

**STATUS OF GEOLOGICAL RESOURCES IN
UGANDA**

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**FOR
THE EMBASSY OF THE REPUBLIC OF KOREA
IN UGANDA**

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1.0 INTRODUCTION

The nature of the geological resources in Uganda has been determined based on information spanning 90 years since the founding of the Geological Survey of Uganda. National geological mapping coverage has been increased from 50% to 100% at scales of 1:100000 and 1:250000 (Tuhumwire, 2009). The National Airborne geophysical survey coverage recently increased from 30% to 80%. The geological resources covered in this report are mainly minerals but others such as energy are briefly described.

The minerals include metallic ores, industrial minerals and non-metallic minerals. Potential mineral deposits belonging to the three categories are also included. This report describes the type of mineral, its occurrence/location, its mining history if any, the current activities and the size of the reserves. The available skills, the map of the mineral occurrences (Appendix I), the objectives of the Mineral Policy of Uganda and the use of the Mining Act as well as a list of references consulted are also included.

1.1 Minerals of Uganda

In Uganda mineral exports contributed 30% of foreign exchange earnings at the peak of sector performance during the 1960s to 1970 (MEMD, 2003). However, political and economic instability experienced in the country in the 1970s led to the decline of the sector to its present level of contributing only 1% of the Growth Domestic Product (GDP). It is noted therefore that the decline is not a result of resource depletion but is rather due to bad government policies of the past and poor world prices.

Traditional targets have always been base metals and vein-hosted gold. Recently, however, the focus has been shifted to industrial and other non-metals. Today, over 100 occurrences of gold, base metals, industrial minerals and non-metals are documented.

The investment that the Uganda Government undertook with the French Government (1989-1990) and the United Nations Development Programme, UNDP (1992-1996), in which a number of mineral occurrences were appraised led to the discovery of minerals that have since been mined and/or processed. These include cobalt in Kasese, gold at Tira in Busia, tungsten/wolfram at Nyamuliro in Kabale, tantalite at Wampewo in Wakiso, gold near Kyakidu in Mubende and vermiculite at Namekhara in Mbale.

Nevertheless, current mineral production remains too low to meet even the local demand. Limestone mined for the production of cement and lime is consumed largely in the local market. Small quantities of gold, tin and tungsten concentrates are currently produced largely for export. There are also many high mineral potential areas in Uganda, which remain inadequately explored despite the country's long history of production. In other words, the mineral sector for a long time failed to attract investments after the country's recovery from economic and social upheavals of 1970s and 1980s. As a result, a number of interventions and strategies have been put in place by the Government to promote the development of the mineral sector. These include the Mineral Policy 2001, the Mining Act 2003 and the Mining Regulations, 2004.

The objectives of the Mineral Policy, 2001 are to:

- Ensure mineral resources contribute to overall development of the country.
- Stimulate sector development by promoting private sector participation.
- Minimize and mitigate the adverse social and environment impacts of mineral exploitation.
- Develop local capacity for mineral development and management.
- Regularize and improve artisanal and small scale mining.
- Remove restrictive practices on women participation and protect children against mining hazards.
- Encourage value addition and mineral trade.

Under the policy framework, Government shall carry out geological, geochemical and geophysical surveys of the entire country at various scales; process, analyse and interpret the geoscientific data; archive, package and disseminate the data to potential users through print and electronic media; oblige private operators in the sector to provide acquired geoscientific data at appropriate stage of exploration for enhancing the National Geoscientific Data Bank; and avail mineral prospects to investors.

The Government will also encourage artisanal and small-scale miners to form associations and other organizations in order to improve capacity to produce and market their mineral commodities. The government will apply light-handed regulations in small-scale mining, maintain a continuous dialogue with miners' organizations to address matters of small-scale mining and carry out awareness campaigns targeting artisanal and small-scale miners.

In order to stimulate investment in the mineral sector, Government put in place an investor-friendly and competitive legal and fiscal frameworks, with well-defined parameters for the sector. These are The Mining Act, 2003 and The Mining Regulations, 2004. Other important laws that affect mining include: The Land Act 1998, The Land Regulations Act 2004, Registration of Titles Act 2000, The National Environment Act 2003, Contracts Act 2000, and The Arbitration and Conciliation Act 2000.

The Mining Act was enacted in 2003 to operationalise the Mineral Policy (Tuhumwire, 2009). The Act replaced the Mining Act, 1964 and is internationally competitive. It has new legislations on mining and mineral development, which conforms, and otherwise gives effect, to the relevant provisions of the Constitution, to vest the ownership and control of all minerals in Uganda in the Government. The Act also provides for the acquisition of mineral rights and other related matters. Subject to the provisions of this Act, a person may acquire the right to search for, retain, mine and dispose of any mineral in Uganda by acquiring such right under and in accordance with the provisions of this Act.

In the Mining Act, 2003:

- Ownership of minerals is vested in the Government.

- Mineral licenses/rights include: Prospecting License, Exploration License, Retention License, Mining Lease, Location License, Mineral Dealers License, Goldsmith License.
- Mineral Agreements may be executed for large-scale projects.
- Separation of powers: Administration of the Act visa vi Arbitration of disputes.
- Royalties on gross value: Precious stones (5%), precious and base metals (3%), industrial minerals (quantity-based).
- Revenues from royalties shared by: Government, local governments and land owner (80%:17%:3%).
- Operations to comply with National Environment Management Act.
- Settlement of disputes: may appeal against any administrative decision.
- Minister to intervene prior to complainant proceeding to courts of Law.
- International arbitration or sole expert.

The Mining Regulations was to operationalise the Mining Act. They contain procedures/application forms for acquiring various licenses. Applications for these licenses are made to the Commissioner, GSMD and in some instances through the Office of Chief Administrative Officer at the district.

To address the technical constraints in the sector, funds from the Government of Uganda, the World Bank, the Nordic Development Fund, the Asian Development Bank, and a grant from African Development Bank were obtained to finance a five-year project that commenced in August 2004. This was the Sustainable Management of Mineral Resources Project (SMMRP) which aimed at revamping the mineral sector by creating an environment that would attract investors and ensuring that Uganda was Africa's next mining destination. The specific objectives of SMMRP were to:

- Acquire extensive geoscientific data.
- Develop information on mineral resources potential.
- Build institutional capacity.
- Carry out institutional and regulatory reforms.
- Improve small-scale and artisanal mining.
- Establish environment and social capacity for the sector.

Some of the above objectives have been achieved including acquisition of extensive geoscientific data and development of information comprising largely of airborne geophysical surveys, geological mapping, geochemical surveys and mineral resource assessments. However, many of the project activities are ongoing and are at different stages. The final results of SMMRP-funded airborne geophysical surveys that covered 80% of the country will be useful for mineral exploration. The Karamoja region was not covered in this project.

1.2 Energy Resources (Fuels)

The energy resources currently being explored in Uganda are petroleum and geothermal energy. Production of oil and gas is expected soon and the development of geothermal energy is still in its infancy.

2.0 MINERAL OCCURRENCES IN UGANDA

This section describes the major minerals that were mined in the past and/or are being mined at present or are known to occur. It includes metallic ores, non-metallic and industrial minerals as well as their locations in various parts of the country. (Most of this was compiled using Barnes, 1961 and others listed in the reference section).

2.1 Metallic minerals

2.1.1 Beryl

Beryl was first worked in the south and western parts of Uganda in the late 1930s and in the 1950s it was mined as a by-product of other mining operations. It occurs in acid pegmatites mainly in Mbarara, Ntungamo (at Kazumu), Bushenyi (at Mutaka), Kanungu (at Bulema and Ishasha) and Rukungiri districts. It also occurs at Mbale Estate in Mubende, Lunya in Mukono and there are some indications in Karamoja as well. The minor constituents in beryl-bearing pegmatites include apatite, tantalite, columbite, manganite and tourmaline.

