be used to open the areas adjacent to the veins. Once emerald-bearing biotite phlogophite schist is exposed, mining is done manually with hammer and chisel, by so-called “chisel men.” The recovered emeralds are put into cloth sacks or deposited into padlocked metal boxes. Security is a major problem during the manual extraction phase. The emerald-bearing zones must be heavily guarded at night to prevent access by the numerous illegal miners who become active after sunset. It is also not uncommon for chisel men to cover a newly discovered emerald concentration for later night-time excavation.

Standard washing/screening plants are used to process the ore at some of the mines. The smaller operations do not use washing plants due to a lack of funding and/or security (Gemfields, 2016).

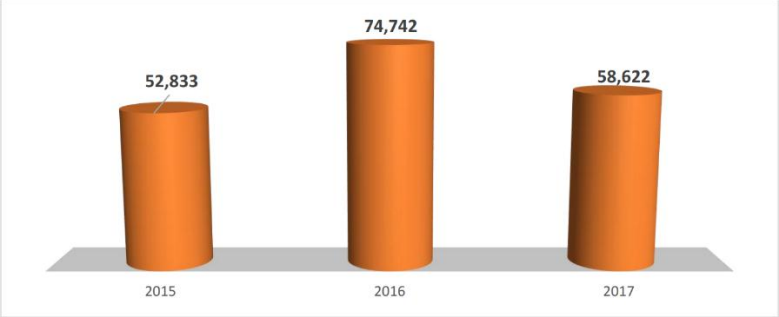
2.3.5 Production of the Rough Emeralds

Emerald mineralization is very irregular, with the crystals often aggregated together. These local concentrations may have grades of several kilograms of emerald per tonnes of ore rock. More typical is a dispersed mineralization of a few grams per ton of ore. Because of the secrecy that surrounds much emerald mining, accurate details of emerald production and the qualities produced are difficult to assess.

Run-of-mine (ROM) emerald typically yields only a small percentage of material that can be faceted. Most of it is of bead to cabochon quality. According to information supplied by Schultz (pers. comm., 2005) and Milisenda et al. (1999), a typical 10 kg of ROM emerald from a favourable deposit would yield about 5 g of extra-fine material, about 100 g of fine material, about 300 g of good material (in terms of both colour and clarity), about 600–800 g of material with good colour but included, about 3 Kg of low-quality material, and the remaining 6–7 kg of very low commercial value.

Production of rough reportedly exceeded US$100 million in the late 1980s (Milisenda et al., 1999). More recently, the value of emerald production from the Kafubu area was reported to be about US$20 million annually—according to 2002 statistics from the Export Board of Zambia for the officially declared export value of rough emerald. A conservative estimate is that at least another US$5 million worth of rough is smuggled out of Zambia, although some sources (mainly the Zambian media) place the number much higher.

Emerald and Beryl production reduced to 58,622 kgs in 2017 from 74,742.2 kgs in 2016 (see figure 2.1). Total production of Amethyst, Quartz, Garnet, and Aquamarine reduced to 1,446,488.22 kgs in 2017 from 2,090,726.50 kgs in 2016. The decline was partly due to inadequate capitalisation in the sector especially by small scale miners. During the period, total sales of US $ 84 million were recorded representing a 16 percent increase from US $ 70.2 million in 2016 (Ministry of Finance, Economic Report, 2017). The Figure 2.1 below summaries the emerald and beryl production (Kg) from 2015 to 2017.



Source: Ministry of Mines and Minerals Development

Figure 2.1: Production of Emerald and Beryl in the year 2015-2017 (Economic Report, 2017)

2.3.6 Distribution of the Rough Emeralds

Most of Zambia's emeralds are exported to India, mainly for use in that country's domestic market, and to Israel for international distribution. According to Tank (pers. comm., 2005), India receives 80% of Zambia's emerald production by weight, and 70–75% by value, with the cutting done in Jaipur. Israeli buyers usually purchase the higher-quality material.

The larger mining operators have well-established trading arrangements. For example, Kagem offers their production four times a year at a closed tender auction in Lusaka and also abroad. The dates are flexible, depending on when sufficient material is available. The very small operators and illegal miners rely on local traders, who are mainly of West African origin (e.g., Senegal and Mali) and often supply them with food and other necessities in exchange for emeralds.

2.3.7 Market Demand

An England Financial Times article says demand for emeralds is on the up, with jewellers such as David Morris and Bulgari confirming that the green gemstones are fast becoming a popular alternative to white diamonds. According to statistics from the UN Commodity Trade Statistics Database, sales of diamonds have been slowing while those of emeralds and other coloured gemstones have been mounting significantly in recent years. (Zambian Economist, 2013)

Jaipur's emerald cutting industry receives emerald in its rough form primarily from Zambia but also from Brazil (mostly from mines in the state of Bahia). While Colombia is a famous major emerald producer, much of its production is cut there,

especially better-quality material, with some of the lower-quality material cut in Jaipur. A high percentage of the rough cut in Jaipur today is from Zambia, higher than all other sources combined (The Emerald Cutting and Trading Powerhouse, 2016).

It was reported in the Bank of Zambia annual report 2016 that Non-traditional export (NTEs) earnings fell to US$1,740.1 million from US$1,848.6 million largely due to lower exports of gemstones, scraps of precious metals, maize and cane sugar (Table 2.1).

Table 2.1: Major Non-Traditional Exports (c.i.f.) (US$ million), 2015 to 2016

Commodity/Product	**2015**	**2016**	**% Change**
Gemstones	111.3	28.4	-74.5
Sulphuric Acid	57.3	39.1	-31.9
Industrial Boilers and Equipment	95.7	117.9	23.3
Cane Sugar	146.6	120.0	-18.1
Gasoil/Petroleum Oils	12.3	118.3	864.6
Cement & Lime	65.1	71.6	10.0
Electricity	39.0	13.6	-65.2
Raw hides, Skins & Leather	12.5	11.5	-7.6
Sulphur	19.6	2.7	-86.0
Burley Tobacco	106.4	89.6	-15.8
Copper Wire	58.6	67.3	14.9
Scrap of precious metals	49.1	0.2	-99.6
Maize & Maize Seed	215.9	188.5	-12.7
Electrical Cables	20.7	14.4	-30.6
Cotton Lint	54.1	64.5	19.2
Soaps	51.4	45.5	-11.6
Fresh Fruits & Vegetables	12.5	13.9	11.4
Manganese Ores/Concentrates	1.5	6.6	343.3
Wheat & Meslin	12.0	7.2	-40.2
Fresh Flowers	13.3	10.8	-19.1

Source: Bank of Zambia (2016)

2.4 Gemstone Mining Methods, Processing and Promotion of Value Addition

Gemstone mining is carried out in many different ways depending on tradition, geology, geography, the nature of the minerals, and available resources. Prospecting and exploration are usually done in the most basic manner and uses a mix of tradition, opportunism, rumours, observation and luck, all these techniques being refined and perfected over a period of time. The main indicator of presence of mineralization are outcrops and alluvial deposits which the miners first dig up and then follow underground.

Over time, gemstone miners have developed an understanding of the local geological formations in which these gemstones occur and this has acted as their guiding principle in the prospecting and digging operations. Very few if any, mostly small-scale miners with access to geological information, employ the use of formal prospecting in their mines. Lack of information and therefore a lack of in-depth understanding of the geology of these gemstone mining areas hinder the efficiency of mining as most operations essentially amount to trial and error, wasting a lot of time, effort and resource.

Mining operation of any Ore body can either be underground or surface, and it ranges from manual to mechanized. Gemstone mining also follows this trend, most of it beginning from alluvial deposits on the surface and then advancing underground depending on the mineralization. Alluvial deposits and outcrops of gemstones were a common occurrence in the early days (60's, 70's, 80's) when the sector was budding with only a few people involved, but with more and more players coming into the picture, it is very rare to find alluvial and outcrops of gemstones these days. Most gem mining is done in open pits at present with mineralization tending to occur deeper and deeper in the ground as near surface deposits become exhausted.

Mining of these deposits is a tedious undertaking given the effort required to break rock and primarily involves the use of hammers, chisels, shovels and buckets and in some advanced cases drills, compressors, explosives and excavators. Gemstone miners usually apply the most basic of techniques to laboriously dig up open pits and then follow mineralized reefs/zones.

Loose soil normally forms the overburden but this soon turns to hard host rock which requires immense effort to dig through. This is done manually using hammers and

chisels, pneumatic rock drills and aided in some cases by prior blasting to loosen the rock.

Larger scale gemstone miners such as Gemcanton mine and Kegam mine employ more or less the same method of mining, the only difference being that they are able to employ machinery such as excavators, generators, water pumps etc. This enables them to mine in a relatively more planned and structured manner as compared to gemstone miners owing to more information, better prospecting and a larger pool of resources. In both cases, support of the mined out areas is not of much concern to the miners as they deem the host rock to be competent enough to support itself, though few pay attention to the fact that it is dangerous especially during the rains.

Most of the gemstones once mined, usually do not undergo any form of processing or treatment. They are just separated from the surrounding rock which they are normally associated with and thereafter sold as just raw or uncut stones. However, a few gemstone miners and brokers attempt to add value to the gemstones. A simple process may involve: separation (sorting after extracting the gemstone) this is done by hand, washing (using water) and shining (using glycerine).

The operational gemstone miners are usually well connected and are able to sell their gemstones directly to the international market. Very minimal processing or value addition in terms of cutting for jewellery is done by small-scale miners for the chief reason that it is very difficult to find a buyer for cut stone which he/she did not make an order for. Essentially, it is easier to sell rough stones to be faceted by the buyers than it is to sell a stone which you cut to your own specifications not knowing what the market demands. This has been the greatest obstacle to any meaningful value addition being done to gemstones before they leave the region and has hence contributed to loss of revenue which would otherwise have remained in the local economy, had value addition been done.

2.5 Occupational Health and Safety

Mining – both small-scale and large scale, formal and informal – is one of the most occupationally hazardous activities in the world. In addition to injuries and fatalities from accidents, miners experience high rates of cancer, respiratory illnesses and other diseases (Stephens & Ahern, 2001). The occupational health and safety issues that

plague gemstone miners can primarily be attributed to its informal and often illegal nature, lack of financing that leads to inadequate equipment, neglect of safety measures, a frequent lack of expertise and insufficient training. The fact that most gemstone mining activities have remained unregulated by government authorities with no clear guiding legal framework, means that enforcing of laws and basic safety standards is a major challenge. This has in turn lead to negligence and risk-taking on the part of miners for various reasons including ignorance on importance of occupational health and safety, desperation, cost-cutting, lack of access to safety equipment and the finances to acquire such, remoteness of mine sites, lack of inspection and law enforcement and a general lack of accountability. Most occupational hazards in the gemstone sector generally include ground failure (to a small extent), falls into open pits, equipment or mechanical accidents, noise and vibration, dust and fumes and physical over exertion.

Caving in or ground failure is generally uncommon in the gemstone mines due to the competence of most of the rock within which mining takes place though there have been a few such cases. The injuries include cuts and knock on the hands, fingers, legs, and feet and also splinter into the eyes from the breakage of rocks. This is further compounded by the fact that most mines are far away from health centres or clinics and don't have first aid kits in place meaning that anyone injured must travel long distances to receive treatment (Rop 2014).

The use of pneumatic rock drills is the main source of noise and exposure to vibration in most of the operational mines. The miners are exposed to high levels of noise and vibration due to their close proximity to drills and the enclosed environment within which they work. Frequent or extended exposure to loud noise can result in hearing impairment. Although ILO (2001) recommends use of ear plugs or muffs at levels above 90dbA, it can be assumed that most of these sources emit sufficiently excessive noise to warrant use of protective gear. Irreversible noise-induced hearing loss can occur once noise levels are sufficient to interfere with spoken communications (WHO, 2002).

Repeated and prolonged exposure to vibration from hand held machinery can produce pain and numbness in the hand and arm. Even exposure as brief as one hour daily can produce harmful effects, including a condition called "Vibration White Finger (VWF)

that commences with numbness progressing to loss of feeling and potentially gangrene (ILO, 2001). Use of low vibration equipment, decreased operation times, and employment of a relaxed grip on handles can reduce the harmful effects of vibration (ILO, 2001).

Fine mineral particles, or dust, are generated from drilling and blasting, loading and hauling, crushing and grinding (ILO, 2001). The inhalation of fine mineral particles can result in the accumulation of scar tissue in the lungs. As this occurs, the presence of foreign material in the lungs can result in cancer. Silicosis and pneumoconiosis generated from inhalation of crystalline silica dust emitted from blasting or breaking and crushing rock, are the most frequently reported respiratory effects. Conditions resulting from silicosis include emphysema, lung fibrosis and silicatuberculosis. This especially, is of great concern in gemstone mines in Kafubu area since quartz is quite wide spread in gem bearing rocks.

Dust emissions are common in surface mines. The ILO (2001) recommends that exposure to dust be minimized through use of dust masks, wet drilling methods, and water sprays throughout hauling, loading and crushing operations. Fumes released from blasting can also result in serious health effects. Harmful gases associated with blasting mainly include carbon monoxide (CO), carbon dioxide (CO_2), nitrogen and sulphur oxides (NOx, SOx). Gemstone miners normally use explosives and these fumes associated with blasting pose a serious hazard to miners.

The use of explosives also presents a hazard in itself as it is done illegally without regulation by the relevant authorities. Most of the explosives are smuggled to the mine sites where the blasting is done by one person who has over time through experience developed knowledge pertaining to the science. However, handling of explosives is a very sensitive issue as extreme care and caution is demanded when dealing with them. Since they are being used illegally, the pre-requisite logistics are normally not in place for the safe transportation and storage of explosives as is usually required by law. One has to have a permit from the relevant government authority to purchase and transport any explosives and must provide a standardized magazine on site for safe storage of the same (Rop 2014). All these requirements are rarely if at all observed in gemstone mining sites and as such they pose a great safety risk due to the manner in which they are being handled. Most of these health and safety hazards that

most miners are exposed to can be mainly attributed to the informal and illegal nature of gemstone mining, lack of basic personal protective equipment such as gloves, safety boots, goggles, helmets, overalls, dust masks, ear muffs etc. This can be attributed to inadequate finance, ignorance and negligence on the part of miners, poor law enforcement from relevant authorities, and lack of expertise and sufficient training on importance of occupational health and safety.

2.6 Mining Life Cycle and Phases

A formal mining operation normally goes through several phases from its commencement to closure. The first stage is prospecting which involves identification and ascertaining presence of minerals in a given area. This is done by use of either direct or indirect methods in order to determine if or what types of minerals are present (Rop, 2014). Once it has been established that a particular mineral exists, exploration is then done to define its extent and value. If the deposit is feasible enough to warrant exploitation, development of the mine can then begin to open it up for production. Exploitation then follows once the mine has been opened up and this goes on until the deposit is exhausted. Finally, reclamation of the site is done in order to restore the mine site to its original state or even better.

Figure 2.2 below illustrates the mining life cycle.

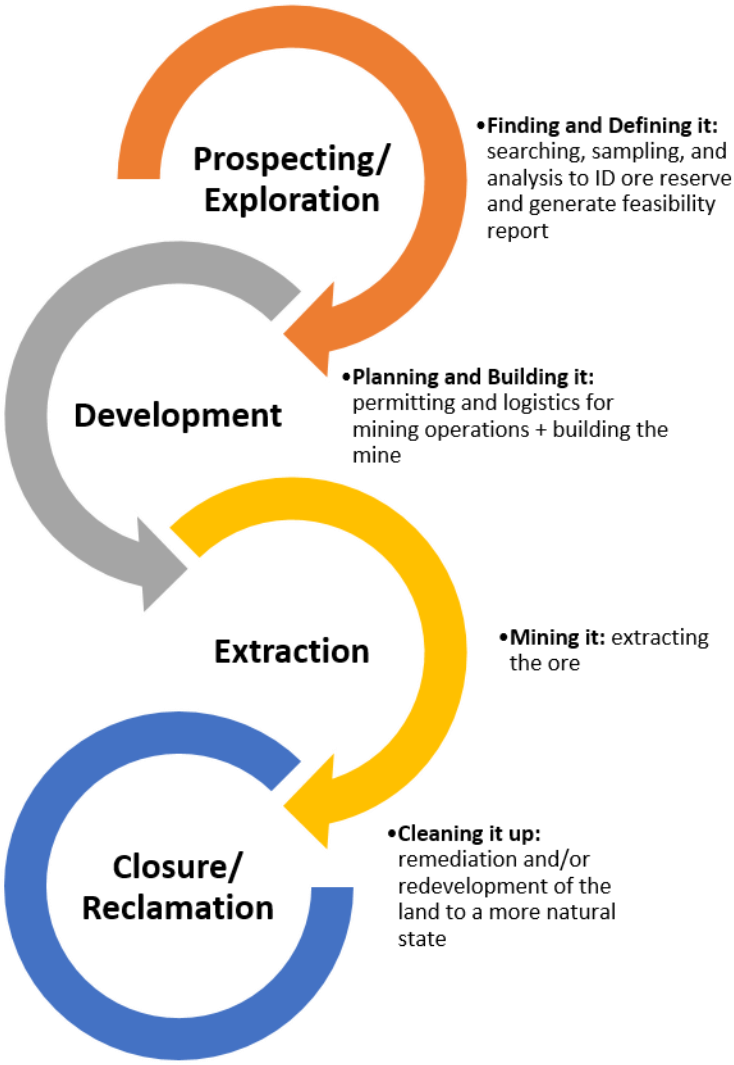


Figure 2.2: The Life Cycle of a Mine

Most gemstone operations in the area are mostly semi-formal or informal and they rarely follow the standard life cycle of a mine. Gemstone miners normally use traditional methods to prospect for and identify deposits and once this has been done, mining immediately follows. Generally, the presence of gemstones near the surface is usually taken as an indicator that more exist underground and this forms the basis of exploitation of the deposit. Most artisanal and small-scale miners do not know the extent of and general characterization of the deposits that they mine and as such their operations are mainly optimism-based, their faith that they will soon hit a jackpot being what keeps them going.

This also means that most mines that are not promising are usually abandoned and are therefore not a priority when it comes to reclamation. The informal nature of gemstone mines means that reclamation efforts are scarcely considered and this can be attributed to the fact that authorities in the first place do not follow up or enforce environmental regulations in these remote sites, miners do not feel the importance or just simply neglect and lastly due to the cost associated with reclamation which miners feel is an unnecessary expense. A few small-scale miners do however pay attention to this aspect of mining and are able to do some reclamation by backfilling abandoned or mined out areas. Otherwise, the lack of reclamation in these mines in the long run present a serious environmental problem which is compounded the longer it goes on unattended to (Rop, 2014).

