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Technological Measurement in the Mining Industry in Relation to Environmentally Friendly Mining

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<p>The purpose of this thesis is to discuss in detail the significance of technology trends to the mining industry. Technological measurement in the mining industry in relation to environmentally friendly mining is examined. The main research question seeks to find out how technologies have transformed the face of the environment and future potentials.</p> <p>The methodology employed in the study, scope and the importance of the research are discussed. The present study has attempted to prove that newer technologies have transformed the face of the environment in relation to green mining and future potentials in the mining industry.</p> <p>Recommendation for improvement and adoption by mining industry and technology developers, and recommendation for future research in the subject of study have been given.</p>	
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PREFACE

The idea of this thesis was as a result of my practical training which I did in The Centre for Measurement and Information Systems (CEMIS), under the supervision of Dr Anas Al Natsheh and Perttu Huusko whom i greatly appreciate for the opportunity they gave me to work with them.

Technology was not my field of study, but during my training I acquired the skills which contributed a lot to the success of my thesis.

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CONTENTS

1.	1 INTRODUCTION	1
	1.1 Background	5
2.	2 LITERATURE REVIEW: MESUREMENT TECHNOLOGY IN MINING.	7
	2.1 HEALTH AND SAFETY IN THE MINING INDUSTRY	8
	2.2 THE MEASUREMENTS IN MINING: THE CURRENT LEVEL OF TECHNOLOGY	12
	2.2.1 Level Measurements	13
	2.2.2 Flow measurements	15
	2.2.3 Toxic and flammable substance/emissions measurements	16
	2.3 IMPLICATIONS OF THE TECHNOLOGY IN THE MINING INDUSTRY: ENVIRONMENTAL DEGRADATION AND THE NEED FOR GREEN MINING.	16
	2.4 BARRIERS TO EFFECTIVE TECHNOLOGY APPLICATION IN THE MINING INDUSTRY: Green Mining	19
	2.5 THEORITICAL FRAMEWORK: TECHNOLOGICAL TREND ANALYSIS	21
3.	3 STUDY METHODOLOGY: MARKET RESEARCH PROCESS	24
	3.1 SOURCES OF DATA:	29
	3.2 DATA ANALYSIS	29
4.	4 RESULTS AND DISCUSSION	31
	4.1 China	31
	4.2 South Africa	33
	4.3 Zimbabwe	33
	4.4 Technological Trends Analysis by Countries (China, South Africa and Zimbabwe)	35
	4.5 Finland	35
5.	5 DISCUSSION	37
6.	6 CONCLUSION	41
7.	7 RECOMMENDATIONS	43
	7.1 RECOMMENDATION FOR IMPROVEMENTS	43

7.2 RECOMMENDATION FOR FUTURE RESEARCH

47

8. 8 SOURCES

48

APPENDICES

LIST OF ABBREVIATIONS

NGO: Non-Governmental organization

MEND: Mine Environment Neutral Drainage

NOAMI: The National Orphaned and Abandoned Mines forum

GMI: The Green Mining Initiative

GDP: Gross Domestic Product

ASD: Advanced System Development

ABB: Asea Brown Boveri

HSE: Health and Safety Executive

MASHAM: Management and Administration of Safety and Health at Mines Regulations

USDL: United States Department of Labour

ICEM: International Federation of Chemical, Energy, Mine and General Workers' Unions

MPE: Mining People and Environment

NRCAN: The Natural Resources Canada

UN: United Nations

1 INTRODUCTION

Mining refers to the removal of precious minerals and other geological resources from the earth crust. Resources gotten from the mining comprise of precious metals, base metals, coal, uranium, and diamonds among others. Mining tools are used for drawing out minerals deep down from the earth crust. The nature of the mining tool and process create a possible unenthusiastic and positive crash on the surroundings. The tools vary in size and shape depending on the minerals being extracted and the method of mining being used.

In the past mining tools and processes have led to negative effects on the environment and this has currently led to most countries adopting regulations for moderating the unenthusiastic results of mining processes. Safety has become a concern and modern mining tools and processes have improved the mines safety significantly. The big challenge for the global mining industry has been how to continue the mining processes without reducing the impact it has on the planet.

The performance of the mining industries regarding the environment has improved a great deal in the recent past in Canada. The significance of the mining to Canada's market makes green mining very critical to it. In conjunction with stakeholders from environmental NGO's, the mining industry, academic circles, territories and provinces NRCan has addressed the environmental problems in mining for a long time. Mine Environment Neutral Drainage (MEND) a multiple stake holders bargaining forum for a safe environment brought forward in 1989 has been analysing best ways of curtailing occurrence of acidic waters in mine locations. The National Orphaned and Abandoned Mines forum (NOAMI) is also a platform to address issues of environmental concerns in the mining industry. It was established in 2002 by territorial, federal and provincial ministers of mines. Their main ob-

jective being to address the subject of abandoned mines. The Green Mining Initiative (GMI) has become bold in this matter though formed recently. (Hogan, C. & Tremblay, G. (2002). Noami and Partners – A Six-year Retrospective)

Green mining looks for ways of getting healthy ecosystems, transformed landscapes and clean water through reducing waste by renovating it into other applications. Build on a foundational principal of technical improvement the prolonged approach taken by the Canadian mining sector has already produced tangible results. The impact of acidic damage from the mining process has been reduced a great deal due to new treatment, prediction and prevention paradigms. The methodology of closing up mines has been enhanced and this also involves new and current mines which need financial guarantees and closing plans given upfront.

The growth in knowledge has led to invention and innovation of the technological world and such advancement is beneficial to virtually all sectors of the economy in terms of improving productivity in various industries and hence sustaining economic growth., western nations have much of their GDP growth-3 to 4%- attributed to technological advancement rather than increase in number of workforce. The mining industry has not been overtaken by events and has been benefitting from the advancement in technology overtime.

The mining industry has become increasingly recognizable following rise of events in the industry; there is increased need and use of mine products, environmental degradation and high deaths at the mines. Commonly mined materials include various metal ores- such as gold, iron, zinc, copper, uranium and many others, coal, limestone, salts, oil, natural gas among others. Materials are distributed oddly across nations, with some nations having multiple minerals, metals and other materials while other nations do not have. As such most of

the developed nations tend to have lesser mineable material and hence tend to concentrate their efforts and resources in mining industry across their borders, especially in developing nations. On the other hand the developing nations in which the material occurs fails to locate the exact mining points and even if they do, most of them lack skilled labour, equipment and technology to extract the materials. Hence the mining industry in most cases is a give and take situation whereby developed nations contribute technology and expertise and benefit from the raw material while the developing nations, who own the raw materials, are utilized for unskilled labour which pays less and they utilize less of the raw material (ASD Inc 2011).

Apart from the unequal sharing of experiences, there is the issue of environmental degradation and rising deaths as a result of direct impact at the mines or pollution that causes chronic diseases. Most mining activities have a negative effect on the environment because in most cases soil has to be removed from its original place to reach the material; grasses, trees, structures have to be brought down to clear way for mining and in the process the natural habitats are destroyed hence affecting living organisms. As the mining continues, there is disturbance of the earths' structure as holes become deeper and risks of mine collapse. Chemicals and processes used to refine the material fetched, end up polluting the environment, either in form of leaked chemicals, dust, emitted gases, or leakage of harmful forms of the material itself. Most of these experiences put the health and safety of those working at the mines and surrounding communities at risk hence several issues has been raised regarding the mining industry; technology comes in as the centre point from which most of the problems mentioned above can be solved, hence the level of technology also affects the extent to which the problem occurs and how it is solved (ABB 2011).