Beryl pegmatites are identical in composition with those for columbite-tantalite. Rough zoning is apparent in most of the ore bodies and this affects the distribution. Beryl is found close to the contacts in Kazumu, close to the quartz core at Bulema and in intermediate albite-muscovite zones at Ishasha. Beryllium-bearing pegmatites in Ankole (Mbarara, Ntungamo and Bushenyi) are invariably kaolonised thus cheap to exploit. Beryllium minerals are also known to occur in certain cassiterite-bearing quartz-muscovite veins in Ankole e.g., both beryl and euclase have been found at Nyinamaherere mine, there are large crystals of beryl at Mwirasandu tin mine, and tailing dumps in Mwirasandu carry large reserves of fine beryl. Within the individual zones of the pegmatites, beryl may be concentrated in pronounced pockets or widely disseminated with pockets being more noticeable closer to the core.

Beryl varies in colour even within a single pegmatite. Pale green variety is found in south west Uganda but more common colours are biscuit, off-white and brown. White, semi-transparent beryl is difficult to distinguish from quartz and probably much of this type has not been recognized in the past and discarded as waste. In Central Uganda (Mubende and Mukono), beryl is mostly yellow in tint although other varieties may be present but not yet recognized. Euclase and bertrandite are found in Uganda but in small amounts. In general pegmatites bearing beryl, columbite-tantalite and casiterite are similar but where casiterite is abundant there is little beryl and vice versa.

During the mining of beryl in the 1950s, only sizes that could be handpicked were recovered and finer beryl was left in the waste. By the 1960s, Uganda's exports accounted for 10% of

world beryl production. Currently, reserves in Rukungiri, Kanungu, Bushenyi, Mbarara, and Ntungamo are estimated at 100,000 tons. No grade has been estimated in any of the locations. Vangold Resources Limited acquired seven non-producing artisan beryllium mines and secured nine joint ventures with exploration license holders including Rwenzori Copper and Nickel, Beryllium Exploration Limited and Dome Mines Limited.

2.1.2 Bismuth

Bismuth is found in Uganda as bismutite ($\text{Bi}_2\text{O}_3 \cdot \text{CO}_2 \cdot \text{H}_2\text{O}$) which is not a common ore. It occurs at Rwanzu and Kitwa in Kisoro, Kitahulira in Kabale, and Muramba in Kanungu district. Only the Rwanzu deposit has been mined in the past. It occurs in highly oxidized ferruginous veins and bodies together with small amounts of native bismuth, gold, wolframite/tungsten and other minerals. The bodies are emplaced in rocks of the Karagwe-Ankolean (K-A) System close to the intrusive granites of the Kayonza arena. Two distinct types of occurrence have been recognized. They are pegmatitic type at Muramba, Kyambeya and Rwenkuba in Kanungu district and hypothermal type at Rwanzu, Kitawulira/Hamabari and Kitwa in Kisoro district.

The pegmatitic ore bodies were emplaced along low-dipping shear zones associated with overturned anticlines developed in the Karagwe-Ankolean rocks during folding movements prior to the intrusion of the Kayonza granite. The hypothermal group occurs further from the granite and forms moderately dipping veins or lenses in K-A rocks. In Rwanzu, the bismutite is unevenly distributed as pockets and blebs and as thin seams close to the footwall. Bismutite has also been identified from the beryl-columbite-tantalite pegmatites of Kihanda, Kinkizi, and from tin-tungsten-veins close to Rwaminyinya, Kisoro district.

The mineral was recovered mainly by hand picking and panning and 48.1 tons were exported from 1948 to 1960. However, the reserves are not known.

2.1.3 Columbite-Tantalite (Niobium-Tantalum)

Columbite and tantalite constitute an isomorphous series i.e., they are a single mineral called columbite if Nb is predominant and tantalite if tantalum is the major constituent. The Nb ores that occur in Uganda are columbite ($(\text{FeMn})\text{Nb}_2\text{O}_6$) and pyrochlore $(\text{NbCa})_2(\text{NbTi})_2(\text{OF})_7$.

Tantalite is the chief ore of tantalum and occurs with columbite in pegmatites. Microlite (up to 70% Ta_2O_5 and 4% U_3O_8) has been mined in the past but others found are euxenite, bismutotantalite (Ugandite), manganotantalite although in small amounts. Workable deposits are confined almost entirely to SW Uganda. It was also recovered as a by-product of beryl mining.

The main occurrences are pegmatites of Kakanena, Nyanga, Rwakirenzi, Nyabushenyi, Rwenkanga and Dwata in Ntungamo, Jemubi and Kabira in Bushenyi, Bulema in Kanungu and Kihimbi in Kisoro district with up to 83% Ta_2O_5 and 70% Nb_2O_5 . Others are Ngoma-Kazumo in the west, Wampewo (bismutotantalite) in Wakiso and Lunya in Mukono district.

Columbite-tantalite occurs either in pockets or as discrete and scattered grains and blebs throughout the orebodies although pockets tend to be closer to the core of the pegmatite. Euhedral crystals are rare and the mineral is usually anhedral, bladed or tabular. The proportion of Nb to Ta in the mineral varies considerably even in one deposit. Many varieties contain a small proportion of fergusonite and are sufficiently radioactive. The pegmatites have usually undergone intense kaolinisation (except in Nyabakweri and Bulema) making it difficult to trace zoning.

Pyrochlore

Pyrochlore is potentially the most important niobium mineral in Uganda. It occurs in carbonatites at Sukulu in Tororo, Bukusu in Manafwa, as well as Napak and Toror in Karamoja. Sukulu is the most important and pyrochlore occurs in residual soils resulting from the erosion of the carbonatite. It is associated with other residual minerals such as apatite, magnetite, zircon and barites. Pyrochlore was to be recovered as a by-product of phosphates. Reserves of pyrochlore-bearing soils in the three valleys at Sukulu are 202 million tons of which 130 million tons average 0.2% Nb₂O₅. Concentration is complicated by its fine size with up to 45% less than 10 microns. The production only went to pilot-plant stage.

2.1.4 Copper-cobalt

Copper has been found at several localities in Uganda but the only major deposit discovered to date is Kilembe, in Kasese district where copper-cobalt sulphide mineralization occurs. The primary ore consists of mainly chalcopyrite, pyrite and pyrrhotite with minor linnaeite. Apart from cobalt, the ore is also associated with nickel and gold and sometimes kaolin. Other areas where copper mineralisation has been noted are Bobong, Lokapelieth and Loyolo in Karamoja region, and Kampono and Kitaka in Mbarara district and in Buhweju.

In Kilembe, the ore is confined to one general horizon, a thin calcium-rich biotite to hornblende granulite with little quartz, and to the upper part of quartz-feldspar amphibolite lying immediately below it. In the northern deposit there is a tendency for the ore to split into a hanging and a footwall ore body, separated by a weakly mineralized zone of quartz-feldspar amphibolites. The thickness of the ore is variable and averages roughly 6m (20 ft) although in the split ore bodies of the northern deposit the total mineralised zone is often more than twice this width. Extensive oxidation is found only in the northern deposit where the weathered rocks are strongly impregnated with malachite, azurite and chrysocolla sometimes to as much as 6% Cu. Secondary sulphides also occur and parts of the ore zone are rich in chalcocite.

The deposit was brought into production in 1956 when the railway line reached Kasese town. Between 1957 and 1979 a total of 16.29 million tons of ore averaging 1.95% Cu and 0.18% Co were mined and treated to 217,000 tons of blister copper which was exported. In addition, 1.1 million tons of cobaltiferous pyrite was stockpiled. The Kasese Cobalt Company installed a cobalt plant in 1997 to carry out bioleaching of the pyrite concentrate. The plans were to process the stockpiled concentrates to recover 1000 metric tons per year. This was to last for at least 12 years or so. By 2003, 5.5 million tons of the cobalt tailings at an average grade 0.114% Co were left.

The copper mine ceased its production in 1982 and has since been on care and maintenance. During its operation, 271,000 tons of blister copper were produced (Tuhumwire and Hinton, 2006). Its closure led to the collapse of formal mining sector in the country and retrenchment of hundreds of trained miners, was an important catalyst in the expansion of Uganda's artisanal and small scale mining sector including that related to industrial minerals extraction. Proven reserves of copper ore at closure were 4.17 million tons with a copper content of 1.77% with opportunities to discover additional resources in the vicinity of the mine.

In Kitaka, chalcopyrite occurs associated with galena, pyrrhotite, pyrite, sphalerite, scheelite and gold. Only lead was recovered from this deposit in the past.