2.7 Finance

Finance is one of the most important challenges confronting the gemstone sector. Finance is the life blood of an organisation and no organisation can function properly in the absence of adequate funds. The scarcity of capital and inadequate availability of credit facilities are the major causes of this challenge.

Gemstone mining fits three categories of mining namely artisanal mining, traditional mining and advanced mining as illustrated in the Figure 2.3. Most gemstone mines fit in the artisanal and traditional sub categories. The first type, artisanal mining (micro-scale mining) encompasses the smallest and simplest operations. It is characterized by the use of simple tools and the absence of a formal enterprise. Artisanal mining ranges from individuals to more commonly family or village groups, mining legally or illegally. The second group comprises the traditional SSM which includes registered and licensed non-mechanized or semi-mechanized mining operations run by organized society members of entrepreneurs with the use of hired labour. The third group is the legally constituted advanced SSM using highly mechanized techniques.

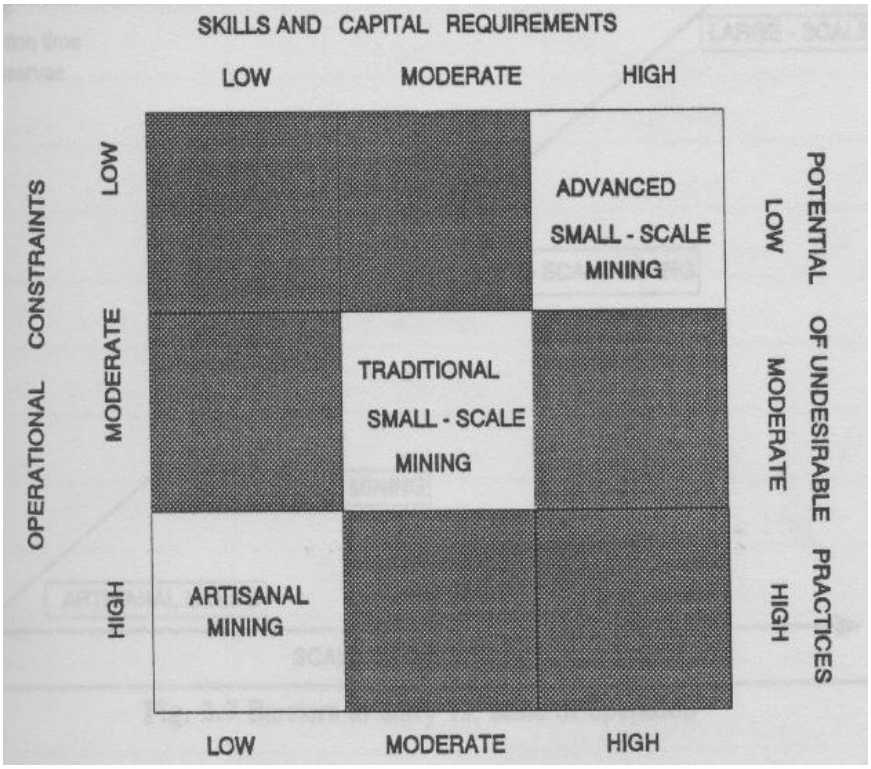


Figure 2.3: Categories of Small-Scale Mining

There are a number of clearly identifiable social and economic benefits associated with SSM in districts with the following advantages:

- Has high employment potential, especially for unskilled labour
- Low investment requirements
- Short gestation periods
- Does not require elaborate infrastructure
- It is an efficient user of scarce capital, and
- Creates opportunities for indigenous entrepreneurial development

One of the major characteristics of SSM is its low barriers to entry in terms of initial capital requirements, infrastructural needs, implementation time and a minimum amount of reserves. Because of these limited barriers to entry, the artisanal and SSM sub-sector has reached significant proportions in a number of districts.

Available evidence indicates that there is a large number of non-performing gemstone licences attributed largely due lack of funds. Financial requirements at any level of mining can be quite significant to achieve any meaningful level of investment in mining. Compared to other mineral commodities (base metals), gemstone mining carries high level of geological risk that has made it impossible to generate confidence in resource and reserve estimations. Inability to define reserves has rendered the sector largely financial unsecure with high risk and hence unable to secure credit facilities normally available to other mineral commodities or other sectors.

It must be emphasized that the lack of capital means miners are unable to hire skills and acquire technology. This has also lead to non-performing entities or dormant licences.

2.8 Legal and Policy Frameworks

Government has devised a strategic framework to support small scale mining development countrywide. Minister of Mines, Richard Musukwa said government wants small scale miners to have a stake in the mining sector and the new measures will assist them with market links among others. The government wants to build capacity in small scale miners so that they make meaningful contribution to the country's treasury (Lusaka Voice, 2018).

2.8.1 Mineral Resources Development Policy 2013

Small-Scale Mining

To develop the small-scale mining sub-sector government has undertaken the following measures:

a) Encourage the use of appropriate, affordable and safe-technology, by increasing its support to the collation and dissemination of information about appropriate technologies, the provision of extension services and, technology demonstrations.
b) Build capacity in Regional Mining offices to enhance their service delivery;
c) Collaborate with small-scale miners associations;

d) Disseminate information to raise awareness on occupational safety, health and environmental risks, and provide occupational health and safety guidelines for small-scale mining;
e) Improve the system of information flow for the mining sector to sensitize and create awareness, especially for artisanal and small-scale miners and rural population, on the opportunities present and the regulations governing the sector; and
f) Facility small-scale miners access to finance for the development of the sub-sector.

2.8.2 Mines and Minerals Development (Amendment)

The Mines and Minerals Development amendment of 2016 states as follows:

89. (1) A holder of a mining licence shall pay mineral royalty at the rate of —

five percent of the norm value of the base metals produced or recoverable under the licence, except when the base metal is copper;

five percent of the gross value of the energy and industrial minerals produced or recoverable under the licence;

six percent of the gross value of the gemstones produced or recoverable under the licence; and

six percent of the norm value of precious metals produced or recoverable under the licence.

2.8.3 Seventh National Development Plan (7NDP)

a) Introduction

Zambia has had three development plans since the re-introduction of the medium-term development planning process in the early 2000s, namely the Fifth National Development Plan, 2006-2010 (FNDP), Sixth National Development Plan, 2011-2015 (SNDP) and the Revised Sixth National Development Plan, 2013-2016 (R-SNDP). These Plans were formulated with a view to meeting the national aspirations as articulated in the Vision 2030. These aspirations are to transform the country from a

primary product-dependent economy to a strong, dynamic middle income industrialised country by 2030.

Following the expiry of the R-SNDP in 2016, the Government spearheaded the formulation of the Seventh National Development Plan which will cover the period from 2017 to 2021. The Plan departs from sectoral-based planning to an integrated (multi-sectoral) approach under the theme "Accelerating development efforts towards Vision 2030 without leaving anyone behind". The formulation of the Plan was guided by the National Planning and Budgeting Policy of 2014, while the Decentralisation Policy of 2014 provided the principles of implementation. Further, the formulation of the Plan was informed by the need to harness the demographic dividend in view of Zambia's youthful population. The key outcomes of the plan include economic diversification and job creation; reduction of poverty and vulnerability; reduced developmental inequalities; enhanced human development; and the creation of a conducive governance environment for a diversified and inclusive economy (Ministry of National Development Planning, 2017).

b) Binding Constraints

In the Seventh National Development Plan the government highlights the binding constraints to economic diversification and job creation**.** Zambia's efforts to achieve economic diversification and job creation can be attained through addressing socio-economic and structural issues which constitute binding constraints. These constraints are related to:

Inadequate infrastructure – Inadequate levels and low quality of infrastructure development lead to low economic activity and high production costs which result in low competitiveness. Critical infrastructure, such as housing, electricity, feeder roads, rail, air and water transport and water supply and sanitation has not been adequate to facilitate the desired levels of economic transformation and leverage private investment.

High cost and limited availability of long-term finance – The high cost and limited availability of long-term finance remain major constraints to growth, particularly for small to medium scale enterprises. The major form of finance in Zambia is commercial bank loans that are mainly designed to support cash flow solutions and not long-term capital. At the same time, rural finance, venture capital and leasing

finance that offer targeted finance products to particular business segments remain underdeveloped. This has posed serious limitations and ability of entrepreneurs to start or expand their operations.

Inadequate water resource development and supply – Zambia's inability to adequately harness its vast water resources is a binding constraint to growth in a number of sectors, such as agriculture, manufacturing, energy, transport, mining and tourism.

Low labour productivity – Productivity is directly linked to improved standards of living in the form of higher consumption arising from higher growth rates. An increase in value addition per employee leads to a growth in GDP. In Zambia, trends indicate that labour productivity has been declining. Increased productivity results in the production of more goods and services for the same amount of relative work and this helps in transforming people's living standards. There is a positive correlation between increase in physical capital, technology and human capital with an increase in productivity. One of the binding constraints to raising productivity has been weak physical capital, which are the resources that people have in savings and investments as well as lack of access to technology to bring about higher production outputs within a short period of time. This is exacerbated by weak human capital as a result of low levels of productive skills in specialised production lines required to improve efficiency in the production of goods and services.

Low access to land – Land is an important resource for investment, production of goods and services in the economy, wealth creation and ultimately poverty reduction. However, there are several constraints in accessing land on title, such as inadequate information on land issues, inefficiencies and delays in processing title deeds and insecure land tenure systems.

Inadequate skills and innovation – Skills development is key in empowering citizens to enable them participate meaningfully in economic activities. Zambia has low entry into technology and science-related fields. There is bias towards arts and social sciences as opposed to technical and vocational-related fields, leading to a skills mismatch between industry needs and the labour market. In addition, there is low capacity for research and development in technical and vocational-related fields as well as low use of ICT. Inadequate skills and technology innovation further

significantly contribute to the low labour productivity, which is a key binding constraint to growth.

High cost of transportation – Reliable, interconnected and relatively low-cost transport is essential for achieving diversified and sustainable economic growth. Apart from human mobility, transportation contributes to economic growth by facilitating both domestic and international trade flows. Due to long distances to major export markets and sources of inputs, Zambia faces higher transport costs compared to her peers that have direct access to the sea. Domestically, the relatively sparse population distribution and poor infrastructure in some instances increase the transportation costs for traded goods.

Weak market information systems and economy-wide coordination failures – Market failures negatively affect the pace of industrialisation, which is a prerequisite for achieving resilient economic diversification. In Zambia, market information systems are still underdeveloped due to low level of ICT connectivity and the high cost of providing wireless data and voice services. This affects the pace of market information acquisition and the ease of doing business. Economy-wide coordination inadequacies also manifest through the failure of the private sector to invest massively in heavy manufacturing and in certain geographical clusters.

c) Development Outcome

A diversified and export-oriented mining sector is one of the development outcomes listed in the Seventh National Development Plan. Zambia has a mining history that spans over 100 years and continues to play a major role in the economic development of the country. The main mining activity is large-scale copper mining while the production, processing and export of other minerals remain underdeveloped. Under this Plan, emphasis will be on broadening the range of minerals to cover non-traditional mining of gemstones, gold and industrial minerals as well as promotion of value addition to mining products and include energy and material efficiency strategies to increase productivity and reduce environmental pollution. This Plan focuses on formalising and empowering small-scale miners to make them more productive, supporting development of lapidaries and local auction sales of gemstones and enhancing the capacity of local businesses to participate in the mining value chains and boost export revenue.

To achieve the developmental outcome, the government has prepared the following strategies.

Strategy 1: Promote Exploitation of Gemstones and Industrial Minerals

Focus will be on increasing exploration, mining, processing and promoting use of industrial minerals and gemstone products, to increase contribution to the growth of other sectors. Emphasis will also be placed on enhancing the capacities of small-scale miners to increase production. The Government will strengthen policy implementation and regulatory enforcement that does not stifle exploration of new mineral deposits.

Programmes:

a) Geological information generation and provision;

b) Mineral processing technology development;

c) Small-scale miner's empowerment;

d) Small-scale mines regulatory framework enforcement;

e) Market linkages development;

f) Strategic environmental assessment and risk management; and

g) Mineral exploration promotion.

Strategy 2: Promote Local and Foreign Participation in Mining Value Chains and Industrialisation

This strategy is aimed at enhancing capacities to participate in mining value chains that have the highest potential to impact economic growth and poverty reduction. Further, efforts will be made to facilitate mining-based value addition and industrialisation by supporting the development of manufacturing industries to produce inputs for other sectors, to contribute to the growth of other sectors.

Programmes:

a) Capacity development;

b) Policy and regulatory framework review and enhancement;

c) Access to finance promotion;

d) Mining value-chain development;

e) Research, innovation and technology promotion; and

f) Investment Promotion.

Strategy 3: Promote Petroleum and Gas Exploration

The strategy will facilitate the establishment and capacity development of relevant institutions to monitor and regulate petroleum exploration. In addition, a governance framework for the sector will be established to attract investment and ensure efficient, safe and environmentally-friendly petroleum exploration.

Programmes:

a) Policy and regulatory framework review and enhancement;

b) Capacity development;

c) Geological and geophysical information generation and provision; and

d) Environmental management.

Strategy 4: Promote Small-Scale Mining

As part of the diversification agenda within the mining sector, the Government will focus on building the productive capacity of artisanal and small-scale miners involved in the exploration of gemstones and industrial minerals. In addition, artisanal and small-scale miners will be formalised.

Programmes:

a) Small-scale miner's empowerment;

b) Small-scale miners access to finance promotion;

c) Occupational health, safety and environment strengthening;

d) Small-scale mining skills development; and

e) Small-scale miners and investors partnerships promotion.

2.8.4 Zambia National Industrial Policy

a) Introduction

The government of Zambia under the Ministry of Commerce, Trade and Industry in its aim at improving the development of the country has placed industry development placed industrial development at the core of its development agenda and in March 2018 the Zambia National Industrial Policy was published which is motivated by the aspirations of the Country's Vision 2030 which aims at transforming Zambia into a prosperous middle income economy.

The Policy sets out Government's approach to the industrial development of the country. It spells out guidelines that will inform the implementation of Government's industrial development agenda, with particular reference to the growth, diversification, upgrading and competitiveness of Zambia's manufacturing sector. The National Industrial Policy is expected to drive the transformation process which will assist the country deliver sustainable jobs, equitable growth and wide spread poverty reduction.

The Policy document outlines the strategic focus for Zambia's industrial development, the policy objectives, strategies and institutional framework necessary to facilitate industrial growth.

The implementation of the National Industrial Policy is expected to stimulate and encourage value addition activities on primary commodities as a means of increasing national export earnings and creating employment opportunities and ultimately transform the Zambian economy into a diversified and competitive industrialised economy which is well integrated into the international trading system (Ministry of Commerce Trade and Industry, 2018).

b) Education

Adequate skilled manpower and high labour productivity are critical to industrial development and competitiveness. Education and skills development therefore play a critical role in the socio-economic development. It provides opportunities for growth, poverty reduction, employment, productivity and human development. Government will commit increased resources to technical, vocational and commercial education and training to develop skills and manpower resources for industrial development.

c) Financing

The new Zambia National Industrial Policy 2018 outlines sources of funding that the government has put in place to help in facilitating economic growth, reducing poverty and creating employment opportunities. The financial sector is critical to industrialisation through the provision of affordable finance to enterprises. Both bank and non-bank financial institutions will be expected to play their role in financing industrial development as follows:

Commercial Banks; Commercial Banks will facilitate affordable financing that supports industrial development.

Institutional Financers; Institutional Financers such as Insurance Companies, Pension Funds among others will provide financing by investing in viable value adding industrial projects.

Development Banks; Development Banks such as Development Bank of Zambia will foster economic development through the provision of development capital complimentary to that offered by private sector banks and other development agencies.

The Banks shall intervene through the provision of suitable financial products to support the growth of Small, Medium and Large enterprises. Specifically, the modes of intervention shall include (though shall not be limited to):

Project financing;

- Co-financing and syndication with other lenders;
- Lines of credit to financial intermediaries;
- Equity participation;
- Loan guarantees;
- Managed funds, loans and grants;
- Banker's guarantees;
- Trade finance; and
- Leasing

Development Banks shall enhance financial inclusion among SMEs by ensuring a balance is created between rural based and urban based projects in line with Zambia's national development plans.

Empowerment Funds; Empowerment Funds shall be up scaled by increased funding and targeting innovative Zambian owned enterprises that will contribute to the industrialisation agenda of the country.

CEE Fund; shall be reserved for enterprises owned by economically vulnerable and marginalised indigenous citizens;

Zambia Export Development Fund; will provide low cost bridging finance to exporters of non-traditional exports with a view to increasing export earnings in the identified sectors;

Trade and Industrial Development Fund; this will support growth oriented Micro Small and Medium enterprises in high growth sectors including agro-processing, manufacturing, tourism, gemstones and infrastructure development.

2.9 Gemstone Challenges in Developing and Developed Countries

Gemstones have been prized for centuries as representations of beauty and status. In 2015, the global market for rough gemstones is conservatively estimated to have been worth between USD 17 billion and USD 23 billion. Yet in many countries where gemstones originate, this resource wealth has only marginally supported development. The industry remains marked by:

Widespread Illegal Activity. Many miners and traders operate outside of the formal sector, slowing the diffusion of appropriate environmental, social, and labour practices, and perpetuating linkages between the gemstone business and organized crime, internal conflict and corrupt regimes in certain countries.

Low Revenue Collection. The gemstone industry's contribution to public spending remains constrained in many cases by the underreporting and undervaluation of production, or by government failure to negotiate a fair deal.

Minimal Value Addition. While the cutting, polishing and processing of gemstones, and their manufacture into jewellery, represents a relatively sustainable source of skilled employment and economic growth, only a small fraction of these activities is conducted in countries where gemstones are extracted.

Weak Oversight. Inadequate regulation, weak traceability mechanisms, and only occasional disclosure of contracts, payments and other crucial information have limited accountability of actors throughout the gems and jewellery supply chain.

Gaps in Available Information. Gemstones' geology, markets, and governance remain poorly understood. Particularly in the case of coloured gemstones, much of existing research has been generated by a handful of industry, academic and civil

society actors. Few opportunities have been identified to discuss country experiences in comparative context.

