National University of Lesotho International Science, Technology & Innovation Conference & Expo
January 23 – 25, 2018
Maseru, Lesotho
nulistice 2018

Mineral Production & Processing and Associated Environmental Issues in Sub-Saharan Africa

M. Nete*, L. P. Mona, W. Purcell

Department of Chemistry, University of the Free State, Bloemfontein, 9300, South Africa

***Corresponding author:** E-mail: netem@ufs.ac.za

Abstract: Minerals are an important commodity and major contributor to the economies of some African countries. For example, in 2005 Zambia produced 19% Co, South Africa 89% platinum group metals, 23% vanadium while the sub-Saharan Africa (SSA) region accounted for 40% of diamonds, 20% of bauxite and 20% of rutile of the global supply. However, it is important to note that to date the mineral resources in the region have been insufficiently surveyed. Despite the mining potential and the resultant economic benefits many SSA countries still face many challenges to fully benefit from these resources due to different factors such as unstable political environments, labour unrests and sporadic power cuts in many of the countries. The aim of this work was to review mining activities in some SSA countries as well as the environmental issues associated with such mining practices.

Keywords: African minerals, mining, economy, environment, impact

1. Introduction

A mineral ore is a naturally occurring rock or sand which contains elements that are economically valuable. Mining involves the extraction of the mineral ore (Figure 1) from the earth's crust. After mining, the ore is processed to isolate minerals or individual elements with specific chemical compositions and constant physical and chemical properties. Many African countries are rich in mineral deposits such as zircon, columbo-tantalite, copper and cobalt minerals. For example, SA is the leading producer of PGMs and Zr minerals [1] while Namibia, Nigeria, Rwanda, Gabon, Mozambique, Democratic Republic of Congo and Zimbabwe make a significant contribution to the world's supply of columbite-tantalite (Ta/Nb) minerals [3].

Reports [4] indicated that in 2003 Africa possessed 16% of the world's Ta/Nb feedstock and that Nigeria, which is the dominant producer of niobium-containing minerals in Africa, possesses tantalite deposits which are extremely rich in Ta_2O_5 content (>40%) [5]. It was estimated that in 2009 approximately 50% of the world's supply of tantalum came from the DRC and Rwanda [6]. However, mining in the DRC, Rwanda and Zimbabwe is very risky due to the political instabilities in these countries and this makes the supply from these countries highly unreliable. It is generally believed that the illegal mining and the subsequent selling of coltan and gold from DRC supplies the finances to sustain the conflicts in this region and this has resulted in serious atrocities being committed against innocent people in that country. These conflicts not only led to the decline of social structures and economic activity in these areas but also to the destruction of the natural resources such as wildlife, endangering the continued existence of eco-sensitive species such as the African mountain gorilla.

Mineral exploration contribution to the African economies

In many SSA countries the mining industry is a cornerstone of the economy and it makes the largest contribution to job creation, foreign exchange earnings and other economic developments. However, mining

Figure 1. Copper mineral from the Democratic Republic of Congo.

has also had several negative environmental and social effects on the people of Africa (figure 2).

In most of African countries, mining still involves the extraction of mineral ore from the earth crust. Once extracted the ores are minimally processed and exported mostly as raw material with low earnings. Clearly these countries lack downstream technologies for processing of the mineral ores and as such lose large amounts of foreign investment and capital due to export of these valuable natural resources. The raw materials are processed to produce value-added products and the elements extracted from these minerals are used for many different applications in everyday life. Applications include steel production, medical, agricultural, aerospace and jewellery to name just a few. As such, mining and related industries are critical to some countries' socio-economic development worldwide. However, Haglund (2011) [7] warns about the high dependency of countries on the mining industry. According to Haglund, the highest dependency of mostly the low and middle income countries was observed during the rise of commodity prices.

Environmental impacts of mineral exploration in SSA countries

The environmental impacts associated with the mining industry derive mainly from the mine waste. The ore which is being mined, physical and chemical processes used to isolate the required mineral or element and the chemicals which are used in the process all determine the chemical composition of the waste that is being generated. Some waste produced in the metal processing industry has high concentrations of acids, cyanides and heavy metals, which have adverse impacts on the environment, human and animal health [8]. The dust from mine waste, fumes, heavy metals (e.g Pb and As) and radioactive metals (e.g. U and Th), may pose different health problems on flora and fauna in the vicinity of the mine waste. For example, dust from coal waste can causes black lung disease while dust from silica-containing waste may cause silicosis while that originating from asbestos can cause asbestosis. All these conditions can lead to death in human beings.