In September 2004, Uganda Gold Mining Ltd (UGM) of Canada signed an agreement with the state-owned Kilembe Mines Ltd in which UGM could earn a 70% interest in the Kilembe copper-cobalt mine by conducting exploration and a feasibility study. Signature Resources Ltd. also obtained exclusive prospecting licenses adjacent to the Kilembe Mine and near Kafunzo.

2.1.5 Gold

Gold is widely distributed in Uganda but has been worked in only a few areas. These are Buhweju and Mashonga in Buhweju district, Kyamuhunga in Bushenyi district (**Buhweju goldfield**), many localities in Kabale, Kisoro and Kanungu districts (**Kigezi goldfield**), Tira and Amonikakine in Busia district (**Busia-Bugiri gold field**), Kamalenge in Mubende district (**Mubende-Kiboga gold field**) and many localities in Karamoja region (**Karamoja goldfield**). In West Nile, only traces of alluvial gold have been found. In most of these areas gold is/was recovered from alluvial deposits except in Tira and Amonikakine mines where it was recovered from reefs (hard rock).

Buhweju gold field

In this field gold occurs in alluvials on and around Buhweju plateau in Buhweju and Bushenyi districts. The plateau is a large Middle Proterozoic basin composed of phyllites, shales, schists and quartzites of K-A rocks. Gravels may be up to 2.2 m (7 ft) thick but many are thinner and deeply covered by the overburden. The extent of the plateau gold field is confined within the limits of the quartzites (Lubare quartzite).

The size of the gold in this field varies between 1-3mm although fine gold also occurs associated with cassiterite and monazite. Gold also varies in form i.e., flattened, irregular, rounded and fine. Coarse crystalline gold occurs in vugs lined by quartz crystals in sulphide veins that lie within the Kitomi forest below the plateau at Kitaka, Kampono and Kanyambogo. At Kitaka the sulphides are scheelite, chalcopyrite, pyrite, galena and sphalerite.

Little reef gold (from hard rock) has been won in Buhweju mainly on the plateau from small gold-bearing veins, from a stockwork of minute quartz stringers transecting quartzite and having pyrite and fine gold at Muti as well as stringers of comb-quartz with both coarse and fine gold.

In Mashonga, alluvial gold ranges from fine to 3 mm. Pieces as large as 9 mm have been found in the past. The gravels are up to 1.2 m (4 ft) thick and frequently overlain by a considerable thickness of overburden.

Kigezi goldfield

Gold in this field is found in small alluvial deposits scattered in Kabale, Kisoro and Kanungu districts. Nuggets of up to 14 g were found at Cherima and concentrates contained cassiterite, tungsten, bismutite, zircon, monazite, chalcopyrite and rutile. The source of the gold is considered to be K-A System rocks or associated porphyritic granite and quartz veins as well as ironstone lenses hosted by these rocks. There are some licenced companies including De Villers Exploration Limited working in this field.

Mubende-Kiboga goldfield

In this field gold occurs in thin quartz stringers in schists of the Singo Series at Kamalenge area and is also found in the saprolite zone of weathering just above unaltered bedrock. A considerable amount of gold-bearing gravels lies in the drainage below Kyasampawo ridge. Mining of gold in Kamalenge is currently being done by Anglo Uganda. Some occurrences are in Kiboga district.

Busia-Bugiri goldfield

In Busia gold is found close to the contact between fine-grained granites and the sediments but thick laterites cap and obscure flatter areas. Gold occurs in darker milky quartz veins whereas the glassy white quartz veins are barren. Both types of veins show evidence of considerable crushing. Galena, sphalerite, chalcopyrite, arsenopyrite and pyrite are associated with the gold below the oxidised zone. In sediments flat-lying veins may occur and the veins pinch and swell, branch and anastomose along their strikes and disappear on meeting dolerites. Vein gold (reef gold) has been mined in this field although alluvial gold has also been mined but to a much smaller scale. M/S Busitema Mining Company Ltd is working gold in Tira mine.

Karamoja gold field

Gold was first reported in gravels of River Kalere near Kaabong in 1960. Commercial gold exploitation was done in 1983 by artisans who worked alluvial, colluvial and eluvial material. The primary source rocks are also known.

In general, most gold production in Uganda has been by small producers who include licensed miners and illegal miners or artisans. Production statistics is only indicative because most operators are not licensed and the licensed ones tend to under-declare. The recorded production between 1931 and 2001 was around 6.5 tons of which the largest came from Buhweju followed by Tira.

2.1.6 Lead-Zinc ores

Galena (lead with minor zinc and gold) occurs mostly in Kitomi forest at Kampono, Kanyambogo and Kitaka in Mbarara district with Kitaka having the largest reserve. Small occurrences are also found in Kikagati associated with cassiterite. Galena carrying gold and silver in solid solution occurs within the quartz veins, along quartz-free joints in metadiorite

and in vugs in quartz. It is also found as small crystals disseminated throughout some of the altered epidiorite. Commonly associated minerals are chalcopyrite, pyrrhotite and small amounts of sphalerite. Small well-formed quartz crystals enclose needle- and blade-like galena whereas coarse crystalline gold is found in cavities lined with the quartz crystals. Pyromorphite, anglesite, malachite, chrysocolla and opal are also found at Kitaka. Galena was mined at Kitaka and production totalled only 750 tons from 1947 to 1960 but the reserves are unknown. Zinc also occurs in association with lead at Kitaka mine and as Cu-Zn-Au-Ag mineralization at Bobong gossan in Karamoja. Silver is also associated with galena at Kitaka and in parts of Mubende granite in Mubende district.

2.1.7 Lithium

Lithium minerals occur in pegmatites in Mubende, Mukono, Ntungamo, Kabale, Kanungu and Rukungiri districts. They have been exploited only from the Nyabushenyi (Ntungamo) and Mbale estate (Mubende) pegmatites in the past. These minerals are mainly amblygonite and Zinnwaldite but minor amounts of petalite and lepidolite have been found in Kabale. Pieces of amblygonite were recovered from tin-bearing quartz veins at Mwirasandu and Lamwine in Ntungamo district. Production of amblygonite from 1949-1969 was only 777 tons. Most of the pegmatites are small and irregular bodies. They are suitable for small-scale production by local entrepreneurs. The reserves are unknown.

2.1.8 Tin (cassiterite)

Cassiterite is found in SW Uganda in hydrothermal and pegmatite veins (often associated with columbite-tantalite) although detrital and eluvial deposits also occur. Cassiterite may occur throughout the orebody but tends to be associated with the most micaceous parts. The deposits are mainly of quartz-mica-cassiterite vein type in shales and sandstones of K-A System closely associated with granitic bodies. The individual veins are thin (rarely more than a metre wide) and irregular. Stockworks and sheeted vein swarms occur at Rwaminyinya (Kisoro) and Kitezo (Mbarara) and these are likely to have large reserves.

Crystals of cassiterite are rare and occur in squat pyramidal form. Normally, the mineral is found as anhedral masses, grains and blebs which vary in size from about a cm to several centimeters. Colour varies from light grey to dull black often in the same vein. At Kikagati and Ndaniankoko pale grey masses are mixed with darker varieties. Bright red resinous cassiterite and black wood tin occur at Kaina with some commonly having various shades of brown.

Uganda's tin concentrate production from 1927 to 2001 totalled about 13000 tons. The bulk of this production came from hard rock deposit with minor eluvial production but no alluvial production. The largest deposit was Mwerasandu (Ntungamo) and substantial production also came from Kikagati (Isingiro). Other producers were Rwaminyinya, Burama ridge (Kabale/Ntungamo border), Ndaniyankoko (Isingiro), Kaina and Nyinamaherere (Ntungamo). Over one million tons are found at Kikagati and Mwerasandu alone.

2.1.9 Tungsten (wolframite/scheelite)

Numerous tungsten deposits of quartz vein type occur in several places in south west Uganda and in Mubende. They occur as vein swarms in graphitic horizons in the phyllitic rocks of K-A System closely associated with granitoid intrusions. Tungsten occurs mainly as ferberite frequently as reinite pseudomorphs after scheelite.

The main deposits that have been mined are Nyamuliro (Bjordal Mine), Kirwa, Ruhija, Mutolere, Rwamanyinya and Bahati in Kabale and Kisoro districts. In Bahati, tungsten occurs as wolframite with about 4% manganese in platy shining pieces grading $>1\% \text{WO}_3$.