According to Asea Brown Boveri (ABB), a world leading engineering company, measurements are required to facilitate processes and ensure efficiency, they “measure, actuate, record and control”. Level measurement is a collective term referring to the processes of determining the extent/degree/depth, of the mines; where the material to be extracted is based. Apart from the material, level measurements may also be done to ascertain the position, extent/depth of toxic substance and other waste material such as accumulated water in the mine veins. Flow measurement refers to the measure of movements of any substances capable of motion; liquids, fluids and gases. Toxic substance measurement refers to the level/quantity of toxic emissions and effluents during the mining process such quantity of carbon dioxide or carbon monoxide. The next chapter will shed more light on the various measurements and their role in the mining industry (Dongjie, 2000).

The main objective of this study is to discuss the current levels of technology employed in various measurements in the mining industry and this will be studied in chapters, for instance chapter one will present the background of mining which includes the history of various types of mining and the evolution of technology in various measurements overtime, definition of various terms, and the current general global status of technology in the mining industry and the need to go green. Chapter two will present reviewed literature on the topic as follows: - an overview of the health and safety status and environmental degradation in the mining industry, overview of various measurements; their functions, pitfalls and their impact on people and the environment in general; The need for technology in the different measurements including an overview of current technology in each measurement and their implication on green mining. Chapter three will seek to prove the claim that the current level of technology in different measurements has impacted positively on the mining industry with reference to green mining; this will be presented in a debate like manner (Cockcroft

2005). Chapter four will discuss a closer look of technology trends and their impacts on the mining industry and, market analysis, growth potential and the market main players.

The final chapter, five, will summarize the findings and discussions in the paper and will also present recommendations for future action. (Creamer 2005)

1.1 Background

Almost every country in the world has something below the earth surface that is worth extracting and thus people have been mining various substances for many years. Today, the reduction in natural resources has brought the attention of the world to the problems associated with mining. Organizations and governments have to rethink mining processes and tools and find alternatives to these precious resources. Mining can be responsible for many things from poisoning water supplies to producing toxic dust clouds or just making the countryside look scarred and ugly.

While industry in the twenty-first century is dominated by technology and the production of electrical machines and computers, mineral extraction are still very important to the global economy. Diamonds, steel, coal and iron are some of the top earners in most countries. There is a large environmental cost in all this exploitation, and mining is one of the most damaging industries on Earth. The big challenge for the global industry is how to continue the process while reducing the impact it has on the planet. New and better improved technologies have been limiting the environmental impact and ensuring more controlled use of resources.

It is evident that the level of technology in different measurements and in various mining processes is high although as noted in Chapter three, there are still disparities among nations with clear distinctions between perceived and actual technological levels. As noted by Yang, more nations just like China are making decision to go green basically not intentionally but probably due to the higher costs being incurred in the “non-green mining” industry. But as more are “going green”, there has been increased realization that “green mining” is the best decision a firm ever makes; this follows the growing habit among consumers to purchase more from companies perceived as green. Investors and other stakeholders on the other hand are also changing their attitudes and investing more in green industries. Therefore the issue of “green mining is becoming everyone’s concern. With the widely destroyed environments, water resources and as a result hydrological cycles, no one will dare reject the concept of “green mining”. (Technology Development 2010)It is interesting that the earlier mining industry was cleaner despite the level technology; it can then be concluded that advancement in technology is disastrous. As much as it makes processes easier and faster, the repercussion of the fast nature cannot be ignored in the mining industry; fast means extensive and deep destruction of the environment. Technically, the technology manufacturers tend to have realized that what they initially produced to make processes in the mining industry efficient have turned sour; therefore they are producing more products each day to enhance further the various processes in the industry. (SICK 2011)

2 LITERATURE REVIEW: MEASUREMENT TECHNOLOGY IN MINING

Health and safety in the mining industry have been two issues of concern since time immemorial. According to the National Research Council-US (1980), in the past the problems caused by mining were fewer with people increasingly worrying of dust and related substance. Currently, given the increasing demands for mine products and advancement in technology, the mining industry has been an open ground of devastating effects, ranging from harmful and toxic emissions, metal toxicity, destruction of forests and habitats and eventual mine collapses. The rising mortalities and disabilities originating from the mining industry have increased hence the need to focus on basic procedures that would prevent the occurrence of the eventualities; measurements are critical for such prevention. Measurements done right during the exploration and mine development processes ensure early detection of anomalies in the rock where mining will take place hence facilitating the roll out of safety procedures and applications in advance. Continuous measurements during the mining and harnessing processes also ensure safety by checking temperature, pressures, concentrations and so on about the mined material or waste products; these tend to keep the whole mining process under check ensuring that anomalies and possible harm is detected and contained early in advance, monitory systems are put in place to help monitor defects in mines which could lead to accidents that are harmful to the environment(Richards, J. Deanna. *“The Industrial green game: implications for environmental design and management”*. Washington DC: National Academy of Sciences, 1997)

2.1 HEALTH AND SAFETY IN THE MINING INDUSTRY

The mining environment can be so hazardous given the risk procedures involved as well as the by-products of the entire process; dust, chemicals, open pits, brittle ground and possibility of mines collapsing. The health and safety of the individuals working in the industry and of the communities living around the mines is often at risk; given the extensive nature of exploitation in the industry, the safety of those living far off the mines is also under question following discovery of toxics in river water and also in the atmosphere; the risk levels vary from one mining industry to the other with deep mining industries noted to have highest risks. Given growing health concerns such as respiratory infections and increased mortalities at the mines, governments have taken steps over years to put laws into place that protect mining professionals and surrounding communities from danger. The journey to the current health and safety legislations began long in the 18th century when various mining industries such as the coal mining, started to gain high momentum given high demand for the products; there were no accurate statistics of the death tolls before the 19th century but it was recognizable that there was a problem-given the high death tolls and increasing incidences at the mines- and something had to be done to improve the situation (Rebecca 2010).

In 1835, the British government saw it fit to appoint a committee to inquire into the mine catastrophes and give a suggestion; the committee decided that legislation would be an appropriate intervention. Another committee formed in 1839 to investigate a different crisis recommended inspection of the mines; the need for legislation and inspection structures grew following rise of cases at the mines, in 1842 through a parliamentary ACT, a mine in-

inspector was appointed. Several changes were experienced and in 1872 there was another Act requiring mine owners to have a qualification certificate; with increased expansion of the mining industry, the government realized growing incidences especially in coal mining and hence the Mines and Quarries Act was put in place in 1954. Other Acts such as the Mines and Quarries (Tips) of 1969, the Coal and Other Mines (Tips) Regulations of 1971 were later put into place and have since been amended through various other Acts that have expanded the scope of legislation in the mining industry (Illawarra coal business 2007).

Various stakeholders are also joining hands to ensure proper compliance; in Britain for instance, as documented in the Health and Safety Executive (HSE), HSE and the Mining Qualification Board define laws that mine operators ought to have in place before they can be approved to begin a mining exercise (HSE, 2011). For instance, they ensure that the necessary frameworks are in place to ensure compliance of the Management and Administration of Safety and Health at Mines Regulations 1993 (MASHAM, 1993); this gives a structure for health and safety management, supervision and inspection at the mines (health and safety, 2008).

Different nations have different histories indicating the journey to their current health and safety legislations. For instance in the USA, Health and Safety regulations have been in place since 1978; the Mine Safety and Health Administration Act provides a framework for the management, supervision and inspections of mines. In most of the legislative Acts, the responsibility of ensuring safety at the mines lies more on the mine operators/managers; they are the ones to ensure inspection, risk assessment, supervision and other necessities are put into place. Joseph Main, the secretary to the Department of Labour for mine safety and health, while giving a statement after the Upper Big Branch Mine tragedy said that “Maintaining a safe mine

is the responsibility of the mine operator” (United States Department of Labor). The mine workers also have a responsibility to ensure the laws and regulations are followed especially by standing firm to demand their rights (health and safety 2008).