Another serious problem is the degradation of water quality from contamination by acid mine drainage. Chemical reactions of sulphide minerals, atmospheric oxygen and water lead to the formation of H_2SO_4 (Equation 1) which lowers the pH of water and thus negatively affecting the biodiversity of aquatic ecosystems and ultimately humans and animals through food-chain processes [9-10].

$$FeS_2 + O_2 + H_2O \longrightarrow Fe^{2+} + H_2SO_4 \qquad [1]$$

Production of waste in the mining industry is completely unavoidable and therefore proper measures for waste management have to be in place. The main requirement is to provide stable, safe and economical waste storages to protect the environment and human

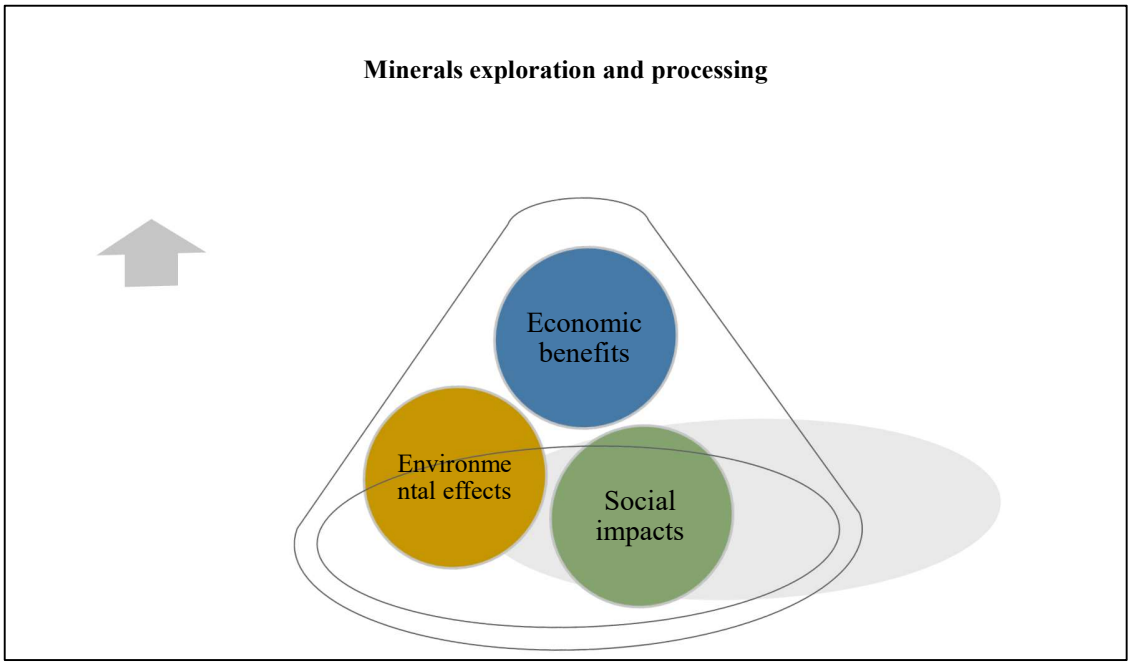

Figure 2. The economic, social and environmental effects of mineral exploration and processing.

health [11]. It is also encouraged that the mine wastes (both solid and liquid) be recycled and/or reused. However, it is important to note that not all waste or waste types can be recycled. Therefore, there has to be long-term management plan for such waste. There have to be plans and preparation for closure to ensure easy post-closure waste management. Preparations usually include growing of plants with high tolerance of toxic levels of heavy metals, covering the waste with a dry substrate such as alkaline materials to inhibit the sulphur and oxygen reactions that lead to formation of H_2SO_4 or covering the waste with clay soils to minimize the amount of water seeping through the solid into surface or groundwater.

Social impacts of mineral exploration in SSA countries

First, there were massive human migrations [12] across many SSA countries which were influenced by these non-renewable resources. The population growth in the many mining areas placed a strain on the infrastructure and services and this led to an increase in informal settlements in these areas. For example, in South Africa many mining area dwellers live in slums and poor environmental conditions such as poor air quality and dirty water run offs everywhere in the village. The economic deterioration in Zimbabwe has forced many Zimbabweans into illegal gold and diamond mining and consequently illegal trading of the minerals across the countries. This illegal exploration of minerals has led to destruction of roads, forests and water supply infrastructure as well as farmlands [13].