Uganda's wolframite concentrate production from 1935 to 2001 has totalled over 5000 tons. The Bjordal mine which has produced over 2500 tons of concentrate has a resource estimated at 10 million tons averaging $0.5\% \text{WO}_3$ and Kirwa mine which was another large producer from late 1940's to 1979 has a resource estimated at 1.25 million tons averaging $0.19\% \text{WO}_3$. Bjordal mine is currently being re-developed by M/S Krone Uganda Ltd. and production is up to 15 tons/month.

2.2 Industrial minerals and non-metallic minerals

This section comprises of the minerals used in the building and construction industry, cement manufacture, fertilizers and other uses. They include aggregate and stone, clay, sand, limestone, phosphates, quartz crystals and salt among others.

2.2.1 Sand

In Uganda, sand suitable for building and concrete making is found close to the lakes. Most parts of Uganda are covered by swampy drainage courses which do not form clean sands. In northern Uganda, coarse, clay-free sands are usually available in river courses often with gravel. Terrace sands usually contain some clay. In the east, sands are available in many parts although they contain clay and silt. In central, sands are difficult to find a way from lake shores and contain clay if located. In western Uganda, clean sand is found in stream courses and on lake shores in the rift areas.

2.2.2 Glass sand (silica sand)

Narrow beaches of white sand formed from the erosion of quartzites occur in several places along the shores of Lake Victoria. Good quality sand is found in several places such as Diimu in Rakai, Bukakata and Lwera in Masaka, Nalumuli Bay and Nyimu Bay in Mukono and Kome Islands in Buvuma. The highest quality ($99.95\% \text{SiO}_2$) glass sands have been mined from Kome Islands for export in the past. At Diimu and Bukakata beaches, over 2 million tons of good quality sands ($99.93\% \text{SiO}_2$ and $0.05\% \text{Fe}_2\text{O}_3$) have been delineated. The East African Glass works Ltd. mined and used glass sands from Bukakata for making glass in the 1960s. Total reserves are up to 100 million tons.

2.2.4 Aggregate, crushed and Dimension Stone

Stone suitable for crushing is available in most parts of the country. Granite, gneiss, quartzite and sandstone are widely distributed throughout the areas of Precambrian Basement. Dolerite and amphibolite also occur in central and eastern Uganda though they tend to be badly weathered. Volcanic lavas, and agglomerates occur extensively in the southwest and east of the country. Marble occurs extensively in Moroto district. There are well established quarries through out the country and different rocks are being quarried at different scales. The reserves are not known but extensive. Stone is used in various forms in construction as aggregate, hardcore, as building blocks and wall cladding and the beautiful coloured rocks mostly granite, gneiss, marble, and gabbro are used in the dimension stone industry as decorative tiles and blocks.

2.2.5 Carbonatites

They are carbonate rocks of volcanic origin. They occur at Sukulu and Tororo in Tororo district, at Napak in Moroto and Toror in Kotido district. They are variable in composition and may be high in phosphorous from associated apatite and may also contain a high proportion of magnetite. Magnesium is low but increases to 8% at Napak. Tororo carbonatite is being quarried by Tororo Cement Industries Ltd. and the reserves are estimated to be over 25 million tons. The old plant set up in 1953 was rehabilitated and expanded to produce 1000 tons of cement per day. The company has adopted the international standard ISO 9002, for which this rock is not considered suitable for cement except with intensive selective mining. Production of cement in Tororo is based on clinker imported from Japan and India. Tororo Cement Industries Ltd is also quarrying good quality marble in Moroto district and transporting it to the plant in Tororo.

2.2.6 Limestone

Limestone is found in the Lake George Basin about 100 ft (30.5m) above the present level of Lake George. They vary in type from calcretes, tufas and sinters at Muhokya and Dura to a true lake limestone at Hima.

Hima limestone deposit: It is far more extensive and covers about 2.5 km². It has variable quality and near the surface, the deposit is principally dark-grey in colour. Past drilling encountered a persistent clay bed of up to 5m thick that separates distinct upper and lower limestone beds. The deposit is being exploited by Hima Cement Limited to produce Portland cement. The most recent evaluation carried out by the current developer indicated about 18-20 million tons of reserves, 6 million of which is suitable for Portland cement manufacture.

Muhokya limestone deposit: The total reserves of this deposit (tuffa) were estimated in 1953 to be about 0.25 million tons. Analyses in 1953 indicated that this limestone is of moderate purity with high magnesia and phosphorous trace content. The deposit has been used intermittently for lime manufacture since 1945.

Dura limestone deposit: Thick bands of almost pure aragonite occur in calcareous sinters in a narrow valley. The deposit has been partially eroded away. Barnes in 1954 estimated 1-2 million tons of good quality travertine that remain.

2.2.7 Marbles

The marble is usually high in magnesia occur associated with Basement Complex. Pure white graphite marble is found at the foot of Mt. Moroto and pink marble near Moroto town. Numerous other outcrops occur in other parts of Karamoja and Moyo. Tororo cement is mining some of the good quality marble and transported to Tororo for cement manufacture. The reserves are unknown.

2.2.8 Mica

Mica occurs in Kampala, Arua, at Morulem in Abim district, Lunya in Mukono, Omwodulum in Lira and Paimol, Parobong, Kacharalum, Agili, Akwanga, Achumo, Kukor, Labwordwong, Namokora, Naam and Okora in Pader district. Muscovite and little phlogopite occurs in pegmatite through out a belt stretching from the Labwor Hills to Kitgum. In Arua, the pegmatites are similar to the above and were mined in the 1940s. In Kampala at Munyonyo high-grade ruby mica is found.

2.2.9 Phosphates

Apatite is the only commercial form of phosphate in Uganda. It is associated with alkaline volcanic centres near Bukusu and at Sukulu in Eastern Uganda. Weathering of the carbonatite cores of these complexes has resulted into the residual concentrations of apatite, magnetite, vermiculite, pyrochlore, barites and zircon in their vicinity.

At Bukusu, the ore lies in the Busumbu-Namekhara-Nakhupa ridge composed essentially of apatite, vermiculite and magnetite with the Busumbu section being the richest. In Busumbu mine lease area, about 5 million tons of apatite were estimated in 1956 and fifty million tons were estimated for the whole reserve. The bulk of the deposit consists of an apatite-bearing soil but in some parts secondary processes have recrystallized the apatite to form a hard phosphate rock consisting of staffelite-francolite. The exact proportion of hard to soft rock is uncertain but estimated at 1:10 and 1:15. Soft rock varies from 3.2% to 24.6% P_2O_5 content and hard rock has high values between 20.4 and 33.9%. Values in soft rock increase with depth as contamination by iron from the surface becomes less.

Until 1956, only the hard rock was mined by Busumbu Mining Company and magnetite was the chief impurity with the best material produced having 35% P_2O_5 and 5% iron. The high alumina and iron contents made it unsuitable for conversion to superphosphate but its high citric solubility makes it useful as a cheap fertilizer. Production ceased in 1963 when Tororo Industrial Chemicals and Fertilizers Limited (TICAF) established their operations for commercial fertilizers from the soils of Sukulu.

At Sukulu, apatite is found in the soils filling three valleys which cut the ring-like group of hills forming the Sukulu carbonatite complex (4 km diameter). The total soil reserves in the three valleys have been estimated at 202 million tons. It is also believed that large deposits occur under the laterite which forms the perimeter of sukulu. Tests have shown an average of 13.1% P₂O₅ in 130 million tons of measured ore and the values improve with depth. No hard phosphate has been found here. The best material produced contained 42% P₂O₅ and only 1% iron which was suitable for the manufacture of superphosphate early in the 1960s. The deposit was mined by TICAF with a 25,000 tons/year single superphosphate fertilizer plant at Tororo from 1964 to 1978. Nilofos Ltd., a local company has acquired a Retention License for Sukulu deposit. The company is seeking a joint venture to develop the mines and manufacture phosphate fertilizers.

2.2.10 Quartz crystals

Some quartz crystals were found in gravels underlying swamps worked for alluvial gold in Buhweju. However, they were heavily abraded making it difficult to determine those of piezo-electric quality. Large quartz crystals also occur at Kitaka lead mine in Mbarara but they usually contain inclusions of galena and are therefore unusable. Only a few hundred kilograms of good quality crystals were exported in the past but no true commercial source has been discovered.

2.2.11 Salt

Salt includes salt for human and animal consumption as well as various salts for industrial use. Salt for human and animal consumption has been extracted on a small scale from hot springs at Kibiro in Hoima district and on a larger scale from the floor of crater lakes Katwe and Kasenyi in Kasese district for centuries. The salt is a mixture of sodium and potassium chlorides with less amounts of sulphate (gypsum). Currently, production is based on solar evaporation in ponds and the product is crude due to mixing of the salts during fractionation and crystallisation as well as with mud at the bottom.

Lake Katwe is one of the clusters of crater lakes within Quaternary tuff material and its brines (dissolved salts) contain a higher proportion of sodium chloride than adjacent lakes. It covers 2.5 km² and has a maximum depth of 75 cm which substantially reduces during the prolonged dry seasons. It has the best known salt reserves in the rift valley. Pitting and drilling beneath the lake floor revealed a thick sequence of evaporates and associated crater-infill sediments. These evaporates constitute a large soda ash (trona) reserve with interstitial brines rich in sodium and chloride ions of similar composition as that of lake brines during the dry seasons. Feasibility studies undertaken by German firms revealed that the interstitial brines can be extracted by pumping. On average, yields of concentrated brine at about 60m³/h could readily be achieved from a series of boreholes. These interstitial brines would be sufficient to maintain production of about 50000 t/y of salt which could be sustained for at least 10 years. Morton (1969) estimated the reserves to be about 22.3 million tons. A resource of about 10 million tons of trona are also reported. Other salts found in Lake Katwe are sodium hydrogen

carbonate, potassium bromide and potassium sulphate. The other lakes in the Katwe-Kisenyi area contain sulphur and are therefore unsuitable for salt production.

2.2.12 Clay

Clay deposits suitable for the manufacture of bricks, tiles, pottery and other uses are widely distributed throughout Uganda. Systematic investigations have been carried out in a few major areas mostly around urban areas of Kampala, Jinja, Entebbe, Mbarara, Masaka and Budaka. Small clay deposits are limited to the alluvium and valleys and tend to be inconsistent in quality. The composition varies from refractory clays of almost pure kaolin derived from the weathering of granites in situ, through clays with increasing iron and quartz in valleys, to sandy brick-earths derived from the breakdown of laterite. The clays show varied reaction to firing which makes it difficult to assess the value of the deposits and to maintain a standard quality of clay products.

The following clay deposits have been quarried in the past:

Mukono (Namanve)- This is essentially a pottery clay but was used to produce low quality bricks and tiles.

Buku- This deposit is near Entebbe Airport. The clay is more suitable for pottery but tiles have been made by a 30% addition of grog. Blue, yellow and white clays occur and they formed from the leaching of Karoo shales below laterite. Blue and white are of moderate quality but the yellow one is of poor quality. Only a few thousands of tons of good material now remain.

Nansana- This deposit is situated about 13 km in Wakiso district on the Kampala-Hoima road and it produced bricks and Broseley tiles in the past. The reserve was estimated at 1-1.5 million tons.

Kasubi- Three types of clay occurs on the margins of a swamp about 12 km from Entebbe. They include blue clay (is the best quality and suitable for pottery) at the water level passing beneath the swamp and fires to a cream colour, dark grey clay in the swamp edge with a higher sand content (was used for bricks and tiles) and fires to buff, and sandy clay which fires to reddish brown.

Kajansi- This is in a swamp is located on Kampala-Entebbe road in Wakiso district. The clays have been described as ball clay with high plasticity but first rate brick and tile clay also occur.

Bugungu- This is a large swamp south of Nyenga in Lugazi district. It was developed and it produced interlocking roofing tiles which compared in quality with Standard Mangalore tiles. The clay is also suitable for wire-cut bricks and hollow clay blocks.

Other suitable clays are found near Luzira in Kampala, at Lutembe on Entebbe-Kampala road in Wakiso, Kamwonkoli in Budaka district, Buteraniro in Mbarara, Butende, Kasukengo in Masaka, Malawa in Tororo and Butema in Hoima.

Careful and detailed investigation could show potential for better quality clays including refractory material and china clay.

2.2.13 Kaolin

Kaolin deposits suitable for industrial use occur in a number of places in Uganda. It is associated with Tertiary laterisation in several localities including Namasera, Migadde and Buwambo in Wakiso district, Mutaka and Kibalya in Bushenyi, Kisai (Koki) in Rakai district, Kilembe in Kasese district and Binoni, Mparangasi, and Nyabinoni in Hoima district. Kaolin usually contains coarse quartz (which can be screened out) and often fine quartz (which cannot be so easily removed). Reserves at Mutaka and Wakiso are large but frequently the material is iron-stained for some depth. High purity kaolin can be produced from these deposits. Mutaka kaolin is associated with pegmatites and is by far the best quality and can be upgraded to a product averaging 87% kaolinite with 54% of the particles less than 2 microns in size and having a brightness of 80% (unfired) and 87% (fire). In Rakai, the material is white and contains a high proportion of very fine quartz which cannot be removed. Some 2.5 million tons have been proven. This Rakai deposit has the potential as a filler and possibly in soap making. It is also suitable for use in insecticides and has an interesting potential for ceramics. About 64000 tons of good material for ceramics have been estimated for Namasera kaolin. Rakai and Namasera deposits were formed by alteration of shales whereas Mutaka, Buwambo and Migade formed from altered/kaolinised granitoids. Other occurrences are in Luwero and Gombe in Mpigi district.

2.2.14 Vermiculite

Occurs at Sukulu and Bukusu alkaline volcanic centres in Eastern Uganda. The main occurrence is on the semi-circular magnetite-apatite-vermiculite ridge of Bukusu. The ridge is about 10 km long and vermiculite is found throughout its full length. The greatest concentrations are at Namekhara, Nakhupa, Surumbusa, Kabutalo and Sikusi of which Namekhara is the most important. Vermiculite usually occurs as minute flakes although books up to 100 cm² and 2.5 cm thick also occur. The colour ranges from a pale, lustreless to lustrous black. From exfoliation tests, black vermiculite is the best quality but only a few isolated pockets have been found. Good quality vermiculite occurs at greater depths.

Recent exploration at Namekhara delineated a resource of approximately 4 million tons of high quality vermiculite and is probably the best in the world at the moment. Gulf Resources (U) Ltd. is currently mining and processing vermiculite with a planned output of 40000 tons/year mainly for export. Previous mining and processing activities were carried out by NPK Resources Ltd, Carmin Resources Ltd of Canada and Rio Tinto of South Africa.

2.2.15 Gypsum

Gypsum occurs as a float and in alluvial Quaternary clays (12 million tons of gypsiferous clay worth 1.2 million tons of gypsum concentrate at 85% gypsum) as disseminated selenite crystals near Kibuku in Bundibugyo district. It is also found at Lake Mburo in Kiruhura district (1.1 million tons of gypsiferous clay worth 290,000 tons of gypsum concentrate at 60-

70% gypsum), Muhokya in Kasese district (3.2 million tons of gypsiferous clay capable of producing 40000 tons of gypsum concentrate at 86-90% gypsum) and in sediments of Lake George basin at Kanyatete, Kasese district.

At Kibuku, selenite crystals are commonly up to 30 cm long and 10-20 cm in diameter. It may also occur as narrow cross-cutting veins embedded in the horizontally-stratified green soapy clay. Gypsiferous clays up to 6 m thick outcrop over an area of about 2 km². On average the clays contain 10% gypsum. X-ray diffraction and surface area measurements indicated a smectite content of 34% which is too low for commercial bentonite. The Plasticity Index of this clay was found to be 21 which is below that of a commercial bentonite (60-600). There has been only limited artisan production to date and all was sold to Hima Cement, but was stopped due to poor mining methods.

2.2.16 Pozzolana

These are volcanic materials (lavas, ash, tuffs, pumice and agglomerates) that are found in the Western Rift valley and the Eastern Uganda. In the west the materials occur in the Fort Portal volcanic field and Ndale volcanic field (Kabarole), Bunyaruguru volcanic field (Bushenyi) and Kabale-Kisoro volcanic field. In the East, these materials are found on Mt. Elgon in Kapchorwa and Bulambuli districts. Both Hima Cement Ltd and Tororo Cement Ltd are quarrying some of these materials and using them in the manufacture of cheap Portland Pozzolana cement.

2.2.17 Asbestos

Occurs in small quantities in several parts of Uganda and is of the anthophyllite or tremolite variety for which there is little demand. It is found associated with amphibolites rocks of the Basement Complex at Anzaiya in Arua, and Morungore in Moroto. It was mined in the past and used for roofing materials until late 1970s but its fibrous crystals were found to cause cancer when inhaled. The reserves are not known.

3.0 POTENTIAL MINERAL DEPOSITS

This section describes minerals which occur in Uganda but in small amounts. There is a possibility that much bigger deposits may exist but have not been fully investigated and quantified.

3.1 Metallic ores

3.1.1 Iron Ore

Iron ore occurs mainly as hematite and magnetite. High quality iron ore occurs in several parts of Uganda. The biggest deposit is hematite found at Muko in Kabale and Kisoro districts with total resources of over 50 million tons and a grade of 90-98% Fe₂O₃ with negligible S, P and titanium. Similar hematite with a resource of 2 million tons occurs at Mugabuzi in Mbarara district.

Magnetite ores occur around the carbonatite complexes of Sukulu in Tororo and Bukusu in Manafwa district. At Sukulu, magnetite occurs in residual soils with apatite (phosphate). A resource of 45 million tons averaging 62% iron, 2.6% phosphate and 0.9% TiO_2 has been estimated.

Within Bukusu, a number of lenses of massive magnetite occur in igneous rocks (syenite) and as residual soils with vermiculite. Twenty three (23) million tons have been estimated at Nakhupa, Nangalwe and Surumbusa. Namekhara contains an estimated resource of 18 million tons with 13% TiO_2 . At Surumbusa, it is titaniferous also with $TiO_2 > 20\%$. Nangalwe is the most promising deposit. Other carbonatites whose iron ore potential has not been tested are Napak in Moroto and Toror in Kotido district.

There has been only limited production of iron ore in Uganda mainly for use as an additive in the steel scrap smelting and for special cement by Hima Cement. The Madhvani Group of Uganda planned to restart production of rebar at its rolling mill Steel Corporation of East Africa Ltd.

3.1.2 Magnesite

Magnesite ($MgCO_3$) from serpentinite occurs at Lolung north of Moroto town. The quality is moderate (40% MgO) but it is a small deposit. Another similar but smaller deposit occurs at Lolukei at the Karamoja-South Sudan border. Both occurrences indicate a strong possibility of larger magnesite deposits in the Basement Complex (BC). Dolomites and magnesium rich limestones also occur in many parts of the BC.

3.1.3 Manganese

Manganese-ore occurrences have been found in Isandara, Gulika, Kirongo and Gweitengya in western region. No deposits of commercial value have been found. Although the correct weathering conditions for the formation of such deposits exist in Uganda, rocks (that have to be weathered) sufficiently rich in manganese to produce the ore have not yet been located.

3.1.4 Nickel

Nickel occurs in association with cobalt at the pyrite-pyrrhotite concentrate stock pile at Kasese. The proven reserve is 1.1 million tonnes at 0.4% Ni. Potential exists for both primary volcanogenic massive Ni-Cu sulphide and secondary nickeliferous laterite deposits in and/or over ultramafics within Precambrian greenstone belts and Lower-Middle Proterozoic sediments, but this has not been fully investigated. Airborne geophysical survey carried out in 1980 over southern Uganda, and later followed by another similar survey of lower altitude and ground surveys identified magnetic bodies that are favourable for hosting nickel and cobalt at Kafunjo in Ntungamo district and Rugaga in Mbarara district close to the border with Tanzania. Similar bodies in the same geological environment in Tanzania have been found to contain nickel mineralization.

3.1.5 Platinum Group Minerals

Potential for platinum group metals (platinum, palladium and rhodium) exists in layered intrusives in the Archean greenstone belts and areas with ultrabasic rocks. Platinum assays of the Nakiloro chromite deposit samples have been as high as 3.0-7.5 g/ton and are indicative of this potential. The geology of the area is similar to the layered intrusives in South Africa, which have large deposits of platinum-group metals. Exploration has been ongoing at Nakiloro (Moroto) and Lolung. Traces of platinum have also been found in the small alluvial gold gravels of the Kafu River.

3.1.6 Chromite

It is found about 6 km long north of Mt. Moroto at Nakiloro and Lolung. Chromite forms isolated pods and veins associated with a number of lenses of serpentinites as well as talc and chlorite schists. The erratic distribution of chromite makes it difficult to predict ore by normal field mapping but the extent of the bodies could be readily determined by geophysical methods. Serpentinites and allied rocks are also present in the surrounding areas but no chromite outcrops have been found. The chromite is rarely pure and usually contains either talc or antigorite. Analyses in the past show that Cr_2O_3 generally forms between 45% to 55% of the ore and the chrome-iron ratio is often less than 2.5 to 1. The chromite also contains 3 to 7.8 g of platinum per ton. There has not been any chromite production in Uganda.

3.1.7 Radioactive minerals

Potential favourable geological environments for radioactive mineral enrichment are the eastern Uganda carbonatite complexes, the Uganda volcanic fields, granitized domes of eastern and western Uganda, the fault zones and the adjacent highlands of western and northern Uganda. Thorium minerals are more common in Uganda than uranium minerals and no economic deposits of either minerals have been found.

Uranium

Most uranium minerals have been associated with pegmatites which is seldom an economic source of uranium. Uranium has also been detected in certain spring waters along the boundary of the western Rift valley which could indicate uranium-bearing rocks in some form below. Euxenite is probably the commonest U-bearing mineral in Uganda. Many pegmatites in Buganda show traces of it, it has been identified at Nanseke in Toro and in pegmatites in Ankole and Karamoja. At Nanseke it occurs in more than trace amounts and several hundred pounds were recovered in the 1950s containing 11% U_3O_8 . Although a source of yttrium, there are no indications that any large quantities of euxenite occurs. Microlite is common in many pegmatites in western Uganda and occasionally occurs in similar bodies in Central Buganda. At Bulema it occurs in appreciable quantities and at least two tons have been mined for its tantalum content in the past. This microlite contains up to 4% U_3O_8 and appears to be an alteration product of tapiolite which usually surrounds it. Others include betafite which occurs in tuffs south of Fort Portal but in small amounts,

kasolite (lead uranium silicate) has been found in small pegmatite at Lunyo, torbernite in minor quantities has been found only in Bulema, uranosphaerite (a bismuth uranium oxide) occurs in Li-Be-pegmatite at Singo in minor amounts. Springs containing above normal quantities of dissolved uranium occur at Kyambogo Farm Institute (50 micrograms per litre) in Toro, Dura in Kasese (16 microgrammes per litre), near Mbarara town and in Berara gorge.

Geophysical interpretation of data from recent Uganda Aerial Mineral Survey of the country identified uranium mineralization in a 2882 km² land owned by IBI Company which is prospecting for uranium. More than 30 anomalies have been identified in Mubende area. With rising values of uranium, it is expected that the demand for uranium nuclear power generation will continue to rise. Investors with technical and financial capability can work with IBI.

Thorium

This is hosted by monazite which is wide spread and largely derived from weathering of granites. It occurs at Kalapata and Kalere river valley in quartz-rutile-ilmenite nodules in a biotite gneiss. It varies in colour from typical honey yellow to almost black and contain 11% ThO₂. They are also found in Mpuywi in Mubende, Buhweju (0.5% ThO₂) and Bugarama (4% ThO₂). Thorite has been found in various places at Lunyo in Lunyo granite which contains numerous thin pegmatites. Columbite, cassiterite and thorite form part of the accessory assemblage in these pegmatites. Much of the thorite is enclosed in magnetite and some specimens contain up to 17% ThO₂. Extensive pitting and Banka drilling were carried out to establish alluvial concentrations of thorite-bearing magnetite that occurs in the wide valleys surrounding Lunyo hills but without success. Other occurrences are at Apeykale in North Karamoja and Surumbusa in Manafwa district.

3.1.8 Rare Earths and Yttrium minerals

There is a potential for small, irregular deposits of limited and tonnage in pegmatites, but has not been quantified. The Sukulu carbonatite contains some REEs but this has not been fully investigated.

Cerium group- This is found in monazites and fluocerite. Fluocerite is found at Mpuywi in a pegmatite in Mubende district. Specimens of this mineral were found to contain 41% Ce₂O₃ and 39% La₂O₃. Economic mineralisation has not been established. Yttrium group euxenite from Nanseke contains between 10 to 23% Y₂O₃ but occurs in small quantities. It is also common as an accessory in many pegmatites in Buganda. Yttrium phosphate (xenotime) is rarer and has only been discovered as floats south of Lomej in Karamoja and has been associated with gold and monazite south of Kanyambarara and also in the Kafu River gravel.

3.1.9 Titanium

The two ores ilmenite and rutile are well distributed throughout the country but are not concentrated in workable deposits. Rutile occurs in sands of the Kalere River in small amounts. Iron ores at Bukusu and Sukulu contain a high proportion of titanium and magnetite at Surumbusa contains about 22% TiO₂.

3.2 Potential Industrial minerals and non-metals

3.2.1 Barites

Barites occur in small quantities at Katoma hill in Bushenyi in a pegmatite, at Lolachat River in Karamoja as veinlets in brecciated gneiss, and in recoverable quantities at Mugabuzi hill in Kanungu district where it is associated with haematite lenses in granitoid gneiss. It also occurs in the phosphate-bearing soils of Sukulu and is the most obvious source if the other minerals occurring with it can be profitably mined.

3.2.2 Corundum

This has been reported from several localities in Karamoja, but so far no workable deposits have been found.

3.2.3 Diamonds

A few small diamonds have been found in Uganda all of which come from gold-bearing gravels in Buhweju. It is also found in small amounts in Kabale and Butale. There are no indicators of any kimberlites in Buhweju though. There has been no exploration for diamonds in recent years but it was carried out from 1965-1974. No economic deposits were discovered but small diamonds and indicator minerals were discovered in many areas such as southern Karamoja, and Katakwi. The basic volcanics in Bushenyi, Kabale and Kisoro districts have potential for diamonds. Cresta Mining Company Limited carried out exploration for diamonds in basic volcanics of Kabale and Kisoro districts. Follow-up work is recommended.

3.2.4 Diatomite

Diatomite deposits are found in West Nile at Panyango, Alui and Atar near Pakwach town as well as on the Amboso River. At Panyango, up to 100 m of almost horizontal Quaternary deposits crop out along the west bank of the Albert Nile. Within a sand-clay-sand sequence, a clay-rich unit of about 35 m thick exists around the middle. In the upper 15-20 m of this clay-rich unit, six diatomite beds are present with a total thickness of about 6 m and the thickest individual bed is about 3.7 m. The general grade is moderate to good quality estimated at 75000 and 100000 tons. At Atar, diatomite of about 1m thick is exposed in Quaternary sediments in a low eroded fault scarp and is overlain by 2.5 m of overburden. At Alui, 1.5 m bed of diatomite is present beneath 1 m bed of overburden and is of limited extent. The three deposits of near Pakwach are similar but they are not continuous. The diatomite here is very white and contains a large proportion of diatoms (>60%) in a kaolin matrix. It has a good

potential for commercial production of both high grade diatomite and kaolin by hydro-cycloning.

3.2.5 Feldspar

Microcline is commonly associated with pegmatites found in the Precambrian Basement. It occurs at Bulema (Kanungu), Bugangari (Rukungiri), Mutaka (Bushenyi), Nyabakweri (Ntungamo), and Lunya (Mukono). It varies from a high quality, white variety at Nyabakweri through to a lower quality, pale green variety at Lunya. Nyabakweri feldspar is associated with beryl and columbite.

There has been negligible production of microcline to date in Uganda due to little demand at present, but significant potential demand for the manufacture of ceramic product exists in the country and throughout East Africa. One ton was mined from Bulema in 1958. South west Uganda has many pegmatites and there is a possibility that those that have not been heavily kaolinised contain recoverable quantities of feldspar.

3.2.6 Topaz

Massive white Topaz forms veins in the albitised beryl pegmatite at Lunya and half a ton was recovered during beryl mining. It also occurs as a minor accessory mineral at Mpuywi in Mubende district.

3.2.7 Garnet

It is common to many parts of Uganda particularly in schists and gneisses. No economic deposits have been found but possible sources may occur in Karamoja derived from the weathering of garnet gneiss.

3.2.8 Graphite

Graphite-bearing rocks are found in the Basement of the Karamoja ranging from crystalline limestones of sparse graphite flakes to coarse gneisses containing up to 25% graphite. It is also found in the Basement gneisses and charnokites of West Nile at Zeu in Nebbi district. It is also found in Matidi and Acholibur in Kitgum district. The tributary valley of the Mobuku river in the Ruwenzori mountains has a band of almost pure graphite 15 centimetres wide and can be traced in a quartzite for a considerable distance. It also occurs at Orom hills in Kitgum.

3.2.9 Kyanite

Kyanite occurs at a number of localities in Acholi, West Nile, Kabale, at Ihunga and Kamirambuzi hills in Rukungiri district and near Murchison Falls in Masindi. The Mica schist at Murchison Falls contains inclusions up to hand size. In West Nile a band of muscovite-garnet-kyanite schist crop out on the road with kyanite forming about 10% of the rock. At Azi hill a band of kyanite-rutile schist occurs carrying up to 80% kyanite and 5% rutile. At Kamera hill, Kabale, sporadic masses of coarse-bladed kyanite occur in K-A schists which overlie the granitic contact.

3.2.10 Potash

It occurs in large quantities in leucite lavas on the DRC border in Kanungu district. Those richest in potash are leucite–basanites (5–7% K₂O) and banakite (5.1–5.4% K₂O). Small areas of kalsilite–lavas and mafurite in Bushenyi district contain up to 7% K₂O. Moderate quantities could also be produced from the salt in the lakes Katwe and Bunyampaka (Kasenyi) in Kasese district and from Kibiro in Hoima district.

3.2.11 Talc

Talc is usually found in Basement type rocks and occurs in small quantities at Kisinga in Kasese, Tega-Manengo and Kyamuhunga in Bushenyi and Lolung-Moruamakale in Moroto. Soapstone also occurs at Zeu hills in West Nile.

3.2.12 Zircon

Extensive deposits of Zircon (ZrSiO₂) and baddeleyite (ZrO₂) occur in the soils of the Sukulu carbonatite complex. High grade concentrates were obtained during pilot–plant separations of apatite and pyrochlore. The working of the deposits for zircornium alone would be uneconomic. There are 202 million tons of soil with grades up to 0.25% of ZrO₂ with possible better grades in the south valley. Smaller alluvial deposits also occur near Moroto town and on the Kalere River in Karamoja.

3.2.13 Bentonite

This has been reported in quaternary sediments around Mt. Elgon in the East and in the Western Rift valley north of Butiaba.

3.2.14 Precious stones

These have been found in Karamoja but no major exploration has been done in the area and there are no estimated reserves.

4.0 ENERGY RESOURCES

4.1 Geothermal Energy Potential

The geothermal energy potential of Uganda was estimated at 450 MW in 1982 (SEAMIC, 2008). There has been studies aiming at establishing new estimates using modern exploration methods. Since 2003 the Government of Uganda has carried out detailed surface geothermal on three major areas namely Katwe, Buranga and Kibiro located in Kasese, Bundibugyo and Hoima districts respectively. The main objective of development of geothermal energy is to compliment hydro and other sources of power to meet the country's energy demand particularly rural areas far away from the present grid (Bahati, 2008). There are other areas in Uganda with the geothermal potential but more investigations need to be done.

There are a number of reasons why the Government of Uganda wants to develop geothermal energy. They include:

- Localised distribution of hydroelectricity sites: They are concentrated in one area (along the River Nile) resulting into long transmission distances and high energy losses.
- Uncertainty of continued availability of hydropower arising from climatic fluctuations.
- Location of geothermal fields in isolated areas without grid connection.
- International Treaties that may limit water usage.
- Environmental degradation as a result of extensive harvesting of existing natural forest (for wood and agricultural land) leading to silting of water bodies.
- Geothermal energy is an environmentally friendly energy source.
- Geothermal energy can also provide direct heat for use in industry and agriculture with a possibility of recovering minerals from the geothermal spent brines.

So far a number of studies have been carried out in the field of geothermal energy as outlined below:

- Geochemical and geological investigations at Katwe, Buranga and Kibiro were funded by the Government of Uganda and Iceland as well as UNDP and OPEC from 1993 to 1994.
- From 1999 to 2007 the Government of Uganda and IAEA sponsored Isotope hydrology studies to delineate flow characteristics of geothermal waters and to identify recharge areas.
- In 2003 the Government of Uganda and the African Development Bank funded geological, geochemical and initial geophysical surveys at Katwe.
- In 2004 geological and initial geophysical surveys at Kibiro was funded by the Government of Uganda and Iceland (ICEIDA).
- From 2005 to 2007, detailed geological, geochemical and preliminary geophysical surveys at Buranga were funded by the Government of Uganda and Germany (BGR).
- From 2005 to 2007 there were also further detailed geological, geophysical surveys and temperature gradient measurements (TGM) carried out at Katwe and Kibiro with funding from the Government of Uganda, World Bank and ICEIDA. Six shallow boreholes of 200-300m were drilled for TGM.

From the above investigations, the following results were obtained:

4.1.1 Katwe

The geology is dominated by explosion craters, ejected pyroclastics, tuffs and abundant granite and gneissic rocks from basement. There are also lava flows in Kitagata and Kyemengo craters, extinct hydrothermal deposits in and around Lake Katwe and Lake Kikorongo, and surficial deposits (Rift valley sediments). Geochemistry shows subsurface temperatures of 140-200°C, neutral to alkaline fluids with salinity of 20,000-27,000 ppm and high hydrogen sulphide (40 ppm). TEM Surveys indicate two low resistivity anomalous areas

around Lake Katwe and between Lakes Kitagata and Kikorongo. Gravity surveys locate faults along the anomalous areas. A temperature gradient of 30-36°C/km was obtained but 13°C/km was observed in the control borehole. This temperature gradient suggests a deep-seated geothermal reservoir in Katwe. However, the reservoir could be offset from the suggested position.

4.1.2 Kibiro

The geology east of the escarpment is dominated by granite and granite gneisses and west of the escarpment are rift valley sediments about 4-5 km thick. Maximum surface temperatures are 86.5°C but a temperature of 150°C and 200-220°C was inferred by solute geothermometry, SI and mixing models. Also found are neutral fluids, hydrogen sulphide of 10-17 ppm, hot spring waters of salinity up to 4,000-5,000 ppm. Isotope hydrology shows that there is movement of groundwater from the south and east of Kibiro along the faults and recharge from high ground in Kitoba subcounty. Isotope geothermometry gives subsurface temperatures of 140-160°C. Source of sulphates are rocks or minerals with a possible magmatic contribution. Strontium isotopes indicate interaction of water with granites and/or gneisses. Geophysics showed low resistivity anomaly traced into the crystalline environment suggesting conductive alteration minerals in fractures. The gravity high coincides with low resistivity suggesting a deep high density intrusive. From TGM, a temperature gradient of 31°C/km close to the escarpment and 16°C/km away and east of the escarpment was obtained. However, the anomalous areas drilled East of the escarpment may not be geothermal anomalies.

4.1.3 Buranga

It is located at the foot of the Ruwenzori Mountains in a sedimentary environment. There is no evidence of volcanism on the surface but it is highly tectonically active. It is the most impressive of the geothermal manifestations in the Western Rift Valley with surface temperatures of 98°C. Fluids are neutral with salinity of 14,000-15,000 mg/kg TDS (total dissolved solids). Subsurface temperatures from solute geothermometry are 120-150°C but isotope geothermometry gives 200°C. Minerals or rocks are the source of sulphates with possible magmatic contribution. Carbon isotopic composition of CO₂ ($\delta^{13}\text{C}$) indicate a mantle source of gases released at Buranga. A magmatic source was confirmed by helium isotopes indicating a contribution of >30% (R/Ra =28) mantle helium.

Micro-seismics show high seismicity (about 500 local earthquakes per month). They also locate an anomaly in a 10 km depth south of Buranga hot spring suggesting the source of the heat.

4.2 Petroleum

Petroleum occurrence was first recorded in Uganda in the early 1920's (NOGP, 2008). One deep well was drilled in 1938 (Waki-1) which encountered some hydrocarbon shows but was not tested. Several shallow wells were also drilled during the 1940s and 1950s for stratigraphic purposes. There was then a period of limited or no activity between 1940 and

1980 mainly due to the Second World War and political instability in the country. Since the 1980s, a modern and consistent effort to establish the country's petroleum potential has been undertaken.

Aeromagnetic surveys undertaken during 1983 and 1992 respectively identified five sedimentary basins in the country. They are: the Albertine Graben, Lake Kyoga Basin, Hoima Basin, Lake Wamala Basin and Moroto-Kadam Basin. The aeromagnetic surveys were followed by ground gravity/magnetic surveys and geological mapping that started in the early 1990s. This was to clearly define the extent and geometry of the sub-basins in these major sedimentary basins and study the types of rocks distributed therein so as to establish their suitability for petroleum generation and accumulation. Follow-up work showed that the most prospective basin to date is the Albertine Graben.

The Albertine graben forms the northern most part of the Western arm of the East African Rift System (PEPD, 2005). It runs for 500 km from Rwanda in the south and along the Uganda DRC border to the Uganda South Sudan border in the north covering an area of about 23,000 km². It contains five basins namely: Lake George-Edward Basin, Semliki Basin, Lake Albert Basin (Kaiso-Tonya and Butiaba-Wanseko), Pakwach Basin and Rhino Camp Basin.

In the 1980s the Government undertook deliberate efforts to promote the petroleum potential of the country (Kaliisa, 2011). This included training of manpower, acquisition of scientific data in areas with potential for petroleum production and using the acquired data to promote and attract investment into the sector. This attracted international oil companies into the country which have made significant investments and discovered commercial reserves of petroleum. The first commercial discovery was Mputa-1 in 2006 in Kaiso-Tonya area and this changed the Albertine graben from a frontier area to a petroleum province. At this point, the business risk of exploring for petroleum was reduced considerably. The government halted the licensing for petroleum exploration in order to introduce a new regulatory framework which would then take into account this reduced business risk and other relevant aspects for the development of the sector. The Government started by formulating a National Oil and Gas Policy through consultative process which evolved from 2006 to 2008 when it was approved.

The companies whose licenses were halted were Heritage Oil and Gas Limited, Hardman Resources Limited, Energy Africa (all these are now Tullow Oil) and Neptune Petroleum. Dominion Uganda Limited got the license in 2007. These licensed companies have continued with the exploration efforts and have since led to the undertaking of over 20 seismic surveys and drilling of 64 wells in the Albertine graben to date. These efforts have also led to a remarkable success rate with close to 90% of wells drilled encountering hydrocarbons and to 20 oil and gas discoveries with the resources in these discoveries estimated at over 2.5 billion barrels of oil of which over 800 million are expected to be recovered. The investments made to date in the sub sector of petroleum exploration are now over USD 1billion. About 40% of the Albertine Graben has been covered so far.

The National Oil and Gas Policy 2008, is now the key policy document under which development of the oil and gas is being taken forward and the whole petroleum sector is regulated under The Petroleum Exploration and Production Act, 1985 (revised in 2000) together with The Petroleum Exploration and Production Regulations 1993. The policy identifies the key issues in the sector and recommends objectives, as well as strategies and actions to achieve these objectives.

The goal of the policy is to use the country's oil and gas resources to contribute to early achievement of poverty eradication and create lasting value to society.

The objectives of The National Oil and Gas Policy 2008 are:

- To ensure efficiency in licensing areas with the potential for oil and gas production in the country.
- To establish and efficiently manage the country's oil and gas resource potential.
- To efficiently produce the country's oil and gas resources.
- To promote valuable utilization of the country's oil and gas resources.
- To promote the development of suitable transport and storage solutions which give good value to the country's oil and gas resources.
- