IMPACT OF VERMICULITE MINING ON SOCIO ECONOMIC DEVELOPMENT OF BUGOBERO SUB COUNTY IN MANAFWA DISTRICT.

BY

MUNGOMA EDDY

BU/UP/2018/3784

SUPERVISOR:

DR. TURYAHABWE REMIGIO

A RESEARCH REPORT SUBMITTED TO THE DEPARTMENT OF GEOGRAPHY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE BACHELOR OF SCIENCE AND EDUCATION DEGREE OF BUSITEMA UNIVERSITY

APRIL, 2022

DECLARATION

I Mungoma Eddy do declare that the findings presented in this research report are original and have never been submitted to any other institution for award of an academic degree or any other award.

MUNGOMA EDDY

BU/UP/2018/3784

Signed……

Date……

APPROVAL

I certify that this research work impact of vermiculite mining on socio economic development of Bugobero Sub County in manafwa district has been compiled under our supervision and that it is now ready for examination.

Dr. TURYAHABWE REMIGIO

Signed…….

Date…….

DEDICATION

I dedicate this work to my parents, Mr. Mungoma Stephen, Mrs. Khamuka Harriet, my siblings Mungoma Eric, Mungoma Emma, Ben, Esther, Beatrice, Rogers, Nick Deo and Joan, Gorret my tireless friends Kaminja Emmanuel, Nakasango proscovia, Asio Sharon Scovia and my course coordinator Bwire Duncan Ngegemi and entire geography class of 2018 who ensured the success of this research, my course lecturers Dr. Turyahabwe Remigio, Dr Hassan and Mr. Okwi john peter of Mbale comprehensive high school for the good foundation and finally my one and only lovely wife Akoth Beatrice Mungoma and son Kalamya Israel xiavior for all the sacrifices that you have made for me to get to this point in my life. May the almighty God reward and give you long life because I still need you more.

ACKNOWLEDGEMENT

Special thanks goes to all my friends who supported me to succeed in this work. I am particularly grateful to my supervisors, Dr. Turyahabwe Remigio for his diligent efforts towards the transformation of this report from the draft stage to its completion. He gave me much confidence and offered practical suggestions for improvement even when the going was not easy due to Covid 19.

I also acknowledge the timely academic and professional guidance and assistance offered to me by Mrs. Mulokwa Judith and Mr. Kiseka Samson and Namulemu Nicolous input came in handy, the support from the managing director of Namekara vermiculite mine for always providing information and permission into the mining Centre whenever needed.

MAY GOD REWARD YOU ABUNDANTLY

LIST OF ACRONYMS

NMCL- Namekara Vermiculite Company Limited.

MI- Mining Industry.

MEMD-Ministry of Energy and Mineral Development.

MSHA-Mineral Safety and Health Administration.

UBOS- Uganda Bureau Of Statistics.

SPSS- Statistical Package for Social Sciences.

ABSTRACT

The research report intends to bring out the effects or impacts of vermiculite mining and associated mining methods on the socio economic development of the people of Namekara Sub County in Manafwa district.

In other word this report shapes out most of the negative, positive impacts of vermiculite mining and the solutions or ways to combat the negative effects.

The study brings out the mining methods that have been used in the extraction of different types of minerals but much emphasis is put on the open cast type.

In this study it has been identified that the mining sector has greatly contributed to the socio economic development but to some extent hinders it.

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

This chapter presents the background to the study, problem statement, purpose of the study, specific objectives, research questions, significance, scope, background of the study area, limitations and delimitations of data collection.

1.1Background to the study.

Ministry of energy and mineral development (MEMD) 2015 defines mining as the extraction of valuable minerals or other geological materials from the earth, usually from an ore body, lode, vein, seam, reef, or placer deposit. This deposit form a mineralized commodity that is of economic interest to the miner.

Some of the ores recovered by mining include metals, coal, oil shale, gemstones, limestone, chalk, dimension stone, rock salt, potash, gravel and clay. Mining is required to obtain any material that cannot be grown through agricultural processes, feasibly created artificially in a laboratory or factory. Mining in a wider sense include extraction of any non-renewable resource such as petroleum, vermiculite, natural gas or even water.

Modern mining process involve prospecting for ore bodies, analysis of the profit potential of a proposed mine, extraction of the desired materials, and final reclamation of the land after the mining is closed. Mining operations usually create a negative environmental impact both during mining activity and after the mine has closed hence most of the worlds nations have passed regulations to decrease the impact. Mine safety and health administration (MSHA). 2008.