Authors point out that SMEs face a number of obstacles despite their perceived benefits to accelerate growth and transform economy, SMEs are still facing many challenges include: lack of skilled manpower, limited access to credit, multiplicity of regulatory agencies and overbearing operating environment, information asymmetry, taxes, over concentration on one market, inadequate market research, inability to separate business and family or personal finances, lack of business strategy, inability to distinguish between revenue and profit, inability to procure the right plant and machinery, inability to engage or employ the right calibre of staff, cutthroat competition, lack of succession plan, high utility tariffs, infrastructure, competitions, high interest rates and prohibitive collateral (Munjeyi 2017; Angu & Emeti, 2014, Nkwe, 2012, Mwobobia 2012; Onugu, 2005).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the overall method of the study. Primarily, the research strategy and approach and instruments used are explained. The chapter then describes the target population where the study was precisely conducted. Thereafter, explains how data collection was done and analyzed in order to address the research problems and objectives of the study. Finally, the challenges and limitations that were encountered during the period of study are outlined.

3.2 Research Strategy and Approach

Qualitative and quantitative approaches were used in this study which depended on the primary and secondary data sources.

3.2.1 Sources of Data

For the purpose of this study, both primary and secondary data have been used. Primary data has been collected from Gemcanton and surrounding emerald mines. Secondary data, on the other hand, has been collected from government national speeches, government documents and textbooks borrowed from libraries and from journal and research articles.

3.2.2 Primary Data

Primary data is original, non-interpreted and new information collected by a researcher in a research assignment. This data encompasses documents that are applied at the same time of the research subject. This data is directly linked to people and mining organisations being researched. Primary research data is collected through various techniques including interviews, questionnaires and surveys.

3.2.3 Secondary Data

Secondary data includes documents that interpret, describe and draw conclusions based on the works written by others. This data is not directly connected to the people or events under study. Secondary data encompasses three quarters of the data at the disposal of many researchers. This data is available in typed, written or in electronic form.

For this research, qualitative method reviewed the available literature on the gemstone industry in Zambia as stated in chapter two. The literature reviewed was predominantly focused on what has been published on gemstone mining in what is known as the Kafubu Emerald Area by scholars, researchers, the media and government institutions in Zambia; and the review of relevant Zambian policy and regulations on small scale mining in particular, and natural resources in general. This approach comprised of secondary data such as published and unpublished data by the Ministry of Mines and Mineral Development, Ministry of Finance and National Planning, Export Board of Zambia, textbooks, periodicals and journals, internet sources, company reports, newspaper articles and reports.

The quantitative method focused on mineral resource modelling and extraction of emeralds at Gemcanton Investment holdings limited. This approach comprised of primary data such as geological mapping and logging of drilled core to observe the lithology structures and mineralization in the underlying rocks with the aim of defining the principal vein systems and structural domains occurring within the open pits mine for geology as well as secure, drill, blast and haul data for mining. Additionally, primary data was also collected through dispensing of questionnaires to the various gemstone mines with the study area and the Emerald and Semi-Precious Miners Association of Zambia (ESMAZ). It involved visiting the gemstone mines in the study areas, making observations, interacting and discussing with the local people and conducting interviews with the miners. This was done so as to identify various challenges faced in gemstone mining in the study area and document the views and concerns of the various stakeholders, such as large and small scale gemstone miners.

3.3 Study Area

The study area is the Kafubu Emerald Restricted Area located about 70km south of Kalulushi town in Lufwanyama District of the Copperbelt province in Zambia. The emerald mineralized area cover approximately 700km^2 within which there are several gemstone mining license holders. Figure 3.1 below presents a map showing the area of the study obtained from geological survey department.

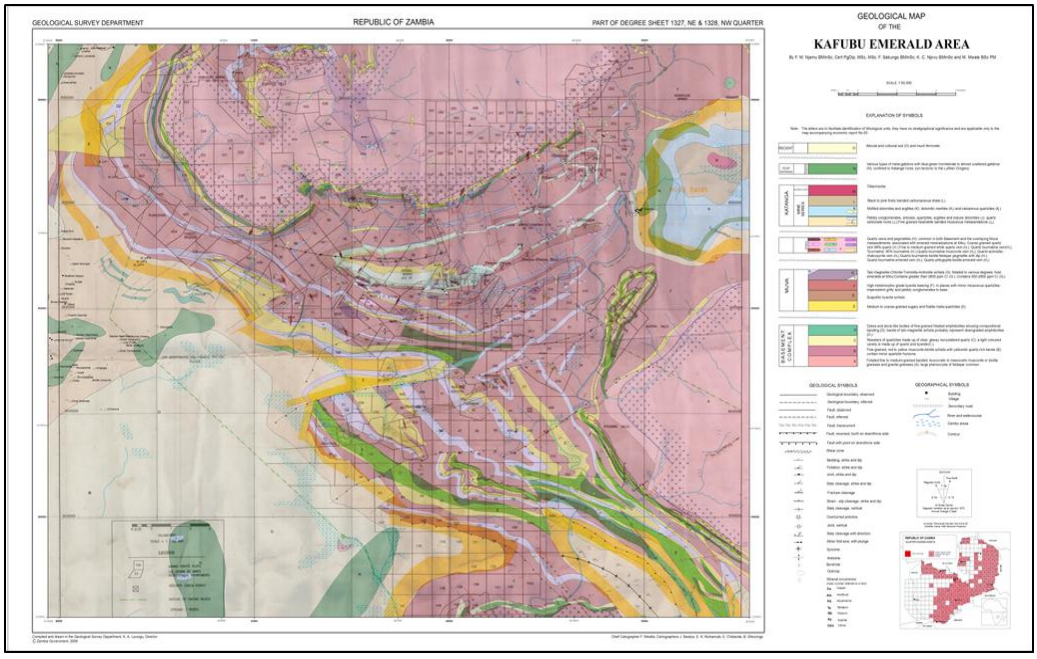


Figure 3.1: Map showing the study Area (Geological Survey Department)

Lufwanyama Gemstone Area has a total of 408 mine plots and of these mines, only 3 are titled large-scale gemstone mines namely, Kagem, Gemcanton mine formally known as Grizzly, and Miku Mines while the remaining 405 mine plots are titled to small scale license holders. Table 3.1 below shows a summary of data relating to the status of gemstone plots in Lufwanyama, gathered from desk assessment that was conducted by a Task Team from the Mining Cadastre Unit at the Ministry of Mines and Minerals Development, prior to undertaking the verification visit.

Table 3.1: The status of Gemstone Mining Plots in Lufwanyama

Status of Mining Plots	**Number of Plots**	**Percentage**
Active	106	26
Expired	145	35.5
Pending renewal	13	3.3
Cancelled	1	0.2
Vacant/Missing information	143	35
TOTAL	**408**	**100**

Source: Mining Cadastre (2016)

3.4 Data Collection Techniques

For the purpose of this study, the following data collection techniques were employed in this study.

- Documents and Records
- Observation
- Interviewing
- Administering questionnaires

3.4.1 Documents and Records

The researcher used available literature/information from past researchers. This method was employed because it was a cost effective and easy technique of collecting data. The study systematically reviewed different literature, theories, concepts and models relating to gemstone mining in developing countries. The literature comprehensively reviewed comprised: news articles; reputable research journals; information from government portals; masters' thesis reports and some international organizations reports. The researcher searched for the data online, collected, prioritized and read keenly to bring out the very critical issues and themes in line with the study (Wellington et al., 2005). Routine follow-ups were made on selected government ministries, departments, agencies and local authorities and also individuals were purposively selected for interviews.

3.4.2 Observation

This involves a researcher attaining membership in or close attachment to an alien or exotic group that the researcher wishes to study. It also involves learning their language, habits, work patterns, etc. The norms of objectivity and validity are deliberately made unstructured and flexible to maximize the understanding of empirical phenomena. Data obtained is often qualitative in narrative or prose form.

The major advantage of observation is that it provides first hand assessment of performance in context. Disadvantages of observation are that it may bring up ethical issues of privacy, may encounter observer bias (i.e. observer only notes what is of interest) and if the researcher doesn't use checklists, interpretation may be subjective.

For this study, the researcher took a minimum of 5 minutes to make field observations at the mine sites visited and took photos of the area, notably on the following concerns:

- The nature of gemstone mining, whether it's formal or informal, organized or disorganized and seasonal or permanent?
- What is the method of mining and level of technology used?
- Level of expertise
- Labour issues relating to mining
- Environmental aspects of mining operations

The information collected from field observation and on the site visits was valuable and very useful in the study.

3.4.3 Interviews

An interview is a data collecting technique that involves oral questioning of respondents, either individually or as a group - it involves on interpersonal role situation. It involves Identifying knowledgeable individuals to provide information on context and meaning of events. It uses interview guides to get information from key informants about the history of the initiative and to identify factors that affected its success or failure.

The researcher conducted interviews on the gemstone mines visited. The target population for the visited mines were mine owners, mine managers and ex-miners for non-operating mines. The interviews were guided by the semi structure questions according to the objectives of the study and each interview lasted about 20 to 30 minutes. The researcher also held meetings at the Ministry of Mines and Mineral Development, National Development Planning, Commerce trade and Industry, Cadastral Unit, Geological Survey Department, Financial institution (Banks) and Emerald and Semi-Precious Miners Association of Zambia (ESMAZ) and after explaining the scope and objectives of the study, valuable information was discussed and included in the study.

3.4.4 Questionnaires

A questionnaire refers to a sequence of questions an interviewer asks a respondent. In a way, it is a process of trying to operationalize the objectives of your investigation.

Constructing a questionnaire, or any other data collection instrument for that matter, is an art in itself. There is no one perfect way recommended for coming up with a good questionnaire. However, to increase your chances of developing better tools/instruments for data collection, there are certain issues you have to consider seriously. These include:

- Choosing the response format that you use for collecting information from the respondent
- Determining the question content, scope and purpose
- Figuring out how to word the question to get at the issue
- How best to place the questions in the questionnaire

The study used both closed and open response questions in the questionnaires. The questionnaire was tested before it was used and amendments made. This was important because pre-testing makes it possible to determine among others the acceptability of the questions asked, willingness of respondents to answer questions and the time required to administer the questionnaires, to conduct observations etc.

These questionnaires were manually distributed to the targeted population as mentioned above. Table 3.2 shows the summary of contents in the questionnaire.

Table 3.2: The Summary of the Content in the Devised Questionnaire

Question No.	**Challenge**	**Key Issues Addressed**
1	Technical Challenges	Geological challenges of the sector Mining challenges of the sector Mitigation measures and improvements
2	Financial Challenges	Funding challenges Causes of lack of funding Mitigation measures taken

3	Regulatory Challenges	Adequacy of policies and regulations Enforcement and monitoring of policy and regulations Adherence to policy and regulations

3.5 Sampling

Sampling is a process which involves the selection of study elements from a population. In research, it is quite impossible to analyse the entire population in a single sitting because of financial and time limiting constraints. A sample is usually selected from a population through the process of sampling. However, special care must be exercised in this process because the sample that is selected must very closely act as a representative of the entire population.

Sampling methods are classified into two namely, probability and non-probability methods. Probability method is one where each element in the population has a chance of being selected. Non-probability method on the other hand is where some elements in the population have a zero chance of being selected.

Probability Methods of Sampling

The following list briefly highlights the probability sampling methods

- Simple random sampling –This is also referred to as an Equal Probability Sampling (EPS) design because every element in the population has an equal chance of being selected. This sampling technique is usually applied to populations that are small and homogeneous.
- Systematic sampling – This sampling method involves arranging population elements in a certain order pattern with an aim of selecting elements at intervals.
- Stratified sampling –This involves dividing the population into sub-populations known as stratums. Population elements within these stratums are then selected through the process of random sampling.
- Multiphase sampling –This sampling method involves generating successive samples through the use of additional information.

- Multistage sampling –This is sampling that is done in stages with smaller and smaller units being employed at each stage.
- Clustered Sampling –This is also known as a two stage sampling method. The first stage involves the selection of clusters. This is proceeded by the selection of elements within the selected clusters using a cluster technique.

- Panel sampling –This involves selecting a sample using the random sampling method and then asking repeated questions to the subjects of the sample, several times and within a certain period of time.

Non-Probability Methods

The following list briefly highlights the non-probability methods that exist in theory

- Quotas sampling – This is closely likened to stratified sampling. The only difference being in the second step. Instead of using random sampling in the second step, the quotas sampling technique selects the elements based on some already defined measure.
- Purposive sampling –This is also known as judgmental sampling. It involves selecting a sample based on the personal judgement of the researcher.
- Convenient sampling – This selects a sample based on what is available and convenient.

From the above stated sampling methods, this study has employed the non-probability techniques which are purposive and convenient sampling.

A total of twenty-one (21) gemstone mines where sampled using purposive and convenient sampling, before administering the questionnaires a short interview with the mine owners, mine managers and care takers (Ex-Miners) found on site was done and the study explained to them. This made it easy for respondents to get clarification from the researcher where necessary. Both producing and non-producing mines that where visited were asked questions related to technical, financial and regulatory challenges they were facing and their responses were recorded in a book. Amongst the 21 mines visited, 14 responded positively to the questionnaires, which is nevertheless a very good response rate enough to command a reliable and quality research.

3.6 Data Analysis

The collected information from the questionnaires and interviews as well as the documents received from the key stakeholders were analyzed using cause and effect analysis with the aim of presenting an accurate and unbiased assessment of the issues affecting the sampled population.

3.7 Software Application

Microsoft Excel was used for easy data sorting, error and omissions checking, and structuring of data for analysis according to the research objective and also for graphical representation of findings. Mining software's, arc GIS software used for geological mapping interpretation and making geological maps and Surpac 3D modelling software for creating 3D models of collected data were also used for the analysis of primary data collected from Gemcanton mine.

3.8 Challenges and Limitations Encountered during the Study

There were a number of challenges encountered during this study. However, they did not fundamentally affect the outcome of this exercise. Some of the limitations encountered worth mentioning are as follow:

- There is a critical shortage or lack of information regarding the gemstone industry. It was not possible to establish for instance the number of people involved in the gemstone mining as there isn't sufficient information available on gemstone mining.
- The gemstone mining activities are shrouded in secrecy so it is not possible to establish the exact amount of income generated from the activity.
- Most small miners are illiterate, therefore they were unwilling to answer some of the questions asked for fear of making wrong statements.

3.9 Research Ethics

All the materials obtained from published and unpublished sources were referenced and acknowledged to avoid plagiarism. The anonymity and privacy of participants were respected and personal information was kept confidential and secure. The study ensured full privacy by giving assurance of confidentiality about information shared. No names were required on the questionnaire. Thus, the confidentiality of participants was ensured. Therefore, this was a voluntary exercise from the side of respondents and no one was forced to give information. The information obtained is only being used for the purpose of this study. Furthermore, in case of the questionnaire, no data was falsified or misrepresented with a purpose of criticizing the participants.

CHAPTER FOUR: DATA ANALYSIS AND PRESENTATION OF RESULTS AND FINDINGS

4.1 Introduction

The 106 active plots reported by the Zambia Cadastral Unit differs from the actual active plots noticed from the verifications visits in the area. It was established that the number of active plots is much less than the 106 reported with a notable difference of 71. The discrepancy in the statistics could be as a result of lack of frequent updates to the database as well as gaps in reporting. The Ministry of Mines and Mineral Development reports that of the 106 recorded active gemstone mining plots only 35 mining plots submit mineral retains showing if there are in production or not, though of only 4 mines show consistency that include Kagem mine, Grizzly (Gemcanton) mine, Tubombeshe mine and Triple S mining. Figure 4.1 shows a plot of discrepancy in the active plots reported against the actual active plots as while as the number of plots visited during the course of the study.

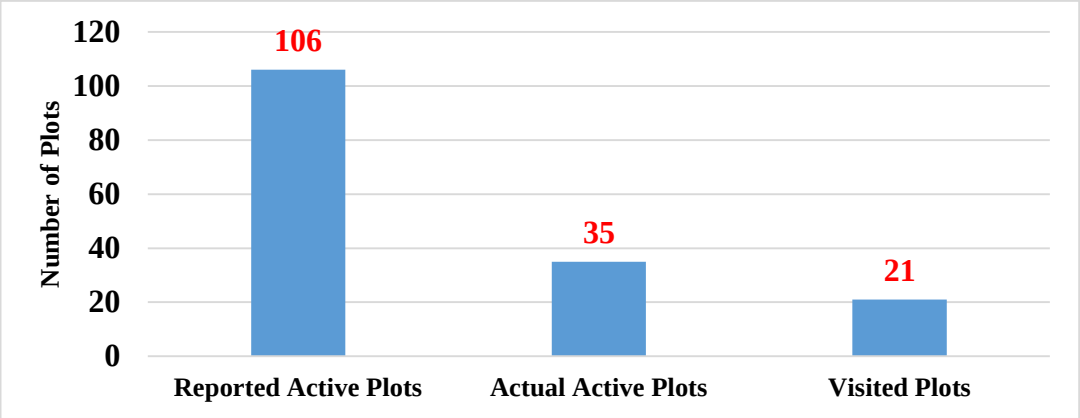


Figure 4.1: Active Plots in the Kafubu Emerald Area

During the study, only 21 gemstone mines were visited and 21 questionnaires administered by using and/or leaving one questionnaire at each mine visited.

Table 4.1 shows the response obtained and their distribution in terms of percentage.

Table 4.1: The Response to Questionnaire

	Interviews arranged and Questionnaires issued	**Response received from Interviews and Questionnaires issued**	**% Response**
Interviews	20	18	44
Questionnaire	21	14	34
Total	41	32	78

From the 21 gemstone mines targeted for interviews only 18 interviews where managed and from the 21 questionnaires distributed only 14 where collected and used for the research. This constituted a total response rate of 78%. This response rate was generally good and could be attributed to the fact the government wants to repossess the dormant gemstone license within the study area. Also, with the government providing loans and grants to gemstone miners thus, most miners thought the researcher was being used to select mines to be considered.

4.2 Challenges of the Gemstone Mining Sector.

4.2.1 Technical Challenges Respondent's Reaction

Figure 4.2 is the response to the question on the technical challenges which sought to find out the geological and mining challenges and measure of mitigating as well as improving the technical part of the gemstone sector.