The recent increase in gold mines' closure in South Africa has left many communities which depended mostly on mining industry stranded. It is important to note that some of the mines were not closed due to depletion of the commodity, but also for other different reasons which include minimal or no profit due to high cost of production or for safety purposes. The abandoned mines which are not back-filled or protected otherwise attract illegal miners. The overall result of this illegal exploration of the mineral resource is conflicts and killings among the Africans. The Democratic Republic of Congo experienced the deadliest conflicts during the 1998 to 2003 period due to illegal mining and trading of gold and columbite-tantalite minerals. South Africa is currently experiencing high and mostly fatal accidents and crimes from the illegal miners ("Zamazamas" in local language). About 10% of South African gold is smuggled and sold out of the country, at a value of about R7-billion per year. The miners form part of a large syndicate group which runs the business as though it were legitimate at a high profit [14].

2. Conclusions

Mineral exploration and mining in Sub-Saharan Africa has come a long way and for a long time, has brought economic prosperities in countries such as Botswana and South Africa. The mining industry has been one of the major job creators in many African countries and with the new discoveries which continue to be made of mineral resources in countries such as Lesotho, there is more hope for the much needed economic developments in the region. However, there have not been much benefits of this exploitation of natural resources to many Africans due to high corruption in many African states and poor governance systems. In fact, more atrocities have been suffered in many of the mineral-rich countries as compared to the benefits.

While the mining industry is still the most important driver for economic developments it is important to take proper measures to protect the environment against the harmful waste from the mining activities. Of utmost importance is the attention which needs to be given to the illegal mining which leads to resources of states being exported unlawfully and ending of lives of citizens who are vulnerable because of their financial challenges. It is upon the ruling governments of states to pass strict laws to end crimes and for the mitigation of adverse impacts of waste on the environment and on health.

3. References

1. J. Holmberg; Natural resources in sub-Saharan Africa: Assets and vulnerabilities, Nordiska Afrika institutet, Uppsala 2008.
2. P.M. Fozzard; Mining development in sub-Saharan Africa: Investment and its relationship to the enabling environment, Natural Resources Forum, **14** (2) 2009.
3. C. Louvain, C.; Tantalum – Raw Materials and Processing; Available from:
http://tanb.org/tantalum
[Accessed on 05-02-2018].
4. Roskill: The Economics of Tantalum; 9th Ed. Roskill Information Services Ltd. 2005.
5. A.R. Adetunji, W.O. Siyanbola, I.I. Funtua, S.O.O. Olusunle, A.A. Afonja and O.O. Adewoye; Assessment of beneficiation routes of tantalite ores from key locations in Nigeria; J. Minerals Mater. Charact. Engin. **4**(2) 2005 67-73.
6. M. Nete; Separation and purification of niobium and tantalum from synthetic and natural compounds; PhD. Thesis, University of the Free State, Bloemfontein, South Africa, 2013 3-5.
7. D. Haglund; Oxford Policy Management: Blessing or curse? The rise of mineral dependence among low- and middle-income countries 2011.

8. A. Akcil and S. Koldas; Metal transport parameters in residual soil with an undisturbed and remolded structure percolated by an acid solution; J. Cleaner Prod. **14** (12-13) 2006 1139-1145.
9. H. Zhao, B. Xia, J. Qin and J. Zhang; Hydrogeochemical and mineralogical characteristics related to heavy metal attenuation in a stream polluted by acid mine drainage: A case study in Dabaoshan Mine, China; J. Environ. Sci. **24** (6) 2012 979-989.
10. S. Oelofse; Mine waste pollution; in (A Turton), Department of Environmental Affairs and Tourism 2008.
11. Standard Guidance (COP 37) Tailings and Waste Rock: Available from:
https://www.responsiblejewellery.com/ files/Tailings-and-Waste-Rock-RJC-Guidance-draftv1.pdf
[Accessed on 06-02-2018].
12. G.W. Strom; Migration and Development, Dependence on South Africa: A Study of Lesotho, Scandinavian Institute of African Studies, Uppsala, 1986 ISBN 91-7106-252-1.
13. A. Mambondiyani; Gold rush fever among poor Zimbabweans leaves trail of destruction; 2017:
Available from:
https://www.reuters.com/ article/us-zimbabwe-mining-landrights/gold-rush-fever-among-poor-zimbabweans-leaves-trail-of-destruction-idUSKBN17J1CJ
[Accessed on 13-02-2018].
14. The truth about South Africa's illegal mining industry: Available from:
https://www.businesslive.co.za/rdm/business/2017-03-27-the-truth-about-south-africas-illegal-mining-industry/
[Accessed on 15-06-2017].