Vermiculite is a hydrated magnesium-aluminum-iron silicate. Raw vermiculite is similar in appearance to mica, contains water molecules within its internal structure, and ranges in color from black to various shades of brown to yellow. When vermiculite flakes are heated rapidly to a temperature of 900 °C or higher, the intermolecular water flashes into steam, and the flakes expand into accordion-like particles, which are gold or bronze in color. This expansion process is

called exfoliation, and the resulting lightweight material is chemically inert, fire resistant, and odorless. The vermiculite association (2021)

On a world review, Global vermiculite production increased by about 6.6% in 2016 to an estimated 404,000 t mostly owing to an increase in production from the world's leading producer, Palabora Mining Co. Ltd. [a subsidiary of Palabora Copper (Pty) Ltd.] in South Africa (Ghilotti, 2016). Data for vermiculite production in China, which may have produced significant quantities of vermiculite, were largely unavailable. Although mines and prospects in Brazil, Peru, and South Africa had the potential to increase the production of medium to coarse grades, expected production increases in 2015 and 2016, especially of coarser grades, had yet to materialize. In Europe, demand was sluggish mostly owing to a continued lack of growth in the region's construction industry. Coarser and more expensive grades, increasingly in higher demand in recent years, continued to be in short supply, and there was excess capacity for very fine sizes (Palabora Mining Co. Ltd., 2013, p. 51; Moeller, 2016, 2017).

In 2016, U.S. production of vermiculite concentrate increased slightly, although reportable production remained at an estimated 100,000 metric tons (t) because of rounding to the nearest 100,000 t to avoid disclosing company proprietary data. Percentages in this report were calculated using unrounded data. Worldwide vermiculite production was about 404,000 t in 2016, up by 6.6% from that of 2015. About 68,000 t of exfoliated vermiculite valued at $62.3 million was sold or used in the United States in 2016, representing a nearly 5% increase in quantity with a slight increase in value from that of 2015. U.S. exports of vermiculite were estimated to be unchanged at about 2,000 t, and imports were estimated to have more than doubled to 46,000 t, from those of 2015. Mineral year book (2016).

Domestic production (sold or used) data for vermiculite are collected annually by the U.S. Geological Survey (USGS) by means of two voluntary canvasses i.e. one is sent to mine-mill (concentrator) operations and the second to exfoliation plants. All individual company data from these canvasses were withheld from publication to avoid disclosing company proprietary data.

Production data for vermiculite concentrate were derived from responses from two U.S. producers accounting for all domestic crude vermiculite mine production. In 2016, production of vermiculite concentrate increased slightly. Virginia Vermiculite LLC mined and processed

vermiculite concentrate at its operation in Louisa County, VA, as did Grace Specialty Vermiculite (subsidiary of W.R. Grace & Co.) at its operations at Enoree and Woodruff, SC. Both companies produced concentrates in finer grade sizes (less than 2 millimeters) from biotite mica ores (Moeller, 2017).

In Brazil,BrasilMinérios Ltd. was by far the leading vermiculite producer in Brazil. The company's largest mine was the São Luís De Montes Belos Mine near Goiania in the State of Goias in central Brazil and its main processing plant was in Sao Luis. The mine had an estimated production capacity of 60,000 metric tons per year (t/yr.) of vermiculite ore with estimated reserves of 1.2 million metric tons (Mt) of vermiculite ore (BrasilMinérios Ltd., 2016). With expansion of its mining operations continuing, BrasilMinérios produced and sold about 52,000 t of vermiculite concentrate in 2016 (DepartamentoNacional De Produção Mineral, 2017, p. 237). About 60% of Brazil's vermiculite products typically are exported, 50% of which are coarser grades and 50% finer grades, with sales in North America (50%), Europe (35%), and Asia (15%) (Torrisi and Patel, 2014). In 2016, BrasilMinérios exported nearly 8,200 t of vermiculite to the United States, a 47% decrease from that of 2015 (JOC Group Inc., 2016; Moeller, 2017; Trade Mining Inc., 2017).

Near Brasilia in Catalao, Goias State, BrasilMinérios owned the mining rights to vermiculite deposits containing vermiculite ore reserves of 2 Mt (Elliott, 2011). BrasilMinérios' total production capacity is expected to increase to 200,000 t/yr. when the Catalao Mine is fully brought on line in the next several years (Torrisi and Patel, 2014; Moeller, 2017). BrasilMinérios expected to meet Brazil's domestic demand for vermiculite for 50 years while continuing to be a significant exporter of the mineral. The company also operated two exfoliation plants one in Sanclerlandia, Goias State, and another in Cosmo polis, Sao Paulo State with combined installed capacity of 15,000 cubic meters per month (BrasilMinérios Ltd., 2013).