Several mine accidents have been blamed on non-compliance to health and safety regulations either due to ignorance or intentional carelessness, and some such as documented in the Health and Safety occur as a result of the adopted legislations which give room for faults and pitfalls. The system of legislation and qualification procedures has also been marred by incidences of corruption where the government-which is expected to oversee that there is compliance to the laws- collides with the industry operators to bend some rules in a bid to make more profit; as documented by Grey, the press conference held shortly after the Crandall Canyon Mine- in Utah-cave in involved the mine owners and some federal government agents and as such was highlighted by the media as a bizarre conference. Later on it was discovered through the statements issued to the press that there was some level of admittance from the government and those in charge of Mine Safety and Health Administration Act (MSHA) that some rules were overlooked hence compromising the safety of those working at the mines. (Illawarra coal Business 2007).

Another recent incidence occurred in 2010 in Chile where 33 workers were trapped in the mines for several weeks, according to international Federation of Chemical, Energy, Mine and General Workers’ Unions (ICEM), workers have no channel of communication through which they can air their problems as experienced in the mines and therefore they are often forced to work under conditions that jeopardize their rights and expose them to high risk (2010). To support their claim, ICEM officials cited the case of China where there are no legal trade unions; the mine death tolls are so high above the mortalities experienced in oth-

er nations. ICEM also blamed poor health and safety laws and regulations, the union noted with concern that there is no proper system to commit nations to ratify various laws and regulations; for instance, the Organization Convention 176 on Health and Safety in Mines has been in place since 1995 or earlier but only 24 nations have since ratified the laws and of this, only a few practice and adhere to the laws as required. Sadly most of the biggest mining countries such as India often have shown poor political will towards enactment and ratification of the laws; India rejected a proposal to hold the regional meeting for Asia meant to discuss the convention (ICEM). Despite the fact that mining has long been established to be a risky activity, the many gaps in the enforcement of laws and regulations pertaining the health and safety at the mines have worsened the situation, Denton notes that over 10,000 people die from accidents or diseases resulting from poor working conditions at the mines. As noted in the SI1/DO's/Disease Quarterly report, since 2006 general mortalities have been on an upward trend but the trends have changed overtime and between 2008 and 2010 they have been declining-possibly due to partial compliance to the health and safety regulations, although the death tolls per unit area are still high. (Illawarra coal Business 2007).

in talviivara mine Finland, there has not really being much mine accidents resulting to death, rather environmental damages and health and safety risk accidents which occurred in two occasions, first being an accidents which occurred during the handling and storage of chemicals and of damage caused by heavy rains and the breakdown of the tight structures used for process solutions and the result of this accidents was soil contamination and water pollution, while another accident caused by traffic in the plant area and the handling of chemicals as well as health risks caused by harmful chemicals in the atmosphere at the workplace. (*environmental risk, occupational health risk and hazards, talviivara 2009*)

2.2 THE MEASUREMENTS IN MINING: THE CURRENT LEVEL OF TECHNOLOGY

As discussed in earlier sections, measurements play a vital role in ensuring the right approximate measures for action are established; from the measurements, the type of equipment, cost, skill-level, risks, among other aspects can be determined in advance. Therefore measurements are important in budgeting and planning during mine development as well as in risk assessment and management. There are several measurements in the mining industry, examples include:-measurements during mine exploration, such as geological measurements to establish exact location of the material to be exploited; water measurements to establish quantity of water necessary for use in entire project or establish level water that may have accumulated in process of mining; level measurements involve determination of real position or quantity of the material/substance in question-may be water, gases, toxic by-products, and so on. Other measurements include flow measurements, toxic effluents, gases and dust measurements. Technology comes in to ensure easier and more accurate measurements; as such this ensures proper use of resources, better care of the environment, reduced health and safety incidences, and reduced pollution of the environment (Technology Development, 2011)

The level of technology employed in the mining process has been observed to have an implication on overall productivity and also in cost hence mine operators tend to choose what they feel is most appropriate to maintain their competitive advantage. According to Cockcroft, it may be difficult to determine the level of technology required but it is important to

consider the value the technology will add to the industry and the risks that may be incurred in its implementation. The greatest challenge in the mining industry has been the inability to match the advancement in technology with human skills; there is inadequacy of skilled and professional miners able to use the technology correctly (ICEM 2010).

2.2.1 Level Measurements

It is difficult to give a particular definition to level measurements given that the term refers to a broad category of measures carried out to establish varied components in the mining industry. For instance during mine exploration process, it will be necessary to establish the level-below the ground-where the potential mine product is located. In the past-pre-historic times- it was very difficult to establish this given that the technology in place was simple and would not detect so in most cases, discovery of mine material was accidental and exploitation was accomplished based on available tools and equipment; open cast mining and mining in shallow grounds was popular. Later in the 18th century, the demand for various mine products such as iron, coal, gold and other mineral increased prompting the mine operators to employ more advanced technology so as to reap more by exploring deeper mines and large-scale mining. Advanced technology also makes the industry at par with new innovations such as automated systems and also makes it easier to manage the environment and maintain health and safety standards. Several companies dealing with the development and manufacture of the various equipment and technologies for the mining industry are competing by developing newer and unique products all the time, this gives the mine operators a wide range of products based on their needs (MINING 2000).

In level measurements, technological products range from mechanical equipments to more sophisticated systems utilizing computer software, in whatever their capacity, they all have simplified processes in the mining industry;

- In mine exploration the Terraspec explorer which utilizes spectroscopy gives immediate identification of minerals and their various properties through specific spectral signatures (ASD Inc).
- Several level measurements can also be made using laser technology such as the laser level transmitters, LM200 and LM80. The LM200 utilizes Infrared rays specifically in iron mining; this facilitates measurement of the level of extraction despite the fact that iron ore passes are narrow and often very deeply placed. The LM80 on the other hand is utilized to establish a variety of level measurements such as inventory measurements (in silos), crusher level among others.
- ABB does have other technologies such as mechanical and electrical level switches which control level systems; these are used to detect buoyancy levels, magnetic strength, thermal changes, can measure vibration strength, rotation angles, and ultrasonic hence they help detect anomalies in advance avoiding catastrophe (MSA the safety company 2011) (ABB).

The main point to note is the shift in technology from the use of mechanically operated machines and equipments to devices that can be handheld and hence portable and ones that can detect and record automatically what goes on deep below the surface of the earth. (Kumar 2005)

2.2.2 Flow measurements

Flow measurements are meant to check normalcy of liquids, gases, fluids or molten substances; in such substances, pressures, velocity, temperature, concentration levels are important, in that slight variations for instance in temperature may lead to explosions. Various technologies have therefore been designed to ensure timely and accurate detection of any anomalies in the flow processes.

Flow can be measured using radioactive sources such as dilution method. This method entails injection of a liquid containing radioactivity into the flow line at a known constant rate; samples are taken further down the line where lateral mixing has been completed. The ratio of the concentrations of the radioactive liquids injected into the line and that of the samples allows the flow rate to be computed.

The optical and spectroscopy technologies are also useful in level measurement. QualitySpec® 7000, which utilizes spectroscopy and optical technology, is able to measure materials on transit via conveyer systems and analyses materials of all consistencies hence providing a multiple of measurement at a single point. Signals and records from the SPEC® 7000 can be transmitted to personal computers via Ethernet; which gives one the flexibility of monitoring processes while off-site. The device is also modelled in a way that it can withstand harsh environments hence best for use in very deep mines. Several other devices and equipment to monitor flow processes are available in the market, as displayed by Direct Industry; they range from flow sensors, flow switches, ultrasonic flow-meters, and electromagnetic flow-meters and so on.

The current level of technology is so complex and sophisticated hence making processes in the mining industry very easy to handle despite their complex and risky nature.(MSA-the safety company 2011) .

2.2.3 Toxic and flammable substance/emissions measurements

Following increased sensitivity to the subjects of environmental conservation and health and safety in the mining industry, measurements meant to detect abnormal levels of toxic substances are vital to the mine professionals and the surrounding communities at large. Currently there level of technology is high; there are varied technologies in the market used in detection of various emissions/effluents. For instance there are variety of Gas sensors and detectors tailored to detect specific gases and levels; there are also flame detectors that may be utilized in cases of excess gases or effluents that may lead to explosions (MSA-the safety company). Other technologies performing similar roles include SICK sensors designed to detect changes in temperatures and pressures , toxic gases and increased of oxygen- as a flame causing agent, utilizing photoelectric technology, the SICK sensors as described in the SICK website are a great safety measure. (Mining people and environment 2011)

2.3 IMPLICATIONS OF THE TECHNOLOGY IN THE MINING INDUSTRY: ENVIRONMENTAL DEGRADATION AND THE NEED FOR GREEN MINING.

The technology in place for use in the mining industry is extremely intensive and broad; there is virtually enough technology to deal with each and every dimension of the mining processes; right from mine detection, material level detection, various measuring technolo-

gies, blast controllers, noise level detectors and controls-the list is endless. It is still not clear why there are many mine accidents given the type of technologies in place. Apart from the accidents, the issue of environmental degradation is of great concern. Over the years, the mining industry has been identified as one of the major contributors to pollution and environmental degradation- terrain deformation, toxic emissions/effluents and destruction of habitats. According to the UN-Secretary Ban Ki-moon, as documented by the “Mining, People and the Environment” the 21st century is not the era for consumption without care but an era where everyone should join in the campaign to salvage the environment by joining the Global Compact(2011). The campaign to reduce carbon levels emitted to the environment and also to promote environmental friendly practices has been on the rise following unpredictable climatic changes that have had devastating effects on virtually all sectors of the economy. This has led to introduction of the concept of “green mining”; the concept has been in place for a long time, although indirectly as environmental conservation. In the recent past, changes in the climate and disasters occurring as aftermath of the mining activity have led to the “green mining” popularity. Various governments, companies and other private stakeholders such as non-governmental organizations and the United Nations are increasing teaming up to ensure the mining industry complies to the standards aimed at conserving the environment. (Mining 2011)

Several nations are trying to ensure that the environment is protected, nations such as South Africa have had to lay down heavy penalties for those not complying with green mining; as observed by Creamer, the most non-compliant in the mining sector will have to pay high taxes following high prices per carbon dioxide equivalents (2011). Canada is another nation fighting hard to restore its image given its black record of several incidences resulting from the mining activities. As noted by Mallet, “green mining” is possible regardless of the dam-

ages already caused; this could only be possible through reducing new mining processes and concentrating on recycling and re-using the already mined material (2011). This argument stands to be a big debate given the high demand for mine products. Mallet further points out that lack of transparency in reporting of toxic waste levels released to the environment will hinder efforts of conservation. Mallet concludes that there is a lot to be done before the mining industry can manage to “go green”. A research conducted by the Australia’s Commonwealth Scientific and Industrial Research Organization, documented by Mining, People and the Environment, shows that some of the industrial wastes would be used for better purposes such as preventing algal growth in waters instead of releasing them to the environment (2011a); this would be a better approach to the environmental pollution and intoxication. (Mining technology 2011)

As the world seeks to go green, the role of technology in the mining industry cannot be overlooked; as discussed in earlier sections, the current level of technology is high and given that almost all dimensions of the mining processes are catered for technology-wise, technology can be the basis of change towards “green mining”. As pointed out in the Horizon Report, advancement in technology especially the computerization of systems and invention of mining Technologies is the point of change in many sectors such as in education and medicine (2011), the mining industry is no exception since such advances in technology have already been experienced in the industry. The only challenge remains in the effective use of the available technologies to reduce accidents in the mining industry and also to find appropriate technologies that can assist in recycling of mine products to reduce newer mining activities and also to dispose waste and toxic materials in lesser toxic forms.

2.4 BARRIERS TO EFFECTIVE TECHNOLOGY APPLICATION IN THE MINING INDUSTRY: Green Mining

Given that the level and variety of the technology meant for the mining industry is high, it is expected that the mining industry would be the safest place to work in despite its risky nature. But that has not been the case as many accidents occur yearly all over the world; this is an indication that there are gaps in the entire system, either with the technologies themselves or the regulatory bodies and authorities. As noted in the Mining-Technology website, for there to be effective use of technology, there has to be a link between the government and the mine operators; the government plays an important role in drawing structures for the regulation of activities at the mines hence ensuring high quality and standards (2010). There is evidence from earlier discussions that various governments have health and safety standards and legislations in place. The greatest challenge has been ensuring compliance to the standards; a lot of corruption cases have been reported in the industry whereby government officials are bribed to overlook some issues that put mine workers and communities at risk. As documented by Mining, People and the Environment, the Transparency International's 2008 Bribe Payers Index shows that the mining industry is rated among the industries prone to the corruption vice (2010). As such there is lack of political good will and lack of commitment from the mine owners to make the mining industry a safe place and one that takes care of the environment. (Mining- Technology 2011)

Another reason why the many technologies in place have not yet transformed the mining industry towards the "green mining" is because of inequalities and disparities between the developed and developing nations. As such the developed nations always wish to be at the

top controlling everything and it has been difficult for the developing nations-which acquire technology and equipment from developed nations- to match the technology and human skills hence have to rely on imported expertise which is often expensive. Due to shortages of such expertise even in the countries of origin, the developing nations are not always assured of getting the professional; sometimes the unskilled professionals with hands on experience are left to man the technologies and this is dangerous especially in times of crisis when professional skills are required. (National Research council –US 2011)

There have also been fears that employment of certain technologies which will enable automated start and completion of mining processes would lead to loss of jobs. This claim has been dismissed by various groups such as the trade unions who instead feel technology would widen the scale of mining hence creating more employment-this is evident in several nations; the US Department of labour records that 11, 000 jobs had been created in the mining industry since 2009 (2011). With increased pressure to reverse effects of global warming and climate changes, it is not clear whether some industries in the mining sector will be forced to close down; as noted in the Illawarra Coal Business Update, “closing down mines, capping or phasing out coal exports won’t have the slightest impact on global warming but will inflict major economic pain”. There are controversies whether to put the environment first or to concentrate on the mining which is a large contributor of income to most economies. (Mining – Technology 2007)

There are a lot of issues to deal with in the mining industry before the various high level technology measurements would be of meaning especially to green mining. The health and safety standards and legislations need to be further streamlined and some method to ensure

government officers do not collude with mine operators to weaken the legislations in place, need to be devised (Mining-Technology-2011). There is also need to seal the gaps between the technology nations and developing nations so as to ensure all those in the mining industry have access to the right technologies and expertise; this will greatly reduce incidences in the industry as well as ensuring optimal environmental care. Also it is time governments, industry owners, technology manufacturers and all stakeholders put their heads together to suggest various technologies that can improve toxic wastes disposal and management; it is time to walk the talk. (Project management system 2011)

2.5 THEORITICAL FRAMEWORK: TECHNOLOGICAL TREND ANALYSIS

Mineral resources can be termed as the Earth's storeroom of valuable minerals, which can be unearthed for use. Resources consist of already identified deposits where minerals are dug up for profit purposes as well as deposits, which have not yet been recovered because of poor economic conditions or technology. All these mineral resources call for sustainability in their extraction from the earth and that is the reason why the concept of 'Green Mining' has become important for most developed and developing countries.

The concept of environmental sustainability comes into play in the trend analysis; it can be defined as "improvement of quality of life of the persons, as on own measurements of con-

servation and as of the environment, of the way of not comprising the expectations of the future generations. All nations both developed and developing have increased their efforts in calling for strong enforcement of health and safety standards by all participants in the mining industry. This will ensure the issue of environmental sustainability in mining. From adapting how people live in the cities and communities to create plans to make mining greener and preserve the environment, Canada has come up with innovative ways of reducing the impact of mining on the earth.

The mining industry greatly affects people daily lives positively and negatively depending on the technology used for mining minerals. In Canada, the environmental performance of the mining industry has greatly improved over the last ten years; however there is still room for environment. This improvement towards going green has greatly influenced the lives of the consumers; they live in safer environments. Improved technologies have promoted the importance of coming up with ways of using natural resources like minerals in an efficient and environmentally responsible manner.

New and improved technologies have improved exploration techniques by optimizing the mining process without causing any environmental damage or pollution, these technologies involves the use of monitoring facilities, bioleaching and other sensors devices which have been mention early on. The Natural Resources Canada (NRCan) has been working with other parties to reduce the footprints created by mining activities, to sustain an unspoiled environment and to create a competitive sector. The relevance of the mining sector to the Canadian economy makes green mining innovation very critical. NRCan has been collaborating with partners from provinces and territories, environmental NGOs and academia to address the mining environmental issues for the last decade. There has also been a multi-

stakeholder Mine Environment Neutral Drainage (MEND) program, which was set up in 1989 to prevent the release of acidic water from mine sites. All these programs as benefitted all the stakeholders in the mining process.

3 STUDY METHODOLOGY: MARKET RESEARCH PROCESS

Market research is the function that connects the customer, consumer and public to the marketer through information, which is used to define and identify marketing problems and opportunities. Marketing research specifies the information needed to address the issues of monitoring market performance and improving the market. The importance of marketing research can then be termed as the objective and systematic collection, analysis and interpretation of information for decision making in marketing problems of all kinds. The marketing research process is a sequence of steps in the systematic collection and analysis of marketing data. The process contains six basic steps (McDaniels & Gates, 2001): Description of the research problem and objectives (step 1): Deciding on a suitable research design (step 2): Preparing the research design (step 3): Fieldwork (step 4): Processing, tabulation and analysis (step 5) and reporting the research results (step 6).

The basis of marketing research is formed by the research problem and objectives (McDaniels & Gates, 2001). This sets the scene for the rest of the research process and is the major criterion for step 2; deciding on the research design. Preparing a suitable research design (step 3), the researcher will need to plan for aspects such as the type of data sources, the data collection approaches, the data collection instrument and the data collection method to be used as well as the sampling plan for selecting the research subjects. The fieldwork logistics are managed in step four. This would, for instance, entail fieldwork control, actual data collection and procedures to ensure the minimal effect of fieldwork error. In step five, the completed data collection forms (questionnaires) are processed, tabulated and analyzed in

order to obtain meaningful results. Thereafter, the research results will finally be reported to management and other interested parties (step 6).

The first step in the market research process is identifying and formulating the problem to be researched (McDaniel's & Gates, 2001). Researchers are communicated to by the marketing managers the nature of the opportunity or threat that is important to the decision makers. The researcher should only consider if the management problem can be formulated into a research problem-that is to ascertain whether the management questions is researchable. Not all questions or problems are researchable and not all management questions are answerable.

The second step is development a suitable research design. It entails developing an advance to the crisis which includes formulating a theoretical framework or objective, research questions, analysis models, hypotheses, an issue that can pressure the research design and identifying characteristics. Discussion with industry and management experts, simulations, case studies, secondary data analysis, pragmatic considerations and qualitative research normally guide the process (McDaniel's & Gates, 2001).

The third step entails preparing a suitable research design. A "research design" is a blueprint or framework for carrying out the promotion study scheme. It minutiae's the process required for acquiring the necessary facts and its aim is to devise a research that will check the interest hypotheses, ascertain probable responds to the study query and offer the information required for making decisions. The process of obtaining data has to be addressed; secondary statistics investigation, qualitative investigate, ways of collecting quantitative data, definition of the needed information, scaling and measurement method, design of questionnaires, sampling size and process and data analysis plan.

The fourth step involves collection of data or fieldwork. This entails collection of data by a staff or field force through personal interviews, telephones or mail. Training, supervision, proper selection and field force evaluation minimizes the errors that result from collection of data.

The fifth process is that of processing, tabulation and analysis of collected data. It entails preparing and analyzing data. Preparing data includes editing, coding, transcribing and verifying data. Every observation form or questionnaire is edited, inspected and if needed corrected. Letter of number codes are allotted to correspond to every response to every problem in the opinion poll. The statistics from the survey are keyed or transcribed on to disks, magnetic tape and keyed in straightforwardly into the computer. Confirmation of collected data makes certain that the questionnaires are transcribed accurately. In cases of a single measurement of every unit or element in the sample, unvaried methods are employed for its analysis. Conversely, multivariate methods are employed in data analysis when there are more than two measurements on every measurement on every aspect and the erratic that are analyzed concurrently.

The sixth step entails preparing and presenting the report. The whole project is acknowledged in a printed statement, which tackles the research approach, research questions, and data analysis procedures and gives the outcome and the main findings (Tustin et al, 2005). The study findings are presented in an understandable manner in order for them to be used in making decisions. Additionally, an oral presentation can be made.

This technological trend analysis on the transformation of the face of technology to green mining follows the six steps in the market research process. In Chapter one of this study, the research problem and objectives are described in details. The main objective of discussing

the current levels of technology employed in various measurements in the mining industry is identified in chapter one. The background of mining which includes the history of various types of mining and the evolution of technology in various measurements overtime, definition of various terms, and the current general global status of technology in the mining industry and the need to go green are discusses.

The second chapter presents a reviewed literature on an overview of the health and safety status and environmental degradation in the mining industry. The process of obtaining data is addressed; secondary data analysis, an overview of various measurements; their functions, pitfalls and their impact on people and the environment in general (Tustin et al, 2005). The need for technology in the different measurements including an overview of current technology in each measurement and their implication on green mining is discussed. This chapter develops a suitable research design for the study.

Chapter three of this study prepares the research design of the study. It seeks to prove the claim that the current level of technology in different measurements has impacted positively on the mining industry with reference to green mining using secondary data analysis. The fourth step in the market research process involves collection of data or fieldwork. In this case, it is done through review of secondary data. It takes a closer look of technology trends and their impacts on the mining industry and, market analysis, growth potential and the market main players.

The fifth process is the market research process is that of processing, tabulating and analyzing collected data. Chapter five of this study summarizes the findings and discussions in the paper. The sixth chapter offers recommendation for improvement and adoption by mining industry and technology developers, and recommendation for future research in the subject

of study. The sixth step in the market process entails documenting the research in a written report, and has the research approach, research questions, and data analysis procedures and presents the results and the main findings. This study will be documented in a written report.

This study follows the six steps in the market research process in analysis of technological trend in the mining process. The general information required has been established; it has shifted the focus towards the research objectives. The definition of the research problems have determined largely the research design-secondary data analysis- that has been used in this study. This study discusses the current levels of technology employed in various measurements in the mining industry and its implication on green mining.

This study seeks to establish that some of the technologies used in the mining industry have led to environmental degradation and thus there is need for green mining. This study discusses the current levels of technology employed in various measurements in the mining industry. The background of mining, which includes the history of various types of mining and the evolution of technology in various measurements overtime, definition of various terms, and the current general global status of technology in the mining industry and the need to go green are covered for the purpose of this study. An overview of the health and safety status and environmental degradation in the mining industry, overview of various measurements; their functions, pitfalls and their impact on people and the environment in general have also been discussed. The need for technology in the different measurements and their implication on green mining are discussed to demonstrate the need for green mining. A debate manner has been employed to prove that the level of technology in different

measurements has impacted positively on the mining industry with reference to green mining; this will be presented in a debate like manner.

3.1 SOURCES OF DATA:

Primary data will be sourced from books, journal articles, newspaper articles and other written sources on mining technology and green mining. A case study method has also been employed to achieve the objectives of the study. Zimbabwe, South Africa, Finland and China are used to establish whether the perceived versus tangible level of technology determines the position of a nation in regard to “green mining” and how this positions affect the success of the nations. The researcher uses Canada to show that the efforts to improve the techniques and equipments have many benefits as it assists countries to go ‘green’. Benefits like offering mine operators a safe and healthier environment and reduction of mine accidents results from these efforts.

3.2 DATA ANALYSIS

Data analysis of qualitative data in this study has been done by observer impression. The researcher examines the data, interprets it, and forms an impression and report the impression in a structured manner. The researcher analyses different countries to establish that improving the level of technology promotes green mining and in turn reduces environmental degradation. By the end of chapter three, the researcher establishes that there is high level technology for the use in the mining industry; virtually all measurements are well taken care of in terms of technology. The level of success in the mining industry is attributed to the

current level of technology in different measurements, with reference to green mining. By using a country and industry case studies; China, South Africa and Zimbabwe to represent high, middle and low technology nations, the researcher is able to establish that green mining is promoted by improvement in technology.

4 RESULTS AND DISCUSSION

Given the discussions in chapters above, there is evidence that there is high level of technology existing in the mining industry. Virtually all measurements are well taken care of in terms of technology. This chapter seeks to establish the level of success in the mining industry that can be attributed to the current level of technology in different measurements, with reference to green mining. It will take a deeper approach from earlier discussions to establish differences in technology level between nations of different technology status. This will be possible by use of country and industry case studies; China, South Africa and Zimbabwe are selected in this study to represent high, middle and low technology nations. More emphasis will be laid on the coal mining as it cuts across the three nations. (Yang 2011)

“Green mining’ continues to be the centre of controversy in the mining industry now that technology is available and there is backing from the governments, it will be important to establish whether or not-despite the barriers- nations have been able to make a milestone towards cleaner environments. It will also be important to establish whether the perceived versus tangible level of technology determines the position of a nation in regard to “green mining” and how this positions affect the success of the nations. (Rebecca 2010)

4.1 CHINA

China is generally perceived to be a nation of high technology; as noted by Mining-Technology, China assumes the third position worldwide in mining power (2007). It also has

several natural resources such as Iron, coal, mercury, aluminium, lead, zinc, uranium and others. Its coal industry is of particular interest because it is the world's third largest coal resource. As such, China is a country of international interest with many investors seeking position in the mining industry. In addition, China has a large population hence the demand for energy is high; with its high demand China has been expanding its mining industry abroad in nations such as Australia and many others in Africa and East Asia. The extensive mining activities would not be possible except for high level of technology-assumption. Apart from the need to meet the increased demand for mine products at home, Project management Systems document that China has been prompted over the years to produce more sophisticated technology, machines and equipment for the mining industry following increased competition from other technology producing nations (2011). (Schmidt 2011)

The controversial discovery is that despite the fact that China is perceived to be among the highest level technology nations, the USA Commercial Service, point out that "most of the mining equipment produced in China still remains 10 to 15 years behind that of other countries with respect to mining efficiency, equipment quality, environmental protection of mines, and safety" (2001-2011). This brings out the difference in expectation; only the national strategic mines utilize current and high level technologies used elsewhere in the world hence what is perceived of China in terms of technology is not what it is in the mining industry. This may imply that the concepts of safety and "green mining" may also be years behind just like the technology in use; this may be explained by the fact that technology has a big role to play in improving the safety and in "going green". This may be the reason why China, according to Rauch, has had very high levels of accidents and mine deaths. All in all it has been trying to attain some little success in "going green"; this has been possible by use

of available technology in recycling such as lead recycling documented by Dongjie. (Rebecca 2010)

4.2 SOUTH AFRICA

Expectations laid on the South Africa Coal industry are a little lower than those for China; it has lesser Coal reserves compared to China, it is the fifth largest worldwide and it is assumed by many that South Africa has less sophisticated technology than China. But what is perceived by many may not be the true happening on the ground, according to Schimdt, South Africa has been setting technological pace for otherwise known technological nations such as China especially in using coal to make liquid fuels (6). It has also been able to use technology such as Underground coal gasification to change coal into gas underground; as such green house emissions are reduced. Hence despite it being rated as middle level in technology capacity there seems to be reversed roles between South Africa and China; SA has a higher current technology level and is seemingly doing more towards “green mining”. (Richards 1997)

4.3 Zimbabwe

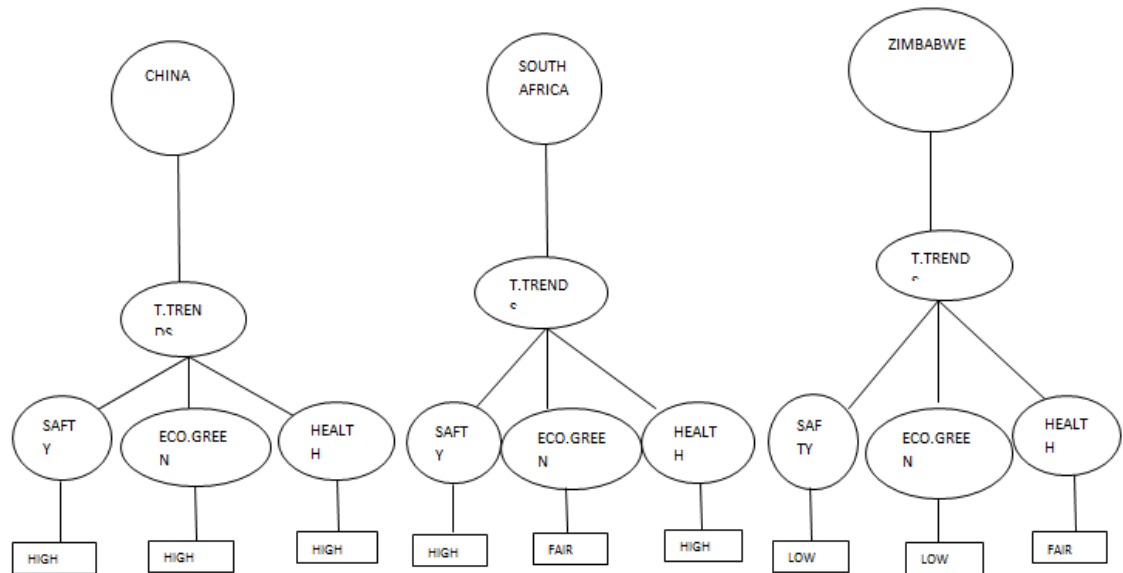
Being a developing nation little is expected of it in terms of technology and “green mining” initiatives. As indicated by Rebecca, in the *Zimbabwean Times*, Zimbabwe has huge volumes of un-mined coal largely due to lack of capital and asses for its exploitation hence foreign investors such as India and China have expressed their interests to assist in the coal

mining (2010). As such, currently there is little worry over environmental degradation and hence the need to “go green” but it is evident that with big foreign firms expressing their interests and developing projects to exploit the extensive coal resources, Zimbabwe will soon be in crisis; extensive environmental degradation and probable high green gas emissions. It will be important for the government and the mine operating firms to put in place preventative measures which include use of current and high level safety and toxic management technologies. (Yang 2011)

It is evident that the perceived level of technology is not the actual in all cases and hence whichever nation with financial power can be able to put into place the most current technology. From the discussion above, the level of technology employed in mining has an impact on the industry outcomes especially with regard to “green mining” and health and safety; current and high level technologies seem to give better outcomes. Despite the level of technology, “going green” is more of an intentional decision rather than a technological outcome though technology plays a big role towards achieving the goal. “Going green has several advantages and therefore those in the mining industry ought to make it part of their corporate social responsibilities so that it does not seem a burden but of day to day corporate activities. For instance Yang documents the China Minister of Land and Resources, commenting on the costs of “non-green mining”. (National research Council-US 2011)

It is so expensive due to high costs incurred in terms of taxes and ground subsidence disasters- earthquakes, mountain cracks, landslides, debris flow and related geological disasters. The next chapter will discuss how the current level of technology in different measurements and the success experienced in the mining industry is beneficial to the mine workers, owners and communities at large. (SI1/DO's/ 2011)

4.4 Technological Trends Analysis by Countries (China, South Africa and Zimbabwe)



The chart above is used to explain the impact of technological trends in different countries based on the country's wealth.

4.5 Finland

Finland has a long mining history and a traditional focus on primary resources which is expected to go on. Exploration especially for gold in the area is expected very high and continues at a very high pace. The operating environment in the country for mining companies is generally favourable for exploration and mining. There is a considerable potential for new minerals to be discovered as the GTK continues to identify industrial and metallic mineral deposits and compile geosciences data. (Geological Survey of Finland, 2008a). The country has a project for nickel-Talvivaara's bioheapleach project which is the only one in the entire world. The project is based on two polymetallic deposits, Kolmissopi and Kuusilampi. The

two deposits form one of the largest known sulphide nickel resources in Europe and, as well as nickel. The country open-pit mine is also expected to produce copper, zinc and cobalt as by-products of the process. This mine uses a process known as bioheap leaching to extract the metals from the ore. This technology enables environmentally friendly and cost effective exploitation of nickel.

China, South Africa, Finland and Zimbabwe are used to represent countries with high, middle and low technology nations.

5 DISCUSSION

The manufacturers have realized the need for increased safety at the mines and also the need to maintain the original nature of the environments: they have been making sure that the technology products in the market cater for various measurements whose accuracy means a lot to the safety of the mine professionals as well as the mining communities and those beyond the mining industry. It is unfortunate that nations perceived as of high technology such as China have not yet realized the need to overhaul old technologies and replace with current ones so as to make the issues of safety and environmental care easier. Although its only a few of the high technology nations that are yet to realize the importance of safety and “green mining”; most of them such as USA, Britain, and Australia are greatly concerned with the concepts and have been doing a lot to ensure the mining industry keeps on with its activities with minimal hurt to the people and the environment. (Yang 2011)

Despite the inequalities experienced between nations in terms of technology levels and death tolls experienced at the mines, there have been increased international efforts such as environmental conventions and calls for revision and stronger enforcement of the health and safety standards by all participants in the mining industry. The main gap remains with the need of most high level technology nations to keep their knowledge and expertise to themselves so that they may have an upper hand when it comes to profits from the mining industry; profits from purchase of technology and expertise, dominant exploitation of the mine resources and finally sale of the finished products to the countries of raw material origin. (The Horizon Report 2011)

Disparities in government authorities have also been a challenge to the war against environmental degradation and the advocacy for health and safety at the mines; most developed nations have been observed to bear the brunt of the whole damage, in that, many foreign investors seeking to develop mines in the developing nations end up violating the health and safety and environmental legislations. (The USA Commercial Service 2001-2011).

Globalization as served more as a neutralizer of effects felt on each nation given the interconnectedness of sectors and nations in business and industry and as such the problems arising from the mining industry are not affecting the developing nations only but have become global in terms of global warming, changing climatic and environmental conditions. Therefore there is need for more global actions; probably an increased need for formation of central governing bodies-probably independent of the governments- that will be in charge of the health and safety issues as well as ensuring all those in the mining industry are focused on the subject of “green mining”. For instance a United Nations based independent committees can be a success because most nations are members of the UN and will therefore have no choice but to ratify and enforce various conventions and standards put into place by the body. (The Horizon Report 2011)

These independent bodies are the ones that can take of issues such as corrupt deals between government and mine operators, compromising the health and safety of the mining populations; these bodies will probably oversee the supervision and inspection at the mine levels by probably following up on government records, they can also check the technology in the market and that which is employed by the mine operators-to help phase out the old technologies in different measurements that are insensitive to various measure that are key to the mine safety. The central bodies can also ensure that foreign investors with interest in mines

in developing nations adhere to the various safety and environmental standards as they should be. There is also need to streamline the education curricula especially in developing nations so that it is possible to develop own technological expertise and avoid overdependence on foreign experts; this can be made possible through academic exchange programs. As stated by Dongjie 2000, nations such as China are making it recycling mining products such as lead; such technology success stories and many more from other nations can be learnt across the globe to ensure certain steps to “going green” cut across the mining industry in whatever location worldwide; this way the concept of “going green” will be roll out widely and effects will be faster, but if one nation is “going green” and the neighbours are practicing “non- green mining” then it will all be in vain and the global problems experience now will exist forever. There have also been suggestions such as that noted in Mining, People and the Environment, to put industrial waste products to meaningful use; such considerations should be further researched on and if the outcomes can be workable then they can be

The mining communities-those working in the mines and those living around the areas also need to be educated about their health and safety and the need to safeguard the environments; integration on communities in projects ensures their success because there tends to be increased ownership of the projects and as such more concern. As such illegal waste disposal, non-procedural mine exits and other safety compromises can be reported to the necessary authority; this will call for improved communication and a more interactive approach rather than authoritative ones. The mine workers can also know their rights such as rights to be in workers (The Horizon Report 2011)

Many may wonder if all the above mentioned efforts are really necessary but “Green mining” has a lot of benefits; it will see mine operators more safe and healthy and hence the in-

dustry will have little medical expenses and low compensations for incapacitations and deaths resulting from accidents and disasters. As such there will be general GDP growth and increased consumer purchasing power; the mining industry provides many employment opportunities hence an economical booster to the mining communities, death or incapacitation of mine workers has direct impacts on the families' dependent of the mine workers and may cause increased poverty. Further, control of disasters resulting from land deformation also saves on funds spent on disasters such as earthquakes each year-of course the disasters do not affect only the mining communities but several other people depending on the magnitude; nations often take years to recover from the effects of such disasters therefore when there is repeated occurrence of such disasters the growth of a nation is virtually stagnated. Safety and health ensures workers at the mines are comfortable and their unit production increases hence more capital for the industries and the mine families; economic growths can be experienced further. (United States Department of Labour 2011)

The advantages of keeping the environment safe are also numberless right from preventing minor accidents such as falls due to open pits, diseases related to pollution, sustaining natural habitats hence letting the living organisms enjoy their lives and resources such as forests are important in the hydrological cycles and hence their maintenance ensures stable climatic conditions. Predictable climatic changes and environmental conditions mean sustainable livelihoods especially for agricultural dependent nations- more in developing nations. Alternatives to non-renewable energy sources need to be invested in; for instance people should be thought how to make energy for small scale use such as for cooking and lighting and also on energy saving methods. (The USA Commercial Service 2001-2011)

6 CONCLUSION

The future of the mineral industry depends upon the research and development of techniques and equipment that are greatly improved. The above discussion has established that many gaps in the enforcement of laws and regulations pertaining the health and safety at the mines have worsened the situation, Denton notes that over 10,000 people die from accidents or diseases resulting from poor working conditions at the mines. This means that there is need for establishing safe standards for safeguarding mine workers.