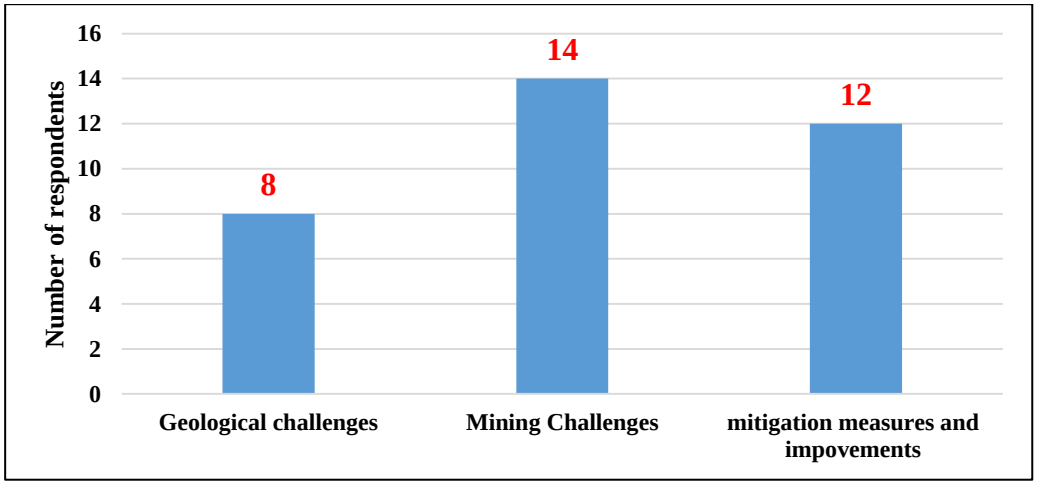


Figure 4.2: Technical Challenge Response

4.2.1.1 Geological Challenges Respondent's Reaction

From the 14 questionnaires administered, only 8 responded to have geological challenges which represents 57% response. Whereas the remaining 43% claimed to have geological reports and only needed capital to start mining. Figure 4.3 shows the proportions of the geological challenge responses.

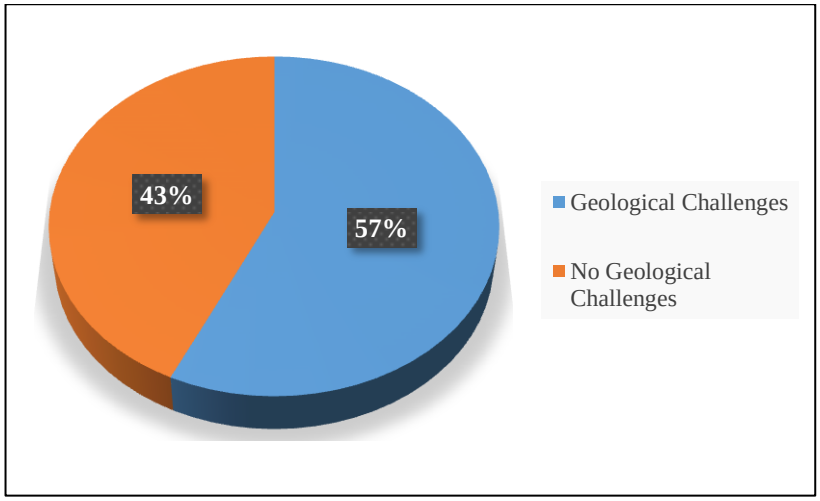


Figure 4.3: Proportions of Geological Challenge Response in the Kafubu Emerald Area

The major geological challenges noted from the 8 respondents where difficulties in defining the gemstone (emerald) ore body and estimating the amount/quantity of gemstone (emeralds and beryl) that are to be mined from the mine area. Other challenges included lack of geology skill and profession in gemstone mining and lack of diamond core drilling machines to probe the underlying rock formations.

From the interviews and field observations the research noted that most of the gemstone mines interviewed lacked geological understanding of their mine areas such as understanding the controls of emerald mineralization. The researcher also observed that most of operations at small scale mines lacked geological skills like identification of minerals using physical properties such as mineral hardness, mineral appearance, colour streak, specific gravity, and magnetism. The workers had little understanding of the basic geology of their area. They did not understand the occurrence of the ore deposit, the types of rocks and how to interpret geological maps. Some of the small-scale miners' mine without any tangible geological information input. They lack

geological information such as minerals resource potential information putting them at a disadvantage with developing policies as well as negotiating contracts under the relevant legislation, and the lack of data also reduces the levels of investment in minerals exploration and mining activities including related upstream and downstream economic activities.

4.2.1.2 Mining Challenges Respondent's Reaction

All the 14 respondents stated to have mining challenges. This represents a 100% response from the gemstone miners on the challenges of mining gemstones as illustrated in Figure 4.4.

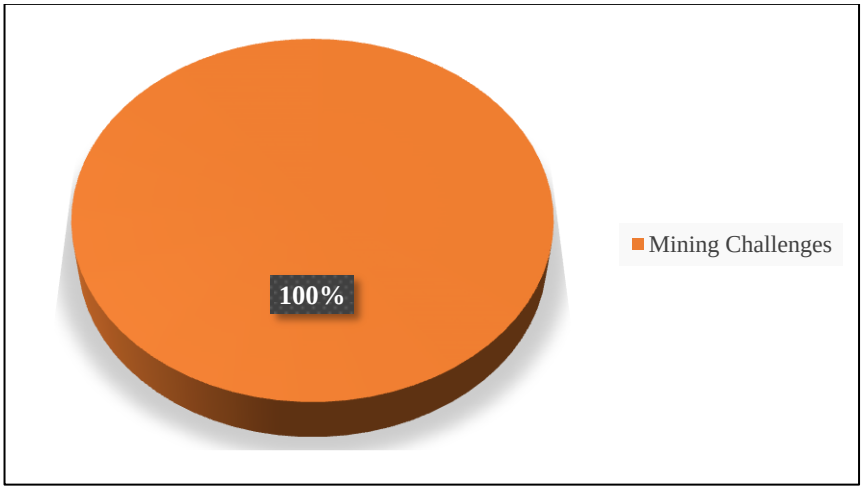


Figure 4.4: Proportion of the Mining Challenge Response in the Kafubu Emerald Area

The most common mining challenges stated from the respondents were lack of mining equipment and the presence of induced cracks in emeralds and beryl's due to vibrations during blasting. The latter was mostly stated by producing mines and those mines which used to produce in the past but where not producing at the time of the study. The other challenges stated include:

- Lack of skills improvement with the coming of new mining technologies
- Limited area for mine development and expansion
- Lack of dumping area
- Difficult to design a pit with standard ramps and benches for small licence areas

- Difficult conducting standard safe mining with limited manpower and equipment

From the interviews and visitation of gemstone mines within the study area, it was observed that some mines had reached levels were traditional mining techniques and low level equipment in excavation or digging could not be applied and require new mining equipment. Most of the pits at this level were flooded with water. Figure 4.5 shows the flooded pits on four different plots.

Figure 4.5: Various Flooded Pits in the Study Area

The researcher noted that there is need for more and better equipment and technology for mining due to the increased stripping ratio in the open pits in order to expose the ore body in some mines.

The researcher through interviews and observations also noted that the absence of machinery meant work had to be done manually with poor slope and mine stability which caused occupational safety hazards at the mine sites and could thus resulting in injuries and fatalities.

Lack of mining skills, was another observation made by the researcher in the study area. Most miners lacked the technical knowledge to improve their capacity in this

specialized economic area. Miners also usually lacked knowledge about legislation on health and safety, protection of the environment, mineral rights and a decent work environment. Most miners in the industry had poor skills at all levels of the operation.

It was noted from the respondents the use of labour intensive technologies such as hand held pneumatic drills (jack hammers) must be minimized in mining operations and employ the uses of track mounted drill rigs when blasting. This will in turn maximise productivity, minimise the occupational safety and health hazards and minimise on time. A blast pattern drilled using jack hammers is illustrated in Figure 4.6 below.

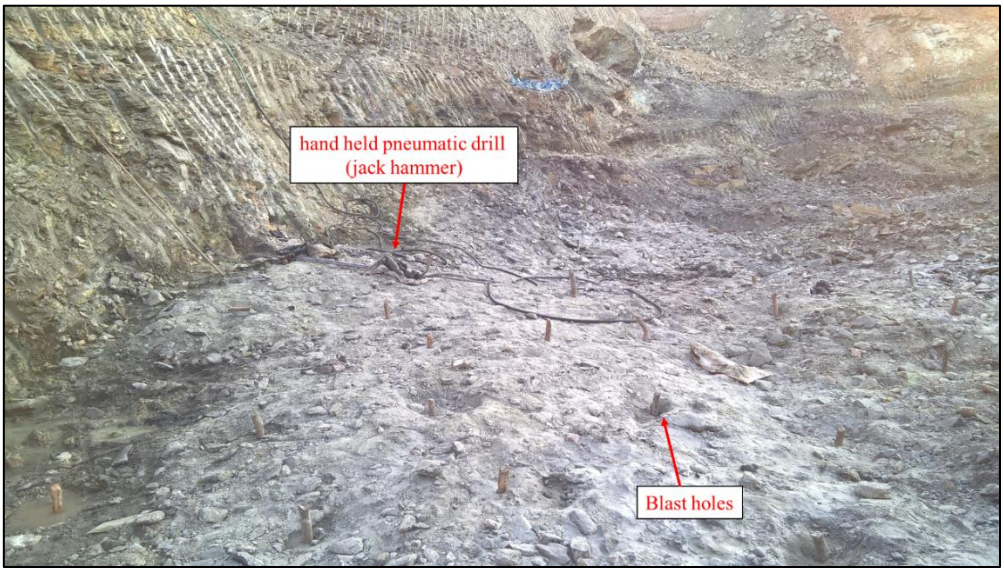


Figure 4.6: Blast Pattern Drilled using Jack Hammers

4.2.2 Financial Challenges Respondent's Reaction

The plot in Figure 4.7 shows the questionnaire response on financial challenges. The question sought to investigate financial challenges and causes of lack of funding faced by gemstone mines in the study area.

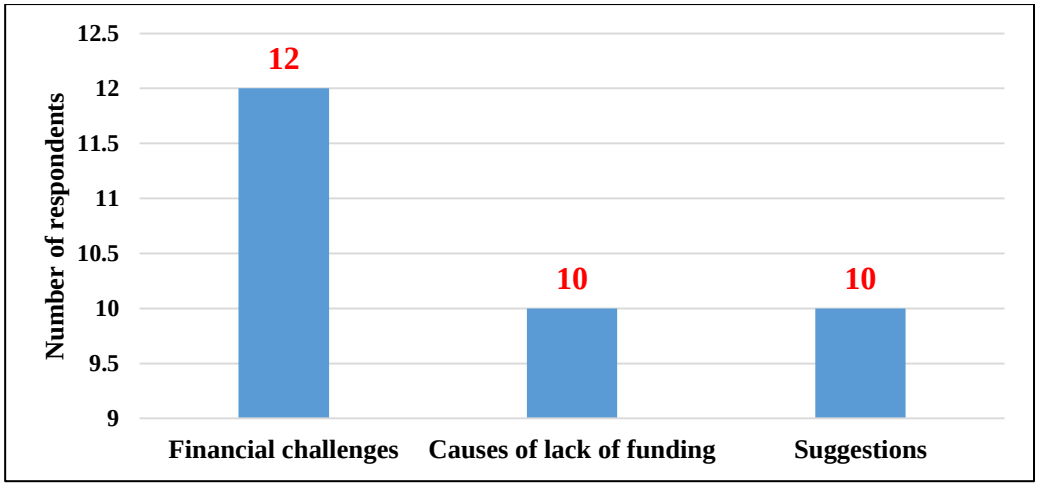


Figure 4.7: Financial Challenge Response in the Kafubu Emerald Area

4.2.2.1 Financial Challenges

Figure 4.8 shows that 86% of the respondents stated they had financial challenges while 14% affirmed that they did not have financial challenges at the time of the study.

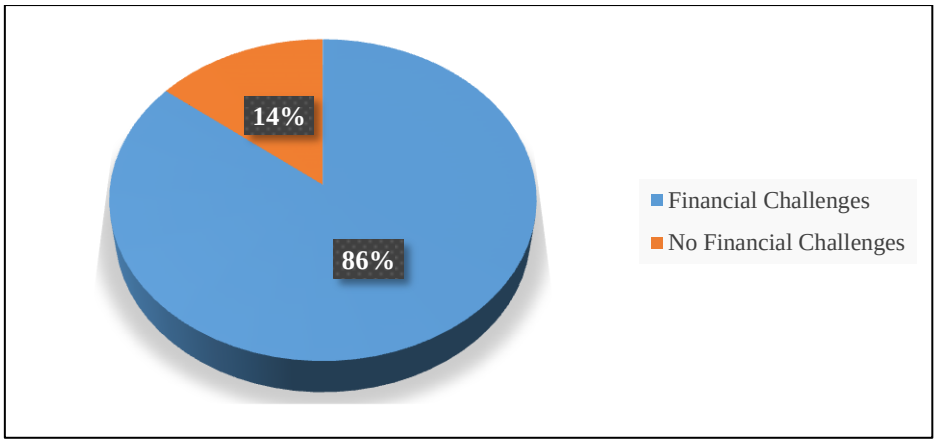


Figure 4.8: Proportions of Financial Challenge Responses in the Kafubu Emerald Area

The financial challenges stated by the respondents include:

- Lack of start-up capital such as capital required for exploration and siting up of the mines.
- Lack of working capital required for running the mining operations.

- Lack of credit facilities such as banks and other financial institutions to give credit to the gemstone miners.
- Limited investors in the gemstone industry making it difficult to access funds.
- Lack of collateral
- Lack of marketing
- Lack of financial statements by gemstone miner
- Lack of business and management skills.

From the researcher study, the biggest challenge that has affected the gemstone sector is finance. Lack of proper capital base has made gemstone miners to remain behind in terms of sustainable development. There has to be a long-term financing that is efficient from the prospecting and exploration stage right through to the closure and reclamation of the mines. Access to capital is a major stumbling block affecting most of the gemstone mines in Kafubu area as this was highly evident from the fieldwork conducted. Prospecting, exploration and other mining activities for example, demand a lot of input on the part of potential miners. The energy invested are usually rendered useless as lack of proper prospecting, exploration and mining tools coupled with the little or non-existent technical knowledge become a trial and error exercise which in most instances does not amount to any significant gains.

Literacy levels in most of the gemstone miners in Kafubu area is still low as majority of the miners lack the knowledge required to prepare documents such as a business plan which is a must-have for any investor or a financing institution to even entertain the thought of advancing funds or credit to gemstone miners. Other documents required by banking institutions include; a feasibility study report, mining licence, a document detailing repayment plan for the Credit and a proof of a market for the product to be produced. The business plan for example has to reflect the quantity and quality of mineral reserve in question and involves other technicalities of costing and analysis in order to achieve breakeven point. The aforementioned would be a jargon to most of the miners although a few are able to prepare such documents which are needed by financiers. Such demands continue to encourage the informal nature of gemstone miners hence minimizing the opportunities of growth that would have emerged had a formal partnership with investors been established.

Since most gemstone miners are informal in nature, informal or not so formal partnerships between miners and 'supporters or sponsors' have been adopted in some of the mining sites. The sponsors or supporters would avail the miners with food, water, mining equipment, contingency money and any other relevant item critical to the process of mineral exploitation. Most of these sponsors are exploitative as they get a large slice of the pie resulting from the sale of the gemstones as they are accorded the rights to sell the gemstone leaving only a small percentage to the actual miner. The benefit sharing between the miner and the sponsor in most cases is unfair. This will in turn discourage the miner from formalizing the venture.

4.2.2.2 Causes of Lack of Funding

Accessing finance for gemstone mining has and is still a challenging undertaking. A reason for this can be a lack of understanding of the gemstone industry by the financing institutions in Zambia. Commercial banks and Micro-finance institutions had given the gemstone mining sector a cold shoulder as the sector had not been awarded the level of seriousness it deserved may be due to its meagre contribution to the economy in the yester years as compared to copper mining which usually contributes significantly to the country's GDP; and a common connotation that "copper is the country's backbone" has always been used.

The respondents stated a number causes for lack of funding and access to finances by the gemstone miners. These included:

- Lack of bankable information such as feasibility reports of the gemstones mine, financial statements and business plans. Most of the gemstone mine owners are unable to present this information and don't have funding to hire a consultant do the work for them.
- Lack of collateral such as asset to pledge and inability to meet collateral requirements.
- Withdrew or death of a Promoter/investor.
- Lack of own contribution of which some mine owners do not have funds to invest and continue their mining operations.
- Lack of financial institutions to provide a wide range of financial support to the gemstone mining industry. It is assumed as a risk business with little assurance of paying back the borrowed funds.

4.2.2.3 Financial Institutions

The researcher visited and interviewed four financial institutions namely First National Bank (FNB) Zambia, Stanbic Bank Zambia, Standard Chartered Bank Zambia and Zambia National Commercial Bank on the challenges and obstacles that hinder gemstone mines from accessing finance from the institutions. The researcher noted the following challenges and obstacles from the different institutions.

- The financial institutions stated that most of the gemstone miners have a challenge of providing financial information such as financial statements of their business.
- Gemstone mine owners are unable to provide proof of how profitable their project is and how they intend to invest the funds.
- Since gemstones are considered a high-risk business and have no fixed price like base metals such as copper where in most cases only the gemstone mine owner knows the financial structure and viability of the mine project, the financial institutions are more likely to finance gemstone mines that are able to provide collateral and base their lending decisions on the amount of collateral presented.
- The other challenge noted was that gemstone miners lack business bank accounts with the financial institutions. It is a big challenge for the financial institutions to provide financial assistance to gemstone miners because they do not have any transaction history for the business and do not know anything about the credit-worthiness of the gemstone mine.
- Most applicants that apply for funds fail to meet the collateral requirements set by the financial institutions.

The following findings and important observations where noted by the researcher on financial challenges during the research study:

- Lack of business and management skills among the gemstone mine owners was noted through observations and interviews. Some of the gemstone miners failed to provide financial statements and finance plans of their business when asked by the researcher and it was also observed that most mines do not have accountants to hold their finances.

- Lack of market research. This often makes the gemstone mine owners to under invest in activities and services that could potentially enhance their productivity. The gemstone miners lacked market strategies for advertising and selling the gemstones.
- Adaptation to technological changes. Majority of the businesses are unable to keep up with technological developments.
- The local institutions of finance for advancement of credit have lacked the capacity in the form of gemstone industry professionals. Very few, if any, do have the human resource with the proper background to advice these institutions on the attitude and mode of approach towards the mineral resource industry. However, in the coming years, financial institutions will increase the capacity of its human capital as educational institutions continue to offer new courses in the extractives sector pertinent to strategy focus by the finance institutions on the mineral sector.