In Bulgaria Wolff & Müller Minerals Bulgaria OOD, a German-Bulgarian joint-venture company, mined vermiculite ore from its Belitza opencast mine. The company had limited production at, and continued development of, the nearby Verona vermiculite deposit in southwestern Bulgaria near the capital of Sofia. It processed the crude vermiculite ore into a

concentrate in superfine- and micron-sized products at a plant capable of producing 20,000 t/yr. (Wolff & Müller Minerals Bulgaria OOD, 2017; Moeller, 2017).

In ChinaProduction levels of vermiculite in China were not available, but the Vermiculite Association estimated annual Chinese exports of vermiculite to be 110,000 t in 2016, suggesting that annual production must be at least that much (Ghilotti, 2016). In 2016, about 11,000 t of vermiculite concentrate was exported from China to the United States (Trade Mining Inc., 2017).
Xinjiang YuliXinlong Vermiculite Co., Ltd. mined vermiculite ore from its 14.8-Mt deposit at its Xinlong Mine in the No. 2 sector of the Qeganbulake ring complex in the Bazhou area of Xinjiang Uyghur Autonomous Region. The Xinlong Mine was the top-producing vermiculite mine in China, from which the company's production capacity of vermiculite concentrate and exfoliated vermiculite was 120,000 t/yr. and 30,000 cubic meters per year, respectively.
The company's leading product was a flake vermiculite concentrate ranging in size from 0.3 to 8.0 millimeters. The company exported most of its products, typically to developed countries and regions such as Australia, Europe, Hong Kong, Japan, the Republic of Korea, Russia, Taiwan, and the United States, but also sold domestically (Xinjiang YuliXinlong Vermiculite Co., Ltd., 2017).

In SouthAfrica. Statistics, South Africa continued to be the world's leading producer and exporter of vermiculite, accounting for about 40% of estimated world production.From 2000 through 2016, on average, nearly 90% of the vermiculite produced in South Africa was exported. In 2016, about 166,000 t were produced, most of which was mined by Palabora Mining Co. Ltd. (Ghilotti, 2016).
Under the ownership of a consortium consisting of South African and Chinese entities led by the Industrial Development Corporation of South Africa Ltd. and China's Hebei Iron & Steel Group, the Palabora Mining Co. Ltd. increased production in 2016 by about 20% from that of 2015 from its mine in Limpopo Province (table 4; Ghilotti, 2016). In nearby areas, the company was preparing for the opencast mining of ore that was equally rich in high-purity vermiculite. The new mine will have a production capacity of 1.5 Mt/yr. of ore and yield 170,000 t/yr or vermiculite concentrate, extending the company's total mine life through 2033 (Industrial Minerals, 2016). Because of grade constraints and lower recovery rates from portions of the

vermiculite ore body, the vermiculite product has continued to shift toward fine and superfine grades (Palabora Mining Co. Ltd., 2013, p. 4, 51, 149). Palabora Mining continued to face increased competition in the global vermiculite market including competition from the South American producers, but it regained some of its market share lost in the past few years, in part through competitive pricing (Palabora Mining Co. Ltd., 2014, p. 12, 38).

Palabora Mining marketed its vermiculite products through the company's Singapore office to its three international subsidiaries in Europe, North America (Palabora America Ltd. Vermiculite Division in Kennesaw, GA), and Australia (Palabora Mining Co. Ltd., 2014, p. 38).

In Zimbabwe**.**Samrec Vermiculite (Pvt.) Ltd. [a subsidiary of Imerys SA (Paris, France)], the leading vermiculite producer in the country, conducted intermittent mining at the Shawa Mine (Moeller, 2017). Samrec operated the Shawa Mine, which is about 300 kilometers southeast of the capital of Harare. The surface mining operation with ore to a depth of 40 meters had an expected mine life of more than 30 years in one of the largest vermiculite deposits in the world. In the fourth quarter of 2014, the most recent period for which information is publicly available, the company operated at the rate of 40,000 t/yr. The ore, which included a significant portion of large flake vermiculite, was processed into concentrates, the majority of which was exported to Europe, the Middle East, Japan, and the United States (Lismore-Scott, 2014; Source, The, 2014; Minerals Marketing Corp. of Zimbabwe, 2017, p. 18).

The Minerals Marketing Corp. of Zimbabwe, which was responsible for marketing and selling the country's industrial minerals, reported exports of nearly 30,900 t of vermiculite concentrate at a value of $4.14 million in 2015 (most recent year available), representing a 3.7% increase from about 29,500 t at a value of $4.05 million in 2014. The company cited the country's failing rail infrastructure and lower prices for the small grades of vermiculite as having a negative impact on sales and exports the past several years (Minerals Marketing Corp. of Zimbabwe, 2017, p. 11, 15, 18). In 2016, 1,950 t of vermiculite concentrate was imported into the United States from Zimbabwe, a 15% decrease from 2,280 t in 2015 (JOC Group Inc., 2016; Trade Mining Inc., 2017).

On a smaller scale, Zimbabwe-based Wickbury Investments (Pvt.) Ltd. mined vermiculite at the Dinhidza Mine in Buhera for transport to its beneficiation facilities in Harare. Wickbury marketed its product mainly to Zimbabwe's farming industry as a soil amendment to slow the

leaching of fertilizers from soil after excessive rainfall while also promoting the mineral's slow release of fertilizer to the soils. In drier areas, farmers would benefit from the mineral's ability to swell and store water, increase soil aeration, and transport and store nutrients. In both instances, use of vermiculite would improve the

In East African countries, vermiculite is not dominant apart from Uganda where there is high vermiculite deposits in Manafwa district. In Kenya, much of the vermiculite is exfoliated and managed by insulation world Kenya limited which is the leading distributor of exfoliated vermiculite.

In Uganda**,** Early in the year, Australian developer Black Mountain Resources Ltd. initiated its purchase of the Vermiculite Mine in the Manafwa district of Eastern Uganda from the newly established Africa Phosphate Pty, Ltd. and assumed full control of the operation in November when the acquisition was completed. The company reported an increased estimate of nearly 62 Mt of inferred resources, with a grade of 18.2% vermiculite and containing 11 Mt of vermiculite. The vermiculite resource includes significant quantities of coarse and medium grades. The mine has sufficient resources to operate for more than 50 years at previously announced rates of production. The Namekara Mining Co. Ltd (NMCL). Operated the mine intermittently in 2016. In December, Black Mountain began a drilling program to upgrade about 10% of the inferred resource area to an indicated resource and provide a basis for a new mine plan to be used at the mine in 2017 (Swanepoel, 2016).
Therefore vermiculite mining in Uganda is done in Bugobero Sub County in eastern region of Uganda in Manafwa district and statistics shows that there is more sufficient mineral for over the coming 50 years.

1.2 Statement of the problem.

The extraction of vermiculite mining in Bugobero Sub County in Manafwa district has had a number of both positive and negative effects to the socio economic development of the surrounding people of which some are direct and have affected the local mass and others are indirect and at the same time affects the socio economic development. Therefore this research is

aimed at identifying out the effects both positive and negative to the socio economic development of the surrounding as a result of this mining activities.

1.3 Purpose of the study

The purpose of this research is to assess the impact of vermiculite mining on the socio economic development of Bugobero Sub County in Manafwa district.

1.4 Specific objectives.

To identify the dominant methods used in the extraction of vermiculite mining

To find out the positive socio economic impact of vermiculite mining to the surrounding people.

To study the negative impact of vermiculite mining on the socio economic development of the surrounding people.

To establish the strategies to combat negative socio economic effects of vermiculite mining on the people of Bugobero sub county in manafwa.

1.5 Research questions.

The following are the questions which shall be put in place in order for this research to be successful.

What are the dominant methods used in the extraction of vermiculite in Bugobero Sub County.

What are the positive effects/benefits of vermiculite mining to the surrounding people?

What are the negative effects of vermiculite mining to the surrounding people?

What strategies are to be established to combat the negative socio economic impact faced by the people of Bugobero Sub County

1.6 Significance of the study

The study will equip the researcher with a lot of knowledge and skills about the impact of vermiculite mining on the socio economic development of the people surrounding the area and also this information of the research is vital to others who would be interested in knowing more about this mine and still the information can be uploaded on internet for others also to access it like students who offer geography in schools and other institutions like Busitema university.

The study will equip the researcher with knowledge to identify the impact of the vermiculite mining both positive and negative and the locals will be made aware of this effects by either the government or other concerned bodies through sensitization basing on the knowledge got from the research.

The study will also enable the researcher to be awarded with a Bachelors degree of Science and Education for Busitema University this is because in case of a successful study, a researcher will be able to cite out the remedies to the negative effects of the vermiculite mine to the socio economic development of people from Bugobero Sub County.

1.7 Scope of the study

This research study is intended to cover a list of items concerning the dominant methods used in extraction Vermiculite, positive socio economic development of vermiculite mine, negative socio economic development and the strategies to combat the negative effects of vermiculite mining to the people of Bugobero Sub County in Manafwa district.

The study will cover a number of villages in Bugobero Sub County like Busumbu, Iraka, Namekara, Bumakambo since the mine has occupied a large pieces of land therefore the researcher will carry on the study in different villages and this will require a lot of time around 3-4 months for it to be successful.

1.8 Background of the study area

In this area we shall concentrate much on the physical location, climate, relief, population.

1.8.0 Physical location

The Namekara vermiculite mine is located in eastern Uganda in manafwa district near the towns of manafwa and Tororo approximately 230km from the Ugandan capital city Kampala and close to the border with Kenya. It is on major central African road and rail networks and is 10km from a rail spur that connects to the Kenyan port of Mombasa.

It lies along latitude $0^0$50’23”N and longitude $34^0$15’17”E.

Figure 1.0 Map of uganda showing the location of Manafwa districts.

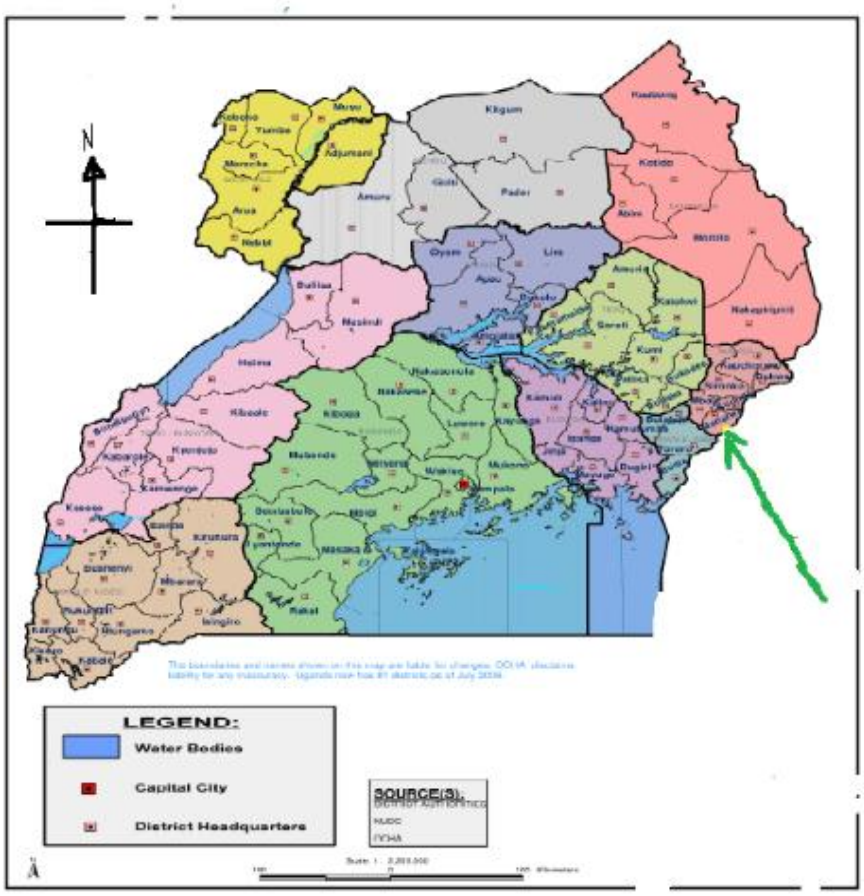
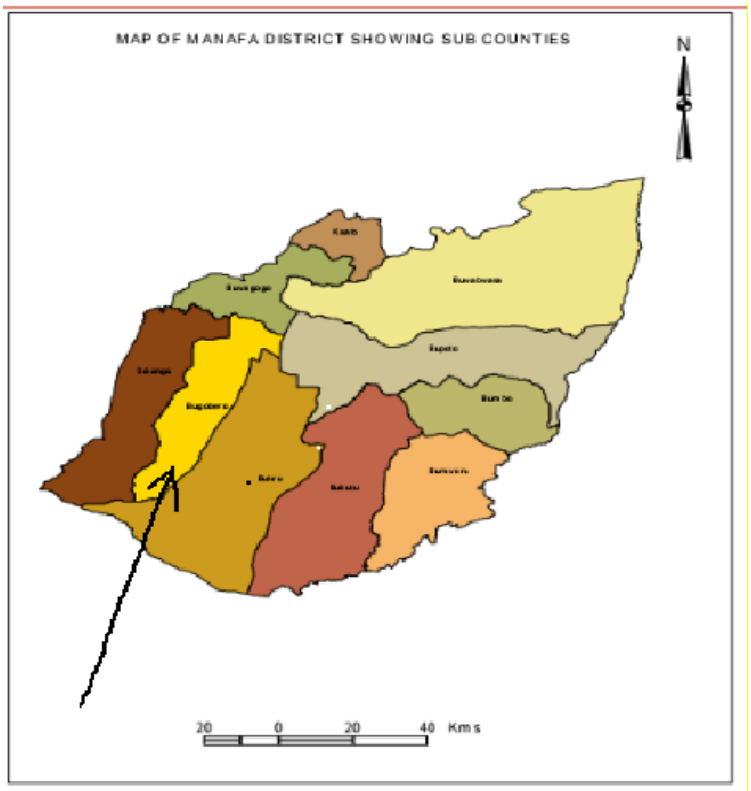
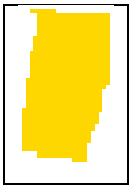


Figure 1.1 map of manafwa district showing Bugobero Sub County.





BugoberoSubCounty

1.8.1 The socio-economic background.

Vermiculite mining in Bugobero Sub County is the leading vermiculite mine Centre in Uganda and East Africa and also among the leading Centres in the whole world. Bugobero vermiculite mining produces vermiculite which is used as an insulator in making fireproof boards, as a replacement of asbestos in brake linings, packaging materials and lightweight concrete in construction. The poorer grades of vermiculite are used in horticulture, tea nurseries due to its ability to retain water for a long time.

There is existence of subsistence farming whereby farmers grow crops and rear animals on small scales majorly for home consumption though little is reserved for sale

The area is majorly settled by the Bagisu who are known as the major natives and the means of communication is lugisu or lumasaba. They also live a united life practicing the one culture that is circumcision.

In 1991, the national population census estimated the district population at 178, 500 before trancation. The national census of 2002 estimated the population at 262,600 inhabitants. In 2012, the population was estimated at 310,000. (UBOS). These population is mainly dominated by the youth.

The mine Centre also employs a number of local people who earns a lot of income at the end thus income generation hence improving the peoples standards of living.

1.8.2 Relief and geology

The vermiculite mine in Bugobero is surrounded by the gentle slopes however there are some neighboring areas of Bukusu with some highlands that have generated the formation of vermiculite and phosphate with in the area.

Bugobero sub county neighbors Bukusu where by the central area of Bukusu, covering about 50 km2, consists principally of intrusive carbonatites and silicate rocks but is poorly exposed. This area is surrounded by a prominent ring of hills of well exposed metasomatic rocks that extend over some 125 km2. There is no outcrop in the central area what little is known of the geology being based on data from a few boreholes and the mineralogy and chemistry of residual soils. The greater part of this area appears to be underlain by heterogeneous melteigite and ijolite with subordinate nephelinesyenite. Pyroxenite, mica pyroxenite and hornblendite seem to form an outer ring. Both the ijolite series and the ultramafic rocks are cut by arcuate masses of carbonatite that only crop out at two localities. (BALDOCK, J.W. 1968)

1.8.3 Climate

The manafwa sub catchment region is located in the tropical Mt. Elgon climatic zone which experiences a bi-modal rainfall pattern. The average annual rainfall totals about 1500mm with rainy seasons occurring in the months of April till June and august to November. The mean monthly temperatures range between 15^0 c and 27^0c. The forest of Mt. Elgon national park is the main ground water recharge source within the catchment. Geo.fu-berlin.de>Uganda.

1.9 Limitations of data collection

The researcher expects to face a problem of language barrier. This is because the fact that information will be collected from the local people, some who are not educated formally, there will be a problem of communication between the respondents and the researcher more so when using English and questionnaires as a mean of data collection.

Inadequate funds to facilitate the study. There will be inadequate money to carry out the research operation such as transport to the study area, purchasing stationery, printing and binding of the research report.