It is also evident that green mining is crucial as it looks for ways of getting healthy ecosystems, transformed landscapes and clean water through reducing waste by renovating it into other applications. Green mining” has many benefits; it will see mine operators more safe and healthy and hence the industry will have little medical expenses and low compensations for incapacitations and deaths resulting from accidents and disasters. As such there will be general GDP growth and increased consumer purchasing power; the mining industry provides many employment opportunities hence an economical booster to the mining communities, death or incapacitation of mine workers has direct impacts on the families’ dependent of the mine workers and may cause increased poverty.

Further, control of disasters resulting from land deformation also saves on funds spent on disasters such as earthquakes each year-of course the disasters do not affect only the mining communities but several other people depending on the magnitude; nations often take years to recover from the effects of such disasters therefore when there is repeated occurrence of such disasters the growth of a nation is virtually stagnated.

Build on a foundational principal of technical improvement the prolonged approach taken by the Canadian mining sector has already produced tangible results. The impact of acidic damage from the mining process has been reduced a great deal due to new treatment, prediction and prevention paradigms. The methodology of closing up mines has been enhanced and this also involves new and current mines which need financial guarantees and closing plans given upfront.

The efforts to improve the techniques and equipment have many benefits as it assists countries to go 'green'. These benefits are like, offering mine operators a safe and healthier environment and reduction of mine accidents results from these efforts. It is thus important that countries come up with better and improved mining technologies. 'Green mining' is critical to Canada's and other countries markets. In conjunction with stakeholders from environmental NGO's, the mining industry, academic circles, territories and province should further address the environmental problems in mining.

7 RECOMMENDATIONS

This chapter offers recommendation for improvement and adoption by mining industry and technology developers, and recommendation for future research in the subject of study.

The technology trend analysis in the previous chapters has shown that changes in technology influence the future direction that a company takes. The mining industry's future is dependent on the changes that occur in terms of technology because; the technology used in mining has an impact on the environment where the mining activity is taking place. Although the advancement of technology in mining has improved the process and promoted green mining, there is still room for improvement.

7.1 RECOMMENDATION FOR IMPROVEMENTS

- The mining industry must continue to be a vital and powerful force in development of the country, economic growth and maintenance of national defence and well-being. To achieve this, countries have to overhaul old technologies and replace with current ones to make the issues of safety and environmental care easier. The technologies should be geared towards making 'green mining' to ensure the safety of the mine professionals as well as the mining communities and those beyond the mining industry
- Countries should set up many bureaus and offices that deal with mineral programs and policies that promote green mining. Such multiple responsibility calls for much coordination to attain efficient and prompt results to ensure environmental sustainability.

- The production of minerals for the society and application of the mining technology to the needs of the society should be basic and important as agriculture. The government and public appreciation need to be stimulated in order to realize the benefits of the mining industry to the society and economy.
- Investments should be made to test and demonstrate the field available technologies that show potential for improving environment sustainability. Research and development efforts should concentrate on technologies that are promising and which enhances survivability of the environments and those that reduce pollution. Countries should work to expedite and prioritize the certification and approval process for technologies that are inclined towards improved 'green mining'.
- Disparities in government authorities, which have been a challenge to the war against environmental degradation, should be avoided by establishing independent bodies for ensuring that mining techniques and procedures conserve the environment. This will discourage foreign investors from violating the health, safety and environmental legislations.
- Countries should upgrade the apparatus support for emergencies to handle the mining equipment problems.
- Every mine should have plans for competent equipment and survey personnel to be immediately availed at every mine to recognize promptly surface locations for drill sites, and every mine should maintain arrangement for emergency equipment.
- The mining stakeholders such as the mining teams and those who live around the mines should be educated about their health and safety and the need to safeguard the environments; integrating all stakeholders will ensure the success of this project as there tends to

be increased ownership of the projects and as such more concern. As such illegal waste disposal, non-procedural mine exits and other safety compromises can be reported to the necessary authority; this will call for improved communication and a more interactive approach rather than authoritative ones.

- Technologies that reduce energy consumption at every step of mining should be developed. Countries also need to invest in substitutes of non-renewable energy sources.
- The mining industry should adopt new machines and methods for obtaining ore from the earth cheaply and quickly.
- There should be increased public awareness of the roles of the mining industry through public displays, popular magazines and television programs. Laying emphasis on all important government publications on the benefits of the mining industry. Giving short orientation courses for high school counsellors and teachers.
- Increased supply of modern reference books and mining texts. Flexible and inexpensive systems with frequent updating should be formed.
- The equipment required for mining should be reviewed periodically and updated in the light of up to date technologies. Once developed the new equipment should be demonstrated and displayed at regional and national training centers. New requirements should take into account things like first aid equipment and imaging devices.
- A broad assessment of the current environment status of tailings from the mining operations and other mineral industry hot spots is required so as to draw an effective plan

for environment impact mitigation and prevention. The state may allocate some money for these operations or money be acquired through donor funding.

- Legislations on mineral extraction should be revised so as to address environmental matters in mineral exploitation, exploration, processing, closing mines, maintenance after closure and mineral waste recovery and recycling
- Mechanisms for defining on going, past and future environment liability especially for rehabilitation after closure of mine for maintenance.
- A financial guarantee requirement should be introduced in mining which can generate fund to be used either during extraction to address potential on going environmental damage or for reclamation.
- A regulatory system should be developed for managing mineral resources paying specific attention to the development and implementation of environmental audit guidelines.
- An industrial cleaner production program should be developed for promoting clean production mining methods. Special pilot projects in the mining industry in respect to wastewater treatment and air pollution should be implemented and promoted
- Before issuing licenses to mining companies, they should adopt a formal environmental management as a requisite. Independent companies performing environmental audits should be accredited
- Data collection, dissemination and processing monitoring systems should be improved. Databases on mineral resources, dangerous geological processes and groundwater

should be developed. The information on state of ground water and mineral resources and their use should be published annually.

7.2 RECOMMENDATION FOR FUTURE RESEARCH

- Future research should expand the knowledge base on conservation of environment during the mining process
- It should focus on a better understanding of fundamental principles to the development of new devices and integration of entire systems
- To extend the findings to the full range of technologies employed in mining, field research is needed to evaluate the effects of new technologies on the environment and the advantages of going green.
- The focus of this study was to conduct a technological trend analysis in mining. This perspective was chosen deliberately as the researcher's interest is in the technology department. In order to create a more accurate general view of the complete mining process research should be continued; it should take the interplay of many factors. This would yield a better understanding of the whole process of mining. In this further research, the question of typology of the mining process should be taken into account as well as the expansion and possible change of the typology included.
- During this research, several other ideas turned up that could be of interest and advisable to explore more comprehensively. This would enable the researcher to get deeper into the study subject

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