4.2.3 Regulatory Challenges Respondent's Reaction

The Table 4.2 summaries the response of the gemstone miners to the questions on the regulatory challenges faced in gemstone mining.

Table 4.2: Regulatory Challenge Responses in the Kafubu Emerald Area

	Yes	**No**
Adequate of policies and regulations	2	9
Enforcing and monitoring of policy and regulations	6	8

4.2.3.1 Adequacy of Policies and Regulations

Out of the total respondents, 15% agreed that the current government policies and regulations in various government Acts and Laws are adequate in boosting the growth of the gemstone industry in the country. Whereas, 64% strongly opposed the notion that the devised policies and regulations were sufficient in improving the development of the industry. Moreover, 21% of the respondents did not give an answer to the closed end question. Figure 4.9 illustrates the ratios of the respondents in relation to the adequacy of policies and regulations.

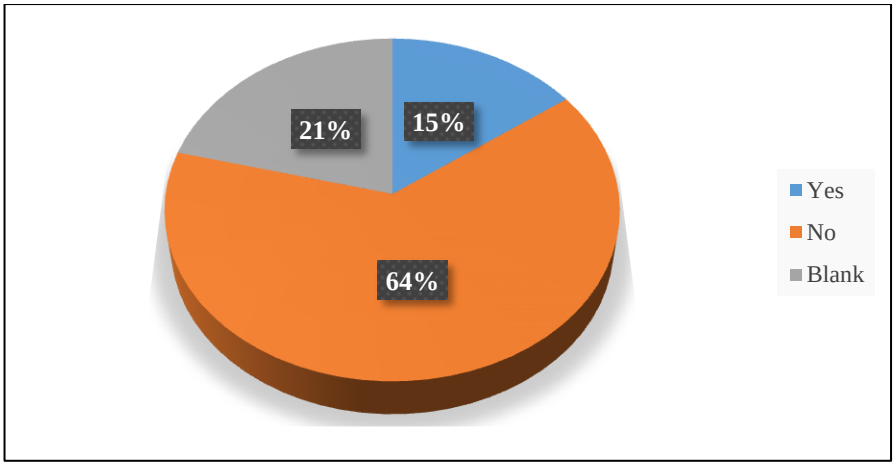


Figure 4.9: Proportions of Respondents Views on the Adequacy of Polices and Regulations in the Gemstone Sector

4.2.3.2 Enforcing and Monitoring of Policies and Regulations

With regard to enforcing and monitoring the polices and regulations devised to enhance the growth of gemstone mining, 43% of the respondents supported that the Ministry of Mines and Mineral Development was adequately implementing the contained strategies and laws. But, 57% of the respondents were in total disagreement, citing irregularities in the implementation practices. Figure 4.10 shows the pie chart partitioning those in agreement and the opposing respondents

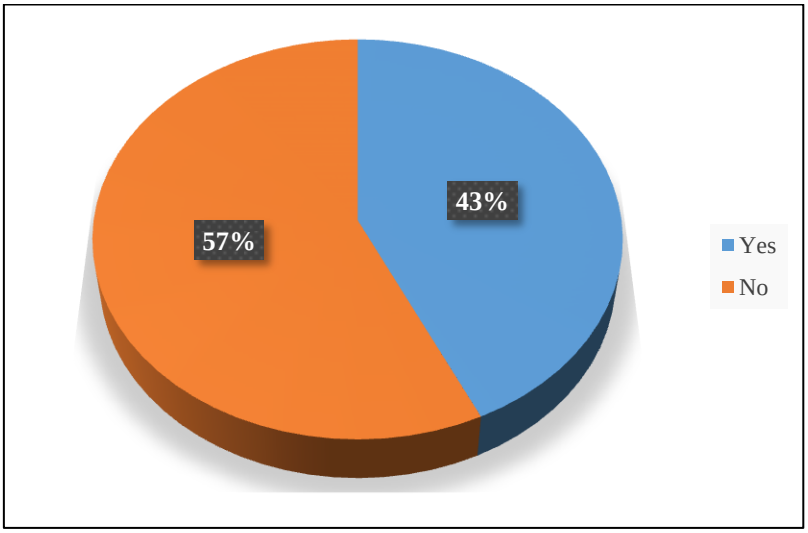


Figure 4.10: Ratio of Respondents View on the Governments Adequacy to Enforce and Monitor the Policies and Regulations in the Gemstone Sector

Additionally, in relation to political and legal challenges encountered by gemstone miners, the subsequent constraints were found to hinder the development of the gemstone sector.

- Difficulties in land accessibility
- Inadequate resources to perform the prospecting task
- Inadequate infrastructure such a roads and electricity to mine sites
- Lack of marketing strategies for gemstones in Zambia
- Smuggling of gemstones out of the country

4.2.3.3 Government Ministries

During the period of data collection, meetings were scheduled with the Ministry of Mines and Mineral Development (MMMD) officials in order to get the governments perspective on the adequacy of the existing policies and regulations that have been formulated to enhance the growth of the gemstone industry as well as its role in supporting its development. The succeeding responses were obtained from the various officials interviewed at the ministry:

- Government has come up with a reserve called Mining Sector Revolving Fund (MSFD), which was formed with the intention of providing credit facility to small scale miners who cannot access credit from private and public financial institutions. The introduction of this fund was developed as one of the government strategy intended to create opportunities to diversify from usual copper mining; improve performance of the small scale miners and engage them in formal economy; realize the potential of the small scale mining sub-sector in contributing to employment creation; foreign exchange generation and facilitate economic development through financing of small-scale miners and providing necessary extension services for safe mining practices.
- Government was working hard to encourage and support the Zambian people to invest in owning mining licences by providing policies and regulations that are favourable to citizens. One such initiative provided was the reduction of mineral royalty for gemstone production from 9% to 6% in the recently amended Mines and Minerals Act, 2016.

The Ministry of National Development Planning (MNDP) was also visited so as to get the views that the ministry had in their national plans to enhance the growth of the gemstone sector in Zambia. An affirmative responses were received stating that government has come up with strategies to promote exploitation of gemstones and industrial minerals, supporting local and foreign participation in adopting mining value chains and industrialization as well as promoting small scale mining as outlined in the Seventh National Development Plan (SNDP) 2017-2021, pp. 69. The strategy in the SNDP focuses on increasing exploration, mining, processing and promoting the use of industrial minerals and gemstone products in order to enhance support the growth of other sectors. This Plan also stresses on formalizing and empowering small scale miners to make them more productive, supporting development of lapidaries and local auction sales of gemstones and enhancing the capacity of local businesses to participate in the mining value chains and boost export revenue.

Last but not the least, the Ministry of Commerce, Trade and Industry (MCTI) was visited to get views on what the government is doing to enhance and promote growth of the gemstone industry. A copy of the National Industrial Policy (NIP) 2018, was made available which revealed the support that the government was rendering to its people. The NIP affirms that the Government of the Republic of Zambia has placed industrial development at the core of its development agenda. Therefore, the NIP is motivated by the aspirations of the Country's Vision 2030, which aims at transforming Zambia into a thriving middle income economy. It also sets out Government's approach to the industrial development of the country. Inscribed in the NIP are guidelines that will advise the application of government's industrial development agenda, with particular reference to the growth, diversification, upgrading and competitiveness of the country's manufacturing sector. The NIP is expected to drive the transformation process which will assist the country deliver sustainable jobs, equitable growth and wide spread poverty reduction.

4.2.4 Other Challenges

Other than the three above mentioned major challenges affecting the growth of the gemstone sector, this study also noted some sociological and environmental constraints hindering the development of the sector. The sociological challenges observed included: superstitions on the formation of the gemstones; lack of shelter

and management ignorance. While environmental challenges where noted were soil erosion, deforestation and water and soil pollution.

CHAPTER FIVE: A CASE OF GEMCANTON MINE

5.1 Introduction

The technical challenge results from this research survey have been applied to Gemcanton mine to show how they can be resolved and mitigated.

5.1.1 Background

Gemcanton mine has progressed from an informal small scale gemstone mine to a formal second largest scale gemstone mine in Zambia. Grizzly Mining Limited (now Gemcanton Mine) was established in 1997, as a gemstone mine. In 1999, the company obtained a Gemstone licence following a court ruling to re - demarcate Pirala Mining Cooperative resulting into two mine licenses being generated. Grizzly Mining Limited became plot 8E and the other remained Pirala Mining Cooperative. Grizzly later bought the adjacent Lumpuma Mines and the combined mines became plot 8E. With time, the demand for dumping space prompted Grizzly to further acquire adjacent Kafubu mine from Kamakanga Mining limited in 2003. In 2007, the company acquired Chimpundu Mine. Later, Aakala and E&M Storti mines were also acquired. In 2015, Grizzly mining limited partnered with Frango Finance Limited to form a new company, Gemcanton Investments Holdings Limited.

5.1.2 Location and Access

Gemcanton mine is located approximately 45km southwest of Kitwe, the main city of the Copperbelt, and is situated within the Kafubu emerald fields. Access to the fields is by a 15km-tarred road from Kitwe to Kalulushi town and then by approximately 30km of gravel road.

Gemcanton Mine covers an area of 349.173 Ha in the Pirala and Kafubu Streams catchment area. The mine is running open pit operations at its combined Camara, Chimpundu East, Chimpundu West and Chainama Pits and producing emeralds and beryls mining. There are also three waste dumps namely North, South and Mozombwe Dumps. Figure 5.1illustrates the location of Gemcaton mine on the Kafubu Emerald area map.

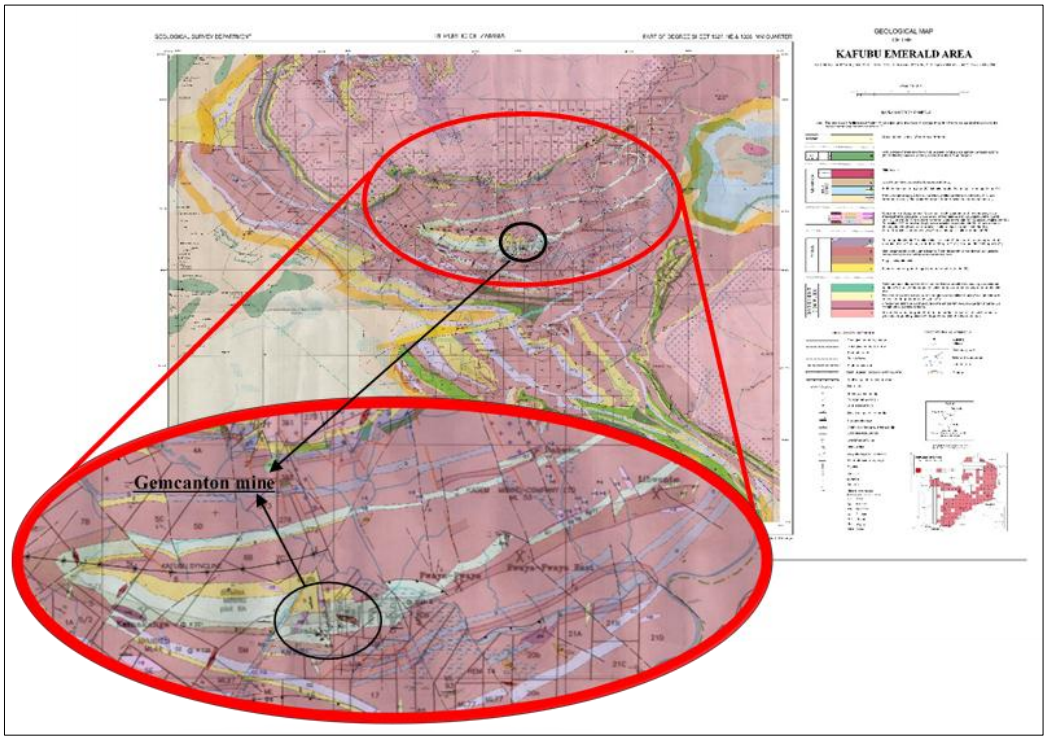


Figure 5.1: The Location and Geological Map of the Case Study Area

5.2 Geology of Gemcanton Mine

Gemcanton mine is underlain by four major rock formation of the Muva supergroup. These rock formations include (following stratigraphic order):

- Laterite and top soil
- Mica schist
- Amphibolite schist
- Talc magnetite schist (TMS) locally called Paidas
- Quartz mica schist

In addition to this sequence occur alteration zones between layers, and especially with the different forms of volcanic intrusions (kaolinitic pegmatites, quartz veins, quartz-tourmaline veins and more). The most relevant alteration zone in which emerald crystallization would occur is the alteration zone between intrusions (especially quartz-tourmaline veins) and the magnesium and chromium rich talc magnetite schist. The rock sequence has an east-west strike and dips 35-50 degrees south. The TMS is

the host rock to the emerald mineralization. Mapping in the pit area has revealed two TMS units locally called the Lower and Upper orebodies.

5.2.1 Geological Controls of Emeralds Mineralization in Kafubu Emerald Area

In the Kafubu Emerald area, the biotite phlogopite schist is the main host rock for the emeralds while the talc-magnetite schist is the minor ore (Hickman, 1972).

The biotite-phlogopite schist occurs in relatively thin zones around the tourmaline-quartz veins that have been emplaced in the talc-magnetite schist. It appears to have been formed by the reaction between the talc-magnetite schist and the hot tourmaline-quartz vein-forming fluids during the emplacement of the latter.

The tourmaline-quartz veins were the source of beryllium, the element that led to the formation of the mineral beryl. The talc-magnetite schist, a metamorphosed ultramafic rock, was the source of chromium, the element needed to transform beryl to emerald i.e. the element that provides the green colour in emerald.

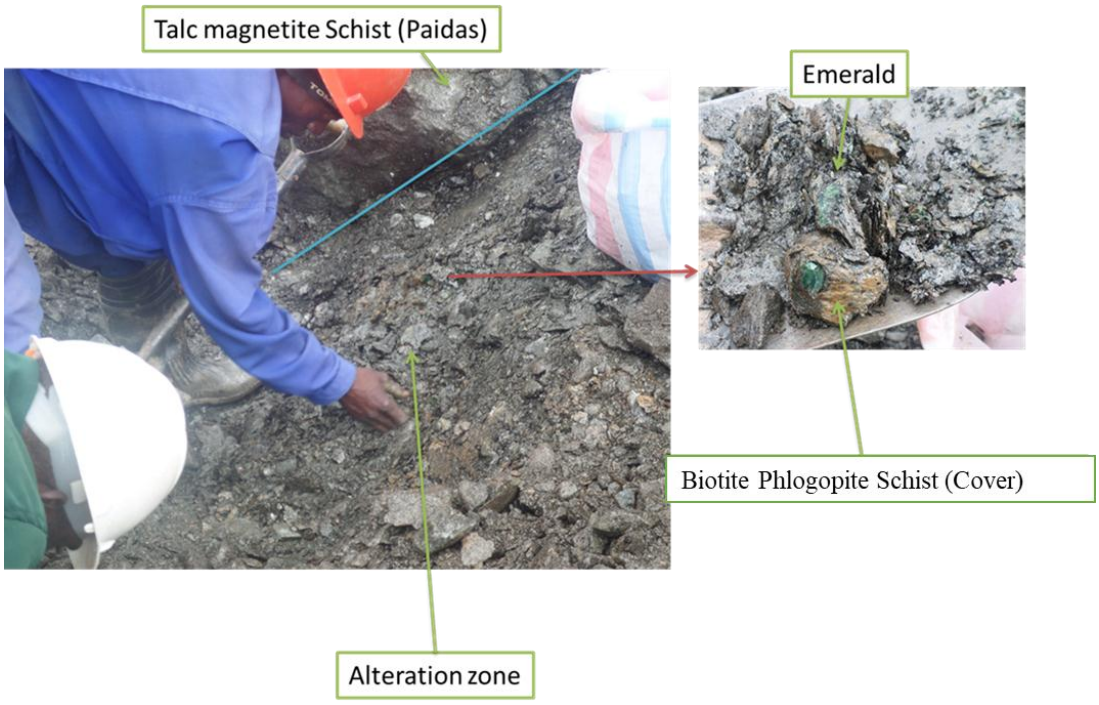


Figure 5.2: A Picture Depicting the Formation of an Alteration Zone in Talc Magnetite Schist

5.2.2 Alteration Zones – "Ore body"

The end result of veins emplacement into the talc magnetite schist is the formation of an alteration zone. This is essentially the "ore body" where beryl's and emeralds grow. The quartz-boron-beryllium silicate rich veins were emplaced in the country rocks as a late hydrothermal process. This Metasomatic reaction in contact with the host talc magnetite schist rocks results into an alteration zone of biotite-phlogophite schist. In the Kafubu area, the talc magnetite schist offers a favorable host because the rich melt has scavenged chromium from the talc magnetite schist into the resultant, beryl thereby giving it the green tint. Where the beryl is green and transparent this resulted into emeralds which are sought for their value. The two main styles of mineralization at Gemcanton mine are; discordant alteration zones and concordant alteration zones.

5.3 Mineral Resources for Gemcanton Mine

5.3.1 Introduction

Mineral Resource estimation at Gemcanton was undertaken using computerized wire framing techniques to produce geological models. Geological models were constructed, estimated and classified for all the mining pit areas, using all available data obtained from pit mapping and core logging. All modelling was undertaken using Surpac 3D modelling software.

5.3.2 Pit Mapping

Geological mapping was done across five pits namely Chimpundu, Camara, Chainama, Pit D and Storti-Geneva pits and the data recorded in the database. The data from mapping was regularly imported into ArcGIS software and incorporated with pre-existing mapping data to produce an updated digital geological map.

5.3.3 Core Logging

Geological data was recorded in a detailed log spread sheet designed to capture key geological information for each interval. This includes rock type, grain size, texture, degree of weathering, colour, intrusive features (such as veining) and major, minor and accessory minerals. A total of 189 drill holes with a total meterage of 13,812.12

meters were recorded in the database for the study. Figure 5.3 below shows the drill hole collars at all the Gemcanton pits.