The time factor may also affect the study due to it being limited in the process of collecting especially when using interview method which needs a lot of time

Unwillingness of the respondents to give appropriate information required by the researcher. This is most likely to affect the appropriateness and validity of the research results.

1.10 Delimitations

Financial problems will be overcome by borrowing money from fellow students, lecturers and friends. Parents will also be able to offer financial support towards the completion of this research.

The problem of language barrier will be solved by the use of interpreters that translate English to the local language and local language to English.

The problem of sample size will be solved by use of statistical secondary data since it normally has a large sample size with clear representation of the population distribution.

REFERENCES

BALDOCK, J.W. 1968. Calzirtite and the mineralogy of residual soils from the Bukusu carbonatite complex, south-eastern Uganda. Mineralogical Magazine, 36: 770-4.BALDOCK, J.W. 1969.

Geochemical dispersion of copper and other elements at the Bukusu carbonatite complex, Uganda. Transactions of the Institution of Mining and Metallurgy, 78: B12-28.BALDOCK, J.W. 1971. Feldspathic vent agglomerates at Bukusu, Uganda - a reinterpretation.

Geological Magazine, 108: 407-12. BALDOCK, J.W. 1973. Potassic fenitisation, trachytes and agglomerates at the Bukusu carbonatite complex, Uganda. Overseas Geology and Mineral Resources, Institute of Geological Sciences, 42: 1-24.BELL, K. and BLENKINSOP, J. 1989. Neodymium and strontium isotope geochemistry of carbonatites. In K. Bell (ed), Carbonatites: genesis and evolution. 278-300.

Unwin Hyman, London.DAVIES, K.A. 1956. The geology of part of south-east Uganda. Memoir, Geological Survey of Uganda, 8: 1-76.MCCORMICK, G.R. and LE BAS, M.J. 1996. Phlogopitecrystallization in carbonatitic magmas from Uganda. The Canadian Mineralogist, 34: 469-78.TAYLOR, R. 1961.

Phosphates. In J.W. Barnes (ed) The mineral resources of Uganda. Bulletin, Geological Survey of Uganda, 4: 44-6.

. CalcinersAnd Dryers In Mineral Industries - Background Information For Proposed Standards, EPA-450/3-025a, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.

P. R. Strand and O. F. Stewart. "Vermiculite", Industrial Rocks And Minerals, Volume I, Society Of Mining Engineers, New York, 1983.

Vermiculite, Its Properties And Uses, The Vermiculite Association, Incorporated, Chicago, IL.

Written communication from Jeffrey A. Danneker, W. R. Grace And Company, Cambridge, MA, to Ronald E. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 26, 1994.

W. J. Neuffer, Trip Report For The September 30, 1980, Visit To W. R. Grace And Company, Enoree, South Carolina, ESD Project No. 81/08, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 6, 1981.

Virginia Vermiculite Limited, Trevilians, Virginia, memorandum from A. J. Nelson,

Midwest Research Institute, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 8, 1983.

W. R. Grace And Company, Irondale, Alabama, memorandum from A. J. Nelson, Midwest Research Institute, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 29, 1983.

Rotary Dryer Particulate Emissions Testing, Performed For Virginia Vermiculite Limited, Boswell's Tavern, Virginia. RTP Environmental Associates, Research Triangle Park, NC, November 1979.

Particulate Emission Compliance Test On Grinder Baghouse On August 8, 1989 At W. R. Grace And Company Kearney Exfoliating Plant, Enoree, South Carolina 29335, Environmental Engineering Division, PSI, Greenville, SC, August 24, 1989.

Particulate Emissions Sampling, W. R. Grace And Company, Dallas, TX, April 2-4, 1990, Turner Engineering, Dallas, TX, April 10, 1990. Particulate Emissions Test Report For W. R. Grace And Company, August 1991, RTP Environmental Associates, Inc, Greer, SC, August 1991

CalcinersAnd Dryers In Mineral Industries - Background Information For Proposed Standards, EPA-450/3-025a, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.

P. R. Strand and O. F. Stewart. "Vermiculite", Industrial Rocks And Minerals, Volume I, Society Of Mining Engineers, New York, 1983.Vermiculite, Its Properties And Uses, The Vermiculite Association, Incorporated, Chicago, IL.

Written communication from Jeffrey A. Danneker, W. R. Grace And Company, Cambridge, MA, to Ronald E. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 26, 1994.

W. J. Neuffer, Trip Report For The September 30, 1980, Visit To W. R. Grace And Company, Enoree, South Carolina, ESD Project No. 81/08, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 6, 1981.

Site Visit: Virginia Vermiculite Limited, Trevilians, Virginia, memorandum from A. J. Nelson, Midwest Research Institute, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 8, 1983.

W. R. Grace And Company, Irondale, Alabama, memorandum from A. J. Nelson, Midwest Research Institute, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 29, 1983.

Rotary Dryer Particulate Emissions Testing, Performed For Virginia Vermiculite Limited, Boswell's Tavern, Virginia. RTP Environmental Associates, Research Triangle Park, NC, November 1979.

Particulate Emission Compliance Test On Grinder Baghouse On August 8, 1989 At W. R. Grace And Company Kearney Exfoliating Plant, Enoree, South Carolina 29335, Environmental Engineering Division, PSI, Greenville, SC, August 24, 1989.

Particulate Emissions Sampling, W. R. Grace And Company, Dallas, TX, April 2-4, 1990, Turner Engineering, Dallas, TX, April 10, 1990.

Particulate Emissions Test Report For W. R. Grace And Company, August 1991, RTP

BALDOCK, J.W. 1968. Calzirtite and the mineralogy of residual soils from the Bukusucarbonatite complex, south-eastern Uganda. Mineralogical Magazine, 36: 770-4.BALDOCK, J.W. 1969.

Geochemical dispersion of copper and other elements at the Bukusucarbonatite complex, Uganda. Transactions of the Institution of Mining and Metallurgy, 78: B12-28.BALDOCK, J.W. 1971. Feldspathic vent agglomerates at Bukusu, Uganda - a reinterpretation.

Geological Magazine, 108: 407-12. BALDOCK, J.W. 1973. Potassicfenitisation, trachytes and agglomerates at the Bukusucarbonatite complex, Uganda. Overseas Geology and Mineral Resources, Institute of Geological Sciences, 42: 1-24.BELL, K. and BLENKINSOP, J. 1989.

Neodymium and strontium isotope geochemistry of carbonatites. In K. Bell (ed), Carbonatites: genesis and evolution. 278-300.
Unwin Hyman, London.DAVIES, K.A. 1956. The geology of part of south-east Uganda. Memoir, Geological Survey of Uganda, 8: 1-76.MCCORMICK, G.R. and LE BAS, M.J. 1996. Phlogopite crystallization in carbonatitic magmas from Uganda. The Canadian Mineralogist, 34: 469-78.TAYLOR, R. 1961.

Phosphates. In J.W. Barnes (ed) The mineral resources of Uganda. Bulletin, Geological Survey of Uganda, 4: 44-6.

. CalcinersAnd Dryers In Mineral Industries - Background Information For Proposed Standards, EPA-450/3-025a, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.

P. R. Strand and O. F. Stewart. "Vermiculite", Industrial Rocks And Minerals, Volume I, Society Of Mining Engineers, New York, 1983.

Vermiculite, Its Properties And Uses, The Vermiculite Association, Incorporated, Chicago, IL.
Written communication from Jeffrey A. Danneker, W. R. Grace And Company, Cambridge, MA, to Ronald E. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 26, 1994.

W. J. Neuffer, Trip Report For The September 30, 1980, Visit To W. R. Grace And Company, Enoree, South Carolina, ESD Project No. 81/08, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 6, 1981.

Site Visit: Virginia Vermiculite Limited, Trevilians, Virginia, memorandum from A. J. Nelson, Midwest Research Institute, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 8, 1983.
W. R. Grace And Company, Irondale, Alabama, memorandum from A. J. Nelson, Midwest Research Institute, Cary, NC, to W. J. Neuffer, U. S. Environmental Protection

Agency, Research Triangle Park, NC, June 29, 1983.

Rotary Dryer Particulate Emissions Testing, Performed For Virginia Vermiculite Limited, Boswell's Tavern, Virginia. RTP Environmental Associates, Research Triangle Park, NC, November 1979.

Particulate Emission Compliance Test On Grinder Baghouse On August 8, 1989 At W. R. Grace And Company Kearney Exfoliating Plant, Enoree, South Carolina 29335, Environmental Engineering Division, PSI, Greenville, SC, August 24, 1989.

Particulate Emissions Sampling, W. R. Grace And Company, Dallas, TX, April 2-4, 1990, Turner Engineering, Dallas, TX, April 10, 1990. Particulate Emissions Test Report For W. R. Grace And Company, August 1991, RTP Environmental Associates, Inc, Greer, SC, August 1991