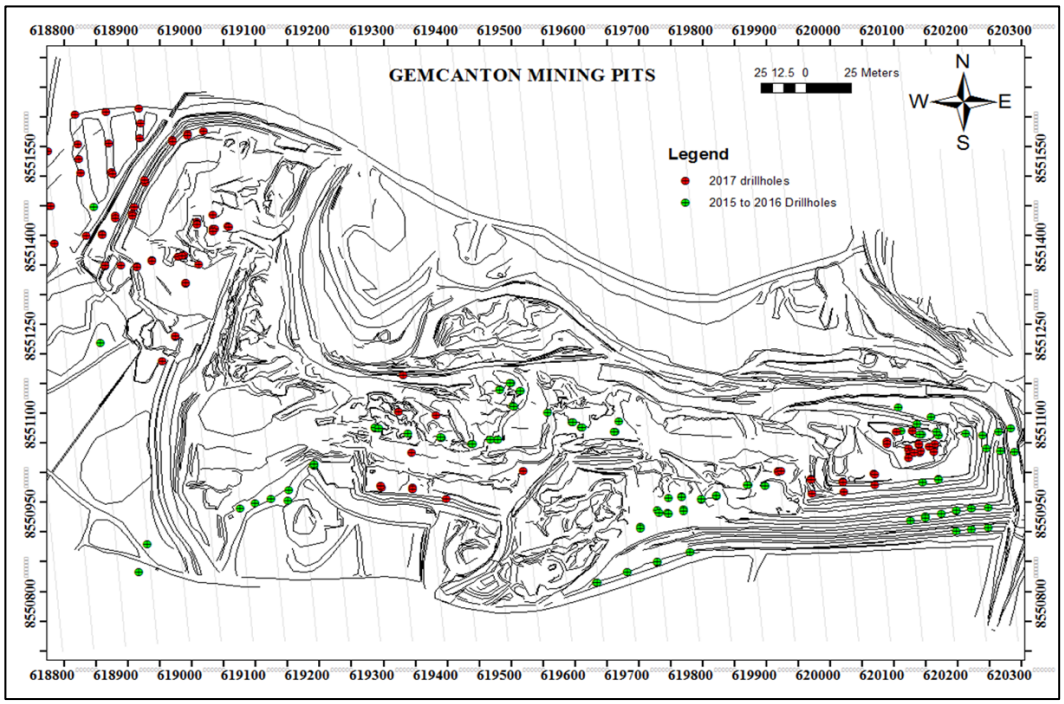


Figure 5.3: Drilled Holes present at Gemcanton Mine

5.4 Geological Modelling, Concentration and Tonnage Estimation

The geological modelling process was largely focused on defining three dimensional solids using Surpac software. Figure 5.4 shows a typical geological model produced with the use Surpac software. The focus of geological modelling has been the concordant alteration zone, as these mineralization style hosts the majority of the emerald mineralization. Concordant alteration zone forms on the footwall of the TMS and follows the basal contact of the TMS and Quartz-mica schist units. There are laterally continuous with an average thickness of 1m and are often intersected by drilling. Numerous sections were created to aid geological modelling with a type section shown below in the Figure 5.4.

The units have been modelled based on the drill hole intersections on these sections. The table below summaries the number of drill holes used in the model.

Table 5.1: A Summary of Drill Hole Data

	Database	**Software Estimates**
Number of Drill holes	189	151
Intersection Meters	13812.12	211.12

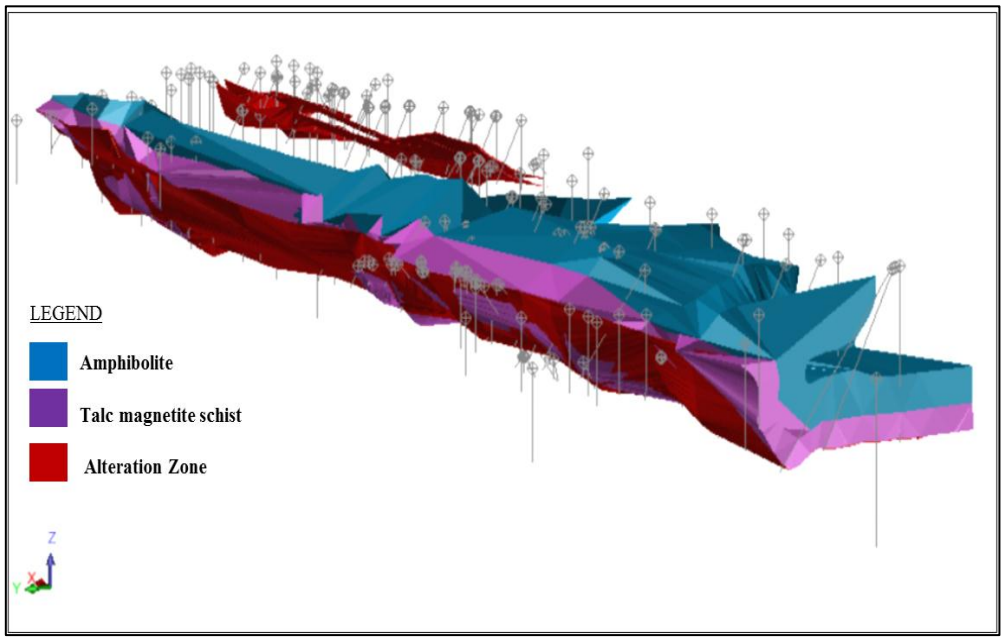


Figure 5.4: Geology Model generated from Surpac Software

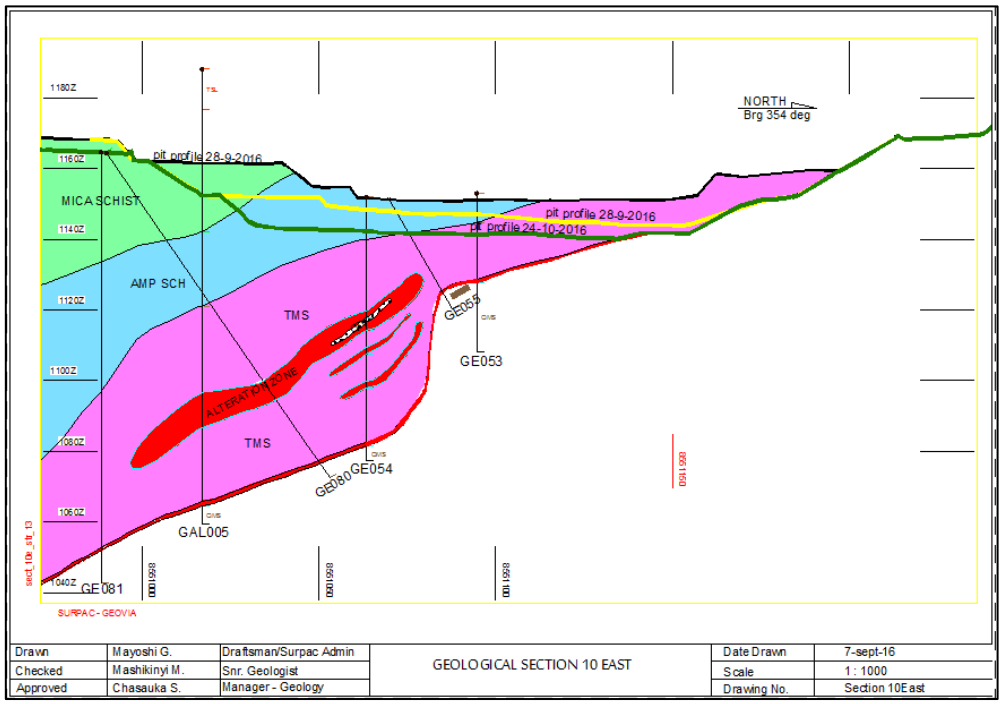


Figure 5.5: A Typical Cross Section of the Geological Model

From the geology model, a mineral resource model was created using the alteration zone (ore body) as shown in the Figure 5.6 below.

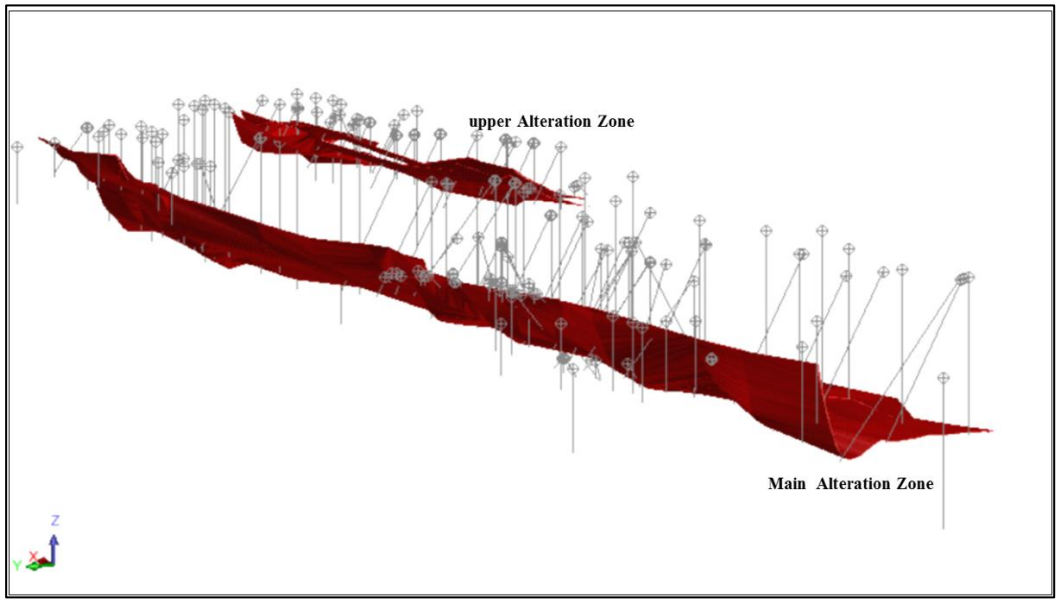


Figure 5.6:The Alteration Zone Model

The footwall concordant alteration zone has been Projected to the mine limit of 1400m of the current pit area while the depth has been projected to the 140m. The respective volume envelopes have been computed.

The volumes of the alteration zones were computed using surpac software. The volume of the alteration was then multiplied by the specific gravity of 2.7 to obtain the tonnes of alteration zone material contained. The same calculation was done on other different lithology units with their respective specific gravity.

Economic concentration of emeralds and beryl's are largely contained within the alteration zones. To obtain the concentration factor to use in the mineral resource model, historical data from Gemcanton mine from 2013 to 2016 has been used. Based on the bulk sampling, plant and pit data the following concentration factors were calculated and applied to the mineral resource estimate.

- Upper alteration zone = 0.1 Kg/tonne
- Main alteration zone = 0.16 Kg/tonne

5.4.1 Challenges and Assumptions

- The distribution of economic concentrations of alteration zones are extremely difficult to sample, estimate and classify as current drilling techniques are inappropriate to provide sufficient data density to enable direct estimation of alteration zone tonnage and grade. Accordingly, drilling as currently employed can only provide information to determine the volume of TMS, of the larger, more continuous concordant alteration zones and the locations relative to other lithology's and geological structures. Derivation of Mineral Resources was largely dependent on the availability of the results of bulk samples or equivalent such as historical production statistics.
- A number of assumptions were made during the modelling process. Based on the available data, it was assumed that the TMS unit remains constant to extents of the modelled unit with no changes in geology or mineralogy. Similarly, it is assumed that there is no changing in the mineralising system with depth and no change due to weathering with depth.
- In addition, the concordant alteration zone has been inferred from the location of the footwall of the TMS unit. An assumed thickness of 1m has been applied

on drill intersections less than 1 m applied based on the mapping and the geological knowledge. The concordant alteration zone was often logged in the drill holes, and is known to exhibit a pinch and swell geometry.

- Concentration data was sourced from historical production data so no direct estimate can be undertaken. Concentration estimates were therefore entirely dependent on historical data for validation. Respective concentration factors were applied to both the upper and main alteration zones in the model as the quantity of emeralds recovered from the alteration zone and TMS was known, but it cannot be specifically stated as being in certain local areas.

5.5 Gemcanton Mine Mineral Resource

The upper alteration zone contained an estimated total of 14,614 kg and the main alteration zone an estimated total of 103,381 kg. A grand total of **117,995 kg** was estimated to be contained in both alteration zones.

The Table 5.2 below summaries the material contained in the models.

Table 5.2: Gemcanton Mineral Resource

Summary of Material	**Totals**
Tonnes of Upper Alteration Zone	146,141
Upper Alteration Zone Concentration Factor (kg/Tonne)	0.1
Contained Emerald/Beryl's (kg)	14,614
Tonnes of Main Alteration Zone	646,131
Main Alteration Zone Concentration Factor (kg/Tonne	0.16
Contained Emerald/Beryl's (kg)	103,381
Total Contained Emerald/Beryl's (kg)	**117,995**
Tonnes of Talc Magnetite Schist	16,144,531
Tonnes of Waste (Amphibolite/mica schist)	67,049,740
Total Tonnes	83,986,544

5.6 Extraction of Gemstones at Gemcanton Mine

5.6.1 Introduction

The mining method used at Gemcanton mine comprises conventional open-pit operations: drill and blast, excavate and load and haul to in-pit backfill, waste rock dump locations and the various ex-pit stockpiles and a stockpile at the wash plant facility. Free dig techniques are employed in the weathered zones at the Mine. Free dig techniques are possible in the upper 20-30 m where weathering is present. The open pit mining activities are undertaken by in-house mining fleet.

The Figure 5.7 below shows a schematic overview of the open pit mining activities, described below:

The mining fleet strips the top 20-30 m of material. The majority of this material is free-dig, with the remaining overburden requiring drilling and blasting.

After completion of mining free-digging material, the second phase of mining waste material to the top of the TMS commences, the majority of which requires drilling and blasting. Access for the waste stripping is provided by haul ramps located on the hanging wall side of the pit.

The third phase involves mining from the top of the TMS to 2 m below the base of the TMS to recover as much alteration zone material as practical. Mining of the TMS requires drilling and blasting, and care is taken to not damage the reaction zones during blasting.

Once the alteration zones are exposed, manual labour is used to remove the gemstones by hand directly from the in-situ ore, and also from machine excavated material. Mining at a single exposed reaction zone is referred to as a production point. The number of simultaneously operating production points is limited to one to two for production rate and security purposes.

Figure 5.7: An Overview of Mining Activities at Gemcanton Mine

5.6.2 Drill and Blast

Drilling and blasting is undertaken by in-house operators. The fleet utilise track mounted drill rigs, drilling 89 mm production holes on 3-6 m benches, and use emulsion based explosives. The drill patterns are drilled on 4 x 4 m and 3 x 3 m square patterns with powder factors of 0.26 – 0.60 kg/m3, depending on rock type. Blasting is generally undertaken most days.

Based on observations made at site, the top 20-30 m of weathered material from surface is free-dig, and does not require blasting. Below the upper 20-30 m the waste rock becomes more competent and is un-weathered (fresh). The fresh rock requires drilling and blasting prior to excavation. The reaction zone material is generally quite soft and able to be excavated using mechanical backhoe excavators or by hand with chisel. The TMS material in the immediate vicinity of the reaction zone is more competent, and is drilled by hand held pneumatic drills (jack hammers) and blasted with cartridge explosives. This blasting method provides relatively 'light' blasting of the reaction zone which enables easier excavation, whilst preventing excessive damage to the alteration zone and gemstones.

5.6.3 Load and Haul

The mines mining fleet consist of a waste mining and production fleet. The waste mining fleet mines only waste rock and the production fleet mines reaction zone ore and some of the waste rock when required. The fleets consist of diesel hydraulic

backhoe excavators (2.4 m3 to 4.6 m3 buckets) and are used in conjunction with a fleet of 45 t, 40 t and 35 t capacity articulated dump trucks (ADT).

The current mining fleet is supported by a number of ancillary equipment including wheel loader, track dozers, graders, fuel truck and water trucks. The

Table 5.3 shows the Gemcanton equipment fleet at the mine site.

Table 5.3: Gemcanton Equipment Fleet

Equipment Type	**Total**
Excavators	14
ADT'S	23
TLB	1
Bull Dozer	4
Loader	1
Graders	3
Water Bowsers	2
Fuel Bowsers	1
Rock Drills	5
Core Drills	2

5.6.4 Production Mining

Where blasting is required adjacent to or within the ore, hand-held drilling is employed to limit the potential damage to gemstones. The steeply dipping reaction zones are mined using manually intensive methods using chisel and shovels with the assistance of hydraulic excavators under close supervision. Mining of Reaction Zones is only undertaken in daylight hours under constant security supervision. All large and high grade emerald stones that are hand sorted at the mining surface are placed in a suck bag which is numbered, tagged, and sealed with seal tape by security. Figure 5.8 illustrates Chimpundu production area.

Figure 5.8: Picture of Chimpundu Production Area at Gemcanton Mine

5.6.5 Waste Rock Dumps

The north and southern waste dumps are used for the majority of the upper 20-30 m and non-TMS waste; however, some of the TMS and other waste rocks are dumped in-pit on the footwall side of the pit. The in-pit dumping face progresses towards the hanging wall. The waste rock is used to construct the footwall haul ramps, and ramps are widened and shifted where required to maintain footwall access.

Laterite material is stockpiled at multiple locations near the pit crest for use as road construction material. Topsoil material is stockpiled at specific dumps separate from other waste rock, and is planned to be used for rehabilitation.

5.6.6 Ore Stockpiles

Current operational practices include an ore stockpiling strategy, where ore is stockpiled near the wash plant facility to manage the expected variability in the gemstone grading distribution and the impacts of the wet season on productivity.

5.7 Induced Cracks in Gemstones

Induced cracks in gemstones caused by blasting vibrations is one of the biggest challenges faced by gemstone miners. The cracks induced reduce the value of the

gemstones and hence increase the cost of the mining operation. Gemcanton mine is one of the mines affected by this mining challenge. In efforts to minimize the amount of emeralds and beryl's destroyed during blasting are research was carried out by the researcher and the mining department at Gemcanton mine on the techniques of rock breakage and how they impact the extraction of emeralds and beryl's. Three application techniques namely hydraulic breaker, Xcentric ripper and Autosterm blasting where suggested and compared to show which one is the best technique of minimizing induced cracks and damage when extracting emeralds and beryl's in production area at Gemcanton mining pits.

A single trial test for AutoStem blasting technique was carried out and results were observed. Recommended application and suitability information of the hydraulic breaker was mainly gotten from manufacturer manual from the internet and a copy supplied by Barloworld coupled with performance record in terms of frequent component breakdowns. Information regarding recommended application of the Xcentric Ripper was all gotten from their official website on internet.

The study compared the suitability of each tool i.e. one with minimal risk of inducing cracks in emeralds, versatile enough to accommodate our varied rock breakage in production areas without misapplying the tool/technique as outlined by the manufacture, serviceability of the tool (operating cost), equipment cost. Recommendations were then made and further work to be done clearly outlined.

5.8 Brief Principle Mode of Rock Breaking of Each Tool & Suitability

5.8.1 Hydraulic Breaker

A hydraulic hammer converts hydraulic power to kinetic energy. The kinetic energy is delivered by the hammer piston to the tool as an impact force. Unlike a slowly transmitted force, such as the force with which a hydraulic cylinder extends, the impact force produced by the piston when it hits the tool, is transmitted through the interior of the tool as a compression stress wave until it reaches the rock, concrete, or other material that the tool is about to break.

Inappropriate application of the hydraulic hammer such as using it as a prying tool and operating it at slanted angles leads to wear down of bushings and bracket bolts.

A comparison between the hydraulic breaker and the Xcentric Ripper was carried out and the performance of each tool in rock with varied hardness and other properties are as indicated in Figure 5.9.

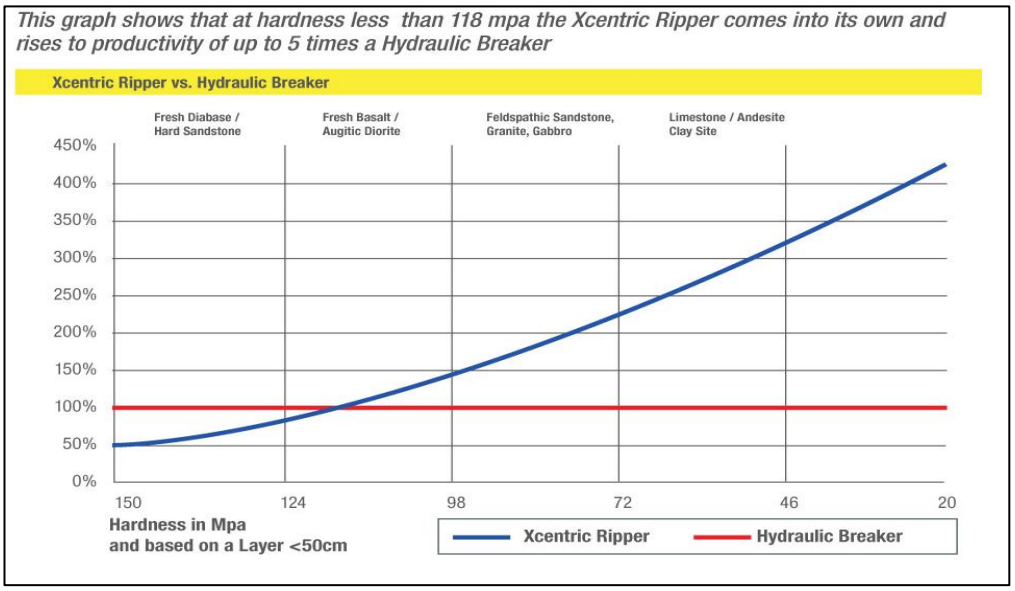


Figure 5.9: Comparison of Xcentric Ripper versus Hydraulic Breaker under varied Rock Properties (http://www.xcentric.co.nz/prod-info.html)

As can be seen from the comparison, breaking a rock with **118Mpa** of uniaxial compressive strength (UCS) with less 50cm thickness, the ripper and hammer perform equally. However, working on rocks with UCS lower than 118Mpa (say **59.2 – 124.2Mpa** for TMS), the ripper outperforms the hammer in terms of productivity detonating suitability of the tool.

5.8.2 Xcentric Ripper

The Xcentric Ripper is an excavator attachment that breaks rock in pretty much a similar way as the hydraulic breaker. Made completely of wear-resistant steel, this attachment device is claimed to be almost maintenance free, less noisy than any other excavation tool, can be used under water without any damage risk and be adapted to countless work sites (limestone, sandstone, granite, quartzite quarries etc.) such as excavation and demolition. It is Thanks to its uncomplicated mechanical design, which has no pricey components, the maintenance costs are very low and down times are ignorable.

Unlike the hydraulic hammer, the ripper can be used as a prying tool. It can also be used in a slanted position as seen in the demo video on: http://www.xcentric.co.nz/video-gallery.html

Figure 5.10 below shows the rock characteristics in which drilling & blasting can be carried out against which the ripper can be used.

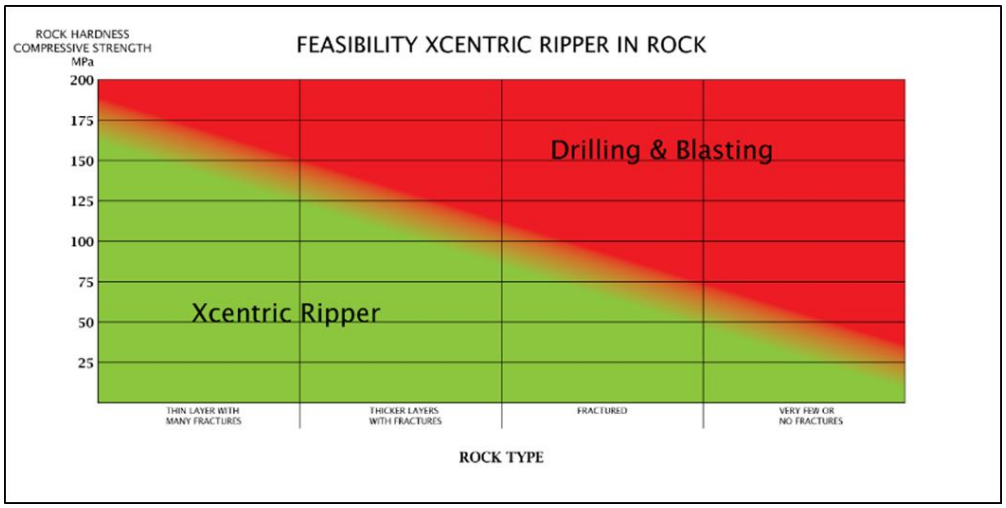


Figure 5.10: Applicability of Ripper versus Drilling Blasting in various Rocks

The TMS has rock hardness compressive strength (also known as UCS) ranging from 69.2-124.2Mpa with fractures and non-in certain instances; rocks with these characteristics can either be blasted or alternatively use a ripper.

5.8.3 AutoStem Explosives

Currently, all explosives on the market break rock by inducing waves in the rock either through deflagration or detonation. The speed of the wave must be higher than the sonic velocity of the rock for it to break. AutoStem explosives are designed in such a way that the velocity of detonation has been reduced by 90% while the principle by which it breaks rocks still remains unchanged, i.e. inducing waves to force the rock to fail and break in compression and tension.

The suitability of AutoStem in production areas is still very low because of waves induced by explosives to break rock.

However, from the test carried out on site it was observed indeed that the risk of flying rocks is very minimal and could minimize tramming distances for machines during blasting.

5.8.4 Comparison Based on Critical Factors

After the study of each tool and its mode of rock breakage, the research looked at critical factors to ascertain the suitability of application of each tool in production areas. These critical factors compare things such as applicability/versatility of the tool for our operation, risk of breaking emeralds by tool, serviceability, customer support among others. The critical factors are as shown in Table 5.4 below.

Table 5.4: Comparisons of Tools based on Critical Factors

Critical Factor	**Tool/Technique**		
	Hydraulic Hammer	**Xcentric Ripper**	**AutoStem Explosives**
Risk of breaking emeralds	low	low	High
Application flexibility of tool such as prying	Flexible	Very flexible	Rigid
Serviceability – cost of spares	High	High[×]	Non
Customer Support/Dealership	Available in Zambia & South Africa	Available in South Africa[2]	Available in Zambia & South Africa
Equipment Cost (Owning + Operating Costs)	Undetermined	Undetermined	Only once off purchase cost

[×]due to limited information from the manufacturer or vendors, it is not possible to rank the serviceability and it would be prudent to contact the dealership in South Africa

[2]dealership can be contacted on: http://www.xcentricripper.com/en/81-uncategorised-all/576-dealers-in-south-africa.html

The research was carried out and it was found out that AutoStem Explosives technique poses the highest risky to cracking of emeralds because of the waves induced when breaking rock. However, it is a great product when blasting oversize rocks and indeed normal blasting because of its characteristic low velocity of detonation, there are virtually minimal to no fly rocks and machines can be cleared to within 40m of the blast thus saving the undercarriage on excavators.

The hydraulic hammer is limited in its application in that it cannot be used for prying or operated in slanting angles (configurations difficult to avoid due to nature of our mining), consequences of doing so include wear of bushings and bracket bolts (two frequent issues we have had with the hammer). The hammer performs better in hard & brittle rocks with UCS greater than 120Mpa as indicated in figure 1 whereas TMS has UCS ranging from **59.2 – 124.2Mpa**. Therefore, the hammer may not be a good fit for this application.

Based on the information gathered from the internet, the ripper is designed to 'rip' which involves prying, a method by which chiseling is done. It can also be operated at slanted angles, once again a desired configuration in emerald extraction. It was also found out that unlike the hydraulic hammer, the ripper is best suited for application in rocks with UCS lower than 124.2Mpa which makes it the most suited tool for this application. However, it is inevitable to get more information such as owning cost, serviceability, matching carrier specifications for the tool from the dealership before any purchasing this tool.

CHAPTER SIX: DISCUSSION OF FINDINGS

6.1 Technical Challenges Faced by the Gemstone Sector

The research study has shown that must of the mines in the area do not have geological information of the license area when they start mining activities on the sites. It was observed and noted from the surveys conducted that most pits were commenced without geological information and have reached depths were tradition and low level mining equipment cannot be used. Low capital requirements and basic techniques can be sufficient to support gemstone production when mines are shallow. However, as mine pits become deeper, working capital must be increased, as each additional meter of pit becomes more expensive to maintain due to increasing technical, safety, and environmental mitigation needs. Geological studies and more sophisticated techniques (both in equipment and organization) are necessary for safer and more cost-effective production. Figure 2.3 in Chapter two shows how of these activities are related.

Without geological information, it is difficult to design and develop a mine in accordance with the mine development standards and statutory requirements hence geological information is very vital for the undeveloped mining license. Therefore, capital and technical expertise are required for continuation of the mining activity. Many owners of small mines do not have the necessary capital or expertise to upgrade their production. For these businessmen, local and external investors can provide funding alternatives to improve mine production, especially at deeper mines. Some investors can bring both capital and expertise, or at least capital to import better techniques. Moreover, investors can facilitate creation of safer and better working conditions for miners by giving better equipment and formalizing working contracts. Investors are likely to be interested in improving conditions as they do not want incur the risks associated with mines closing because of failure to uphold labour laws.

One of the reasons why small scale miners are classified as small-scale miners is because of the kind of equipment and machinery they use. In the gemstone mining sectors, most miners lack equipment and accessories, most small-scale miners use traditional techniques and low level equipment in excavation or digging while other small gemstone miner with very limited finance use rudimentary tools, manual devices or simple portable machines. These tools are often not sufficient to carry out

their activities and thus, they often do not perform to their maximum capabilities. This lack of equipment is worsened by the fact that miners do not have starting capital in order to acquire the tools they require. More so, miners have no access to credit from formal financial institutions for them to finance their operational requirements.

Lack of skills on the gemstone mining sectors, has also been seen as a big challenge to gemstone miners. Most miners lack the technical know-how to improve their capacity in this specialized economic area. Most miners lack education hence have inadequate knowledge on the gemstone sector such as pricing their products, this can be clearly manifest itself in how the miners sell their stones and the prices they sell it for, in comparison to the real value of the stones. Skills and training development is important as all stakeholders will have access to information to make informed decisions in the management of emeralds and for sustainability of the gemstones.

Using the case study of Gemcanton mine, the research study has shown how to and challenges involved in creating a mineral resource model of emerald and beryl ore deposit. Furthermore, from the study done at Gemcanton mine on the extraction of emeralds and beryl's with minimal cracks induced in the stones, the study suggested that the use of the Xcentric ripper for extraction of emeralds as the best technique with the available information. It was difficult to create an economic model.

6.2 Financial Challenges Faced by the Gemstone Sector

The gemstone sector faces a lot of financial challenges in their operation. These challenges range from lack of start-up and working capital, lack of accurate documentation, lack of collateral, regulations, and high interest rates. These challenges have a lot of impact on growth, profitability and financial improvement of the sector. Without proper financing, no prospecting and exploration and mining works can be done and for most ventures to be successful it is very important the prospecting and exploration works are done effectively. Finance is a very important factor for any venture to grow. Standard mining practices cannot be achieved without adequate funding hence most small scale gemstone miners with limited funding prefer to use low level equipment and avoid consulting experts in geology and mining which led to unproductive pits and poor health, safety and environmental standards.

The study has outline the causes of lack of funding as lack of bankable information such as feasibility reports of the gemstones mine, financial statements and business plans, lack of collateral and inability to meet collateral requirements, withdrew or death of a miner owner/investor, lack of own contribution, lack of financial institutions to provide a wide range of financial support to the gemstone mining industry. In most cases, only the gemstone mine owners know their actual financial structure, the actual strength of the investment project and the effective intention to repay the debt, i.e. firms have superior private information (Stiglitz & Weiss, 1981). The financial institutions are in agreement and understand this credit limiting theory by Stiglitz and Weiss (1981) and stated that due to the existence of rough information among gemstone miners, financial institutions are likely to finance businesses that are able to provide collateral and base their lending decisions on the amount of collateral obtainable.

There is no clear marketing policy of gemstones to provide information and knowledge about gemstone marketing and pricing in the sector. Lack of a clear marketing policy has made it difficult for gemstone miners (e.g. Gemcanton mine) to market the mined gemstone to a large number of new potential buyers. Most of the gemstones auctioned are purchased by known buyers and it is difficult for new buyers to participate in the auction. This may lead to bid prices of gemstones to be lowered as there is little or less competition in biding at the auctions.

6.3 Regulatory Challenges Faced by the Gemstone Sector

The response obtained from adequate, enforcing and monitoring of policy and regulations questions shows an institutional weakness by the government. The government has failed to enforce the regulations and policy on acquiring an exploration or mining licence. The regulations state that a person applying for a license must have the finances to develop the licence within a given time frame and if the time frame expires without any development on the licence half of that licence will be obtained back by the government and awarded to another person or company. This has not been done in the Kafubu emerald area and hence has affected the growth of the sector because most of the licence plots were given in the 90s and have not been developed and are still owned by the people who have failed to develop them.

Therefore, the government needs to come up with a systematic way of mitigating this challenge.

The other challenge includes lack of capacity for controlling mines by the state environmental agencies (ZEMA). Environmental agencies find it more difficult to enforce the laws over small-scale mines. These are much more numerous, more widespread, and informal. Most of them are not informed about environmental procedures and laws, nor do they tend to have the technical capacity and resources needed to comply with the law. Gemcanton mine is one of the few large players with the technical capacity and resources to implement law requirements

Licence plots in Kafubu emerald area are not easily accessible physically as road infrastructure is in a deplorable state, and hindering availability of public transportation in most mine areas. Transportation of gemstone production, education, health and other service delivery systems especially during the rainy season between November and April is a very big challenge due to impassable roads. Only roads of interest to advanced mines such as Gemcanton mine are repaired or graded. Road infrastructure in the area are the responsibility of government, however the unwillingness of mining companies to contribute to the improvement of the poor roads they use in the extraction of emeralds is indicative of the failure of mining companies to invest in social services in areas they operate in.

Promotion strategy for gemstone is missing in the sector. This has led to high rate of smuggling of rough gemstones as most small scale gemstone miners do not have the capacity and enough gemstone production to hold an auction. The government must discourage exportation of rough gemstones and encouraging value addition of gemstones through cutting and polishing, organise trade fairs to support the marketing and selling of gemstone and establishing a gemstone exchange centre to curb smuggling of gemstones.

The government has not allocated sufficient funds to encourage further prospecting and exploration of the gemstone sector. This has also affected the growth of the gemstone sector. Due to inadequate resources to carry out prospecting by the government most of the advancement in technologies cannot be employed and utilized in narrowing down the search of gemstones potential ore bodies hence they

are no updates of information by the government with the advance in geophysical surveys technology.

The study has shown that the government through different ministries is working to promote the growth of the sector by provision of policy and regulations supported by recommendations from research studies in and around Zambia that encourage investment of the private sector.

6.4 Other Challenges Faced by the Gemstone Sector

6.4.1 Environmental Challenges

Because emerald mining does not incorporate any toxic materials or chemicals (like acids in the copper mining), the environmental impacts are relatively simple to control. Deforestation happens when mines are located in forested areas. Miners often cut down or burn the forest to have access to mine the gemstones. Erosion is the most common problem in emerald mining. Since most mines starts with trenches and small pits, which become huge holes over time due to natural processes such as rain, leads to uncontrolled erosion when mines are abandoned. Abandoned mines also cause accidents, as people can fall in some of the holes. Soil and water pollution are the most noticeable and widespread environmental problems in gemstone mining. Debris from the mines and waste from the washed biotite phlogophite schist end up contaminating soil and stream water. These contaminations have killed the vegetation and wildlife in some areas along the streams such as the Pilala stream.

6.4.2 Sociological Challenges

Superstition - Some gemstone miners believe that the gemstones are religious stones and require some religious acts to be performed before starting to mine the gemstones. Failure of doing the acts will result in the gemstone miners not finding the gemstones no matter how much there mine out and how favourable the geological condition maybe.

Most of the small-scale gemstone miners are exploited by middlemen (commonly known as Go-Come) on the price and value of the gemstones. Most gemstone miners have little understanding of the pricing of gemstones and since they do not have an open market such as a gemstone exchange centre to market and sell their gemstones

for value worth the gemstones middlemen take advantage and under value the price of the gemstones.

Poor shelter is common among gemstones miners. They do not have funds for them to build go shelter and it becomes worst in the rainy season.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The findings from the research study have highlighted the main technical, financial, regulatory and other challenges faced by gemstone miners. These challenges have hindered the growth and development of the Zambian gemstone sector. Overall gemstone mining is not contributing significantly to the development of the local economy, local business enterprises and infrastructure development considering its economic value.

Technical Challenges

The technical challenges that have been highlighted include geological challenges such as difficult in defining the gemstone ore body and estimating the amount/quantity of gemstone (emeralds and beryl) that are to be mined from the mine area, lack of geology skill and profession in gemstone mining and lack of diamond core drilling machines to probe the underlying rock formations. Mining challenges include lack of mining tools and equipment, induced cracks in gemstones (emeralds and beryl's) due to blast vibrations during blasting, lack of skills improvement with the coming of new mining technologies, limited area for mine development and expansion, lack of dumping area and difficult to design a pit with standard ramps and benches for small licence areas.

The high geological risk associated with the gemstone mining has made potential investor not to invest in gemstone mining as they don't have guarantee that the invested capital will be obtained back with a profit. For this reason, the sector remains highly an explored and literature states that only 2% of the whole Kafubu emerald area has been exploited.

Improvements in human development and in the quality and quantity of education, technology, information research and development is important as all stakeholders will have access to information to make informed decisions in the management of emeralds and for sustainability of the gemstones.

Using the case study of Gemcanton mine, the research study has shown how to and challenges involved in creating a mineral resource model of emerald and beryl ore deposit. Furthermore, from the study done at Gemcanton mine on the extraction of emeralds and beryl's with minimal cracks induced in the stones, the study suggested that the use of the Xcentric ripper for extraction of emeralds as the best technique with the available information. It was difficult to create an economic model.

Financial Challenges

Financial challenges such as lack of start-up and working capital are a major factor that have affected the gemstone sector. Due to financial challenges faced in the gemstone sector most mining license owners do not have geological information need to inspire mining on the license plot. Hence, constant financing to the gemstone sector plays a major role to the development of the sector and without finance no geological and mining works can be done to improve the sector. Other financial challenges faced by the sector include inability to provide collateral and proper financial records which have led to the rejection of loan application when gemstone miners apply for finances from financial institutions.

The marketing policy on gemstones has not been clearly defined for the gemstone miners. It is important that the government develop a clear marketing policy of gemstones by allowing all stakeholders to participate in the formulation of this policy. Marketing is a critical factor to the growth of the sector that is missing in the gemstone sector and without it the real potential value will not be achieved.

Gemstone mining is a high-risk business that requires sufficient huge amounts of steady finance. Some of the gemstone miners who know the real value and potential of their licences plots take the risk and invest in the mining of gemstone which is a big gamble on the financial aspect. Most of the financial institutions and investor do not invest their finances in gemstone mining due to the high geological risk associated with gemstone mining.

Regulatory Challenges

The study has shown that there is institutional weakness by the government to monitor and enforce regulations on the gemstone mining sector is missing. This has contributed negatively to the development of the gemstone sector which has hindered

the growth of the sector. Other challenges included access to land is difficult, inadequate resources to carry out prospecting, inadequate infrastructure such a roads and power to mine sites, lack of promotion strategy for gemstones in Zambia, and smuggling of gemstones. These are some of the challenges that the government need to work on to improve the sector.

The government through the geological survey department needs to conduct a more detailed survey over the Kafubu emerald area taking advantage of the new technologies such as new geophysical instrument and drilling machines so that new and more accurate information can be collected and used for the growth of the industry. The new information will also be able to help the government make informed decisions when allocating funds to help the gemstone sector and will the information obtained can also be used by other gemstone miners in the sector.

Lastly the study has shown that the government through different ministries is working to promote the growth of the sector by provision of policy and regulations supported by recommendations from research studies in and around Zambia that encourage investment of the private sector.

7.2 Recommendations

The following are the recommendations that have been suggested that can help in mitigating the technical, financial, regulatory and other challenges faced in the gemstone sector.

Technical Challenges

- It is recommended that the Kafubu emerald area must be geologically resurveyed by the government with the advancement technology such as geophysical survey techniques and free give the information to the gemstone miners.
- In event that funding is available for purchase of equipment, it is recommended that an effective criterion of identifying needy groups is developed and a committee put in place to oversee the process. This committee will be chaired by an appointee of the government and will include gemstone miners, Civil Society, religious groups, NGOs and any other membership from the stakeholders.

- Provide equipment accessories and consumables to the gemstone miners through direct funding such as loan-based financing through domestic banks and micro credit institutions) as loans or indirect funding such as hire purchase schemes, equity based financing, buyer credit schemes etc.

- Training of personal involved in gemstone mining is of great importance. The study has suggested areas of training that the researcher thought to be relevant to improving the industry after assessing the challenges faces by miners in the gemstone industry. These include mineral identification, basic geology, gemstone cutting and polishing, mining etc. The training area need in the sector are shown in the appendix.

Financial Challenges

- Provide direct or indirect funding to the gemstone sector.

- Organisation of gemstone trade fairs and exposes to support the promotion of gemstones in Zambia

- Institute policy to encourage value addition of gemstones such as cutting and polishing and allow that a certain percentage of the produced gemstone treated within the country.

- Invite investors from India and other advanced countries in lapidary works, and encourage them to start gemstone cutting in the country.

- There is need of formulating a clear marketing policy of gemstones and involve gemstone miners and other stakeholders in crafting policies that affect the sector.

- Research how best to improve access to financing for smaller lapidaries as it offers less risk of financial losses and encourages value addition of gemstones.

Regulations Challenges

- The government must ensure the implementation and enforcement of regulations is fair, efficient and transparent and that regulatory mechanisms are available and beneficial to all gemstone miners regardless of size or political affiliation.

- The 2013 mineral resource policy needs to be reviewed in line with revised seventh national development plan on exploitation of gemstones and industrial minerals.

- There is need for the government to establish or support the establishment of a gemstone exchange centre and allow all parties involved in the gemstone sector to participate. The centre must have all agencies available such banks, lapidary, ZRA etc.

- Sensitise and educate the players in the gemstone sector on the various pieces of legislation addressing issues of mining laws, labour laws, health laws, employment laws, environmental law, Income Taxes etc.

- Re-demarcate the licence plots in the Kafubu emerald area base on the geological position of the area. Some of the licences plots are located in area that do not have favourable geological conditions for emerald mineralization.

- Kafubu emerald area needs physical infrastructure such as roads, bridges and energy supply lines in order to open it up for development, investments and socio-economic growth. Both government and the private sectors should be involved to enhance exploitation of the gemstone resources occurring within the area.

7.3 Suggestions for Further Works

The results of the research have raised the prospect of further research work to conduct in the gemstone sector. The following are the areas the researcher has suggested worth investigating:

- The economic concentration of gemstones in Kafubu emerald area.
- Value addition of gemstones in Zambia
- Marketing policy of gemstones in Zambia
- Opportunities and Treats of a Gemstone Exchange Centre in Zambia

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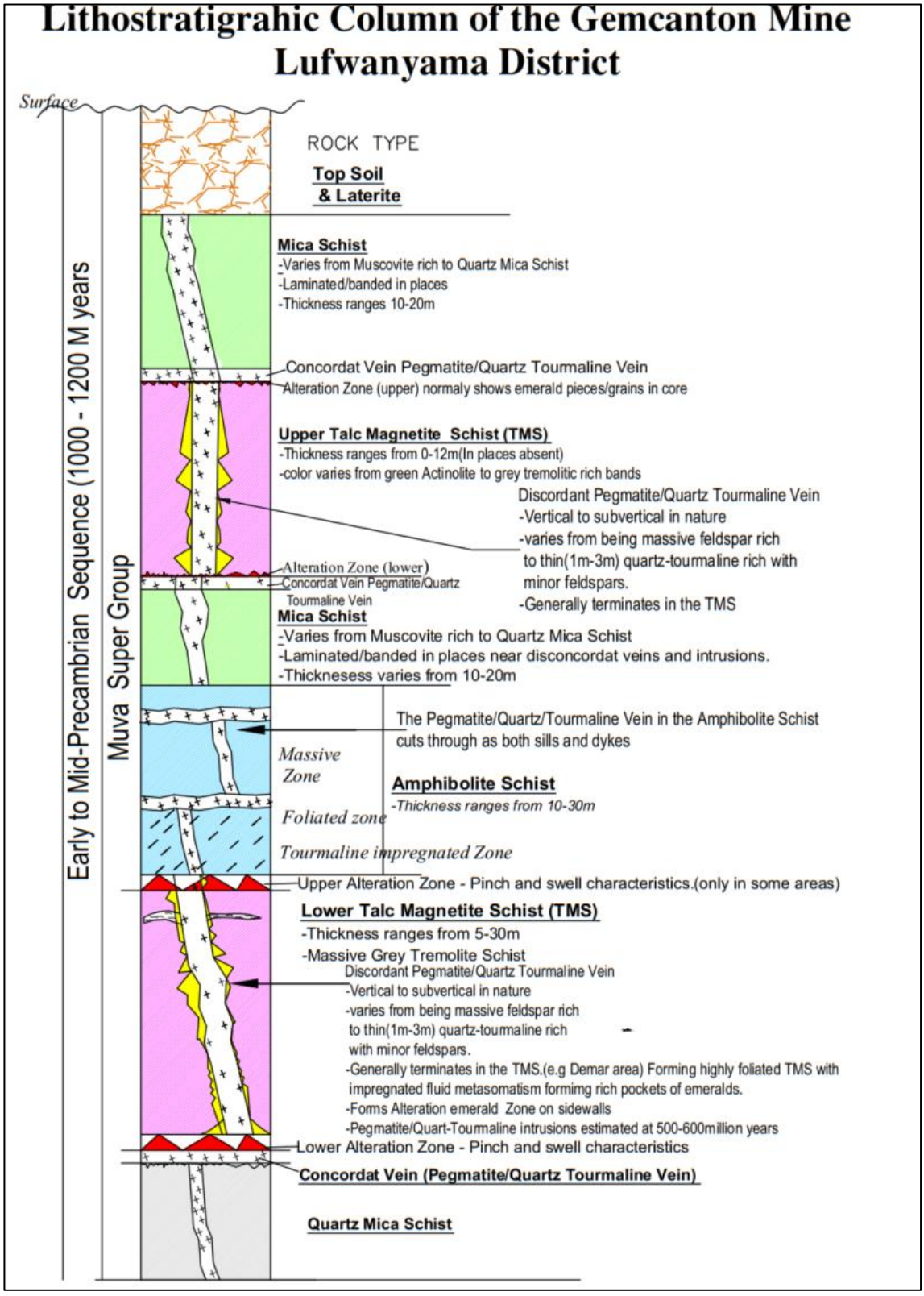
APPENDICES

9.1 Appendix A: Lithostratigraphic Column of Gemcanton Mine



9.2 Appendix B: Table showing the Training Content with the Institutions where they are offered.

Area of Training	Training Content	Training Institution
Mineral Identification	Mineral Hardness, Physical Properties, Mineral appearance, Mineral texture, Specific Gravity, Cleavage, Fracture, Magnetism	UNZA, CBU, Ministry of Mines (GSD)
Basic Geology	Ore deposit occurrence, Types of rocks, Geology, Sources of Geological information, Interpretation of geological maps	UNZA, CBU, Ministry of Mines (GSD)
Gemstone Cutting and Polishing	Evaluating or classifying gemstone Crystallography, Lapidary work	UNZA, CBU, NSR
Health and First Aid	Dressing, Handling emergencies, Managing snake bites, HIV awareness, Hygiene and sanitation	Ministry of Mines (MSD), Ministry of Health
Occupational Safety	Accidents, Protective gears, Rescue operations, Slope and mine stability, Air pollution	Ministry of Mines (MSD), Ministry of Health
Marketing & Business Management	Assessing community vulnerability in marketing risks, Product marketing, Management & Book keeping record, Gemstone valuation, Marketing conditions, Training on access to finance and business skills	UNZA, CBU, Ministry of Mines, Ministry of commerce, trade and industrialization, Any other relevant government institution
Mining	Mining Methods, Waste removal, Mine planning, Excavation design, Dewatering, Handling of explosives	UNZA, CBU, Ministry of Mines
Prospecting	Identification of Ore body (size, shape and depth), Topography, Dilution, Recovery, Appropriate technology	UNZA, CBU, Ministry of Mines
Mining, Machinery Operation and Repairs	Identification and selection of mining equipment (open pit), Training on operation and maintenance of mining machinery	UNZA, CBU, NORTEC, Ministry of Mines

9.3 Appendix C: Research Questionnaire, Interview Questioning Guide and a Checklist of what to Observe

The University of Zambia

School of Mines

Department of Mining Engineering

INVESTIGATING THE TECHNICAL, FINANCIAL, REGULATORY AND OTHER CHALLENGES IN THE ZAMBIAN GEMSTONE MINING SECTOR

(Research work)

Questionnaire

The questionnaire takes about twenty minutes to complete. The outcome will help the license holders and the government to hopefully make corrective measures to improve the gemstone industry.

Mine name:

Location:

Technical Challenges

1. What are the major geological challenges faced by the mine?

    (i)
    (ii)
    (iii)
2. What are the major mining challenges faced by the mine?

    (i)
    (ii)
    (iii)
3. What should be done to improve technology?

    (i)
    (ii)
    (iii)

3b. What should be done to improve skills?

    (i)
    (ii)
    (iii)

4. Any other comments on technical challenges?

Financial Challenges

5. What are the major financial challenges faced by the mine?

6. What are the causes of lack of funding in the sector?

7. Any other comments of financial challenges?

Regulatory Challenges

8. Is the current government policy and regulation adequate to enhance the growth of the emerald industry? (TICK WHERE APPROPRIATE).

☐ Yes ☐ No

If No, what should the government do to make it responsive to the current needs?

9. Has the Ministry of Mines and Mineral development adequately enforced and monitored these regulations? (TICK WHERE APPROPRIATE).

☐ Yes ☐ No

If No, what should the government do to improve?

10. Has there been any problem in adherence to the regulation in the Act? (TICK WHERE APPROPRIATE).

☐ Yes ☐ No

If No, what should be done to improve the adherence.

11. Any other comments on regulatory challenges?

Interview Questioning Guide

Below are guidelines on the areas of questioning that were used the collection of data:

1. Outlook of the gemstone and jewellery business in Zambia including;
    i. Analysis of the sector in the past 10 years
    ii. Recent development and trends currently experienced
2. Challenges encountered as a gemstone miner
3. How can gemstone miners work together as/on a development agenda?
4. The state of security in the mining area and if security is guaranteed
5. The method and level of technology
    i. What equipment is used and what level of mechanization it depicts
    ii. Level of expertise: Mining methods, Geological information, Environmental considerations
6. The owner to discuss the process of acquiring a mining permit especially under the devolved system of governance.
7. Discussion on the legal aspects that promote or hinder growth in the gemstone sector.
    i. Incentives e.g. government subsidies. Is the government clear or what other form of support should emanate from the government?
8. The level of political influence in the politicization of the mining industry in the area;
    i. How it affects and to what extent
    ii. Initiatives that lead to solutions for the stated problem
9. The number of employees employed in the mining operations.
10. Community engagement: CSR programs for social development on part of the operators
    i. Is it a mandatory requirement or implementation is an act of good gesture?
11. Description of the supply chain and value chain and owner in his/her view to provide suggestions to improve value chain.
    i. Exploration-Development-Mining-Mineral Processing- Marketing channels – Sale
    ii. Pricing of the minerals i.e. gemstones at the various stages of the supply chain

12. The Infrastructure to enable diversification
13. The environmental impacts of mining
    i. Reclamation programmes adopted by the mine operator
    ii. How artisanal miners can be encouraged to conserve the mining environment
14. The attitude and role of the government in the development of mineral resources.

A Checklist of what to Observe

1. Nature of gemstone mine in the area
    i. Formal or informal
    ii. Organized or disorganized
    iii. Seasonal or permanent
2. Diversification of economic activities or existence of alternate livelihood opportunities
3. Pricing of the minerals i.e. gemstones at the various stages of the supply chain
4. Method of mining and level of technology employed
5. Labour issues relating to gemstone mining
6. Environmental aspects of gemstone mining
    i. Impact on land resources, water resources and biodiversity
7. The socio-economic impacts as a result of gemstone mining
8. Organisation, composition and activities of mining groups and associations
9. Areas of value promotion along the value chain

9.4 Appendix D: Borehole Logging Sheet

GRIZZLY MINING LIMITED									
EMERALD EXPLORATION PROJECT									
BOREHOLE LOGGING SHEET									
BOREHOLE No		**GS002**		**SECTION**					
UTM CORDINATES			**8551309**	**NORTHINGS**			**619109**	**EASTINGS**	
COLLAR ELE		**1171**							
INCLINATION		**0**							
BEARING		**90**							
FINAL DEPTH		**59.2**							
DRILLING DA		21/05/2015							
GEOLOGIST	**MUKETEKELWA**					**CHECKED BY**	S CHASAUKA		

DRILLED	DEPTH	DRILL	RECOVERED	CORE angle	CORE	GROUND	ROCK TYPE	STRATIGRAPHIC	ROCK DESCRIPTION
FROM	TO	INTERVAL	INTERVAL	(deg)	CONDITIONS	CONDITIONS		FORMATION	
0.00	6.00					Soft	Laterite		Coarse grained with iron oxide.orangish pink in colour
6.00	7.70					Soft	Chlorite schist		it contain a quartz vein and the core recovery is very poor.
7.70	16.00					Hard	Weathred altered TMS		Greenish grey TMS.It contains talc magnetite,tormaline,mica,biotite minerals.it is weathered.
16.00	50.30					Hard	TMS		Greenish colour fine grained magnetic rock.it cotains talc magnetic,mica minnerals.it is massive and it is a fresh rock.
50.30	51.90						Alteration zone.		Foliated rock with quartz,biotite,mica minerals.
51.90	59.20			65		Hard	Quartz mica schist.		Coarse grained,foliated rock with quartz mica biotite minerals it is a fresh rock.
	EOH								

9.5 Appendix E: Statistics of Contained Beryls (Kg) in the Mined Ore

Row Labels	ore	ore_lower	Grand Total	Contained Beryls(kg)
1180	2,142		2,142	214
1170	22,859		22,859	2,286
1160	42,827		42,827	4,283
1150	44,574	21	44,595	4,461
1140	30,139	5,928	36,067	3,962
1130	3,598	29,141	32,739	5,022
1120		41,912	41,912	6,706
1110		45,448	45,448	7,272
1100		51,584	51,584	8,253
1090		62,733	62,733	10,037
1080		80,787	80,787	12,926
1070		144,394	144,394	23,103
1060		112,486	112,486	17,998
1050		55,078	55,078	8,813
1040		16,619	16,619	2,659
Grand Total	146,141	646,131	792,272	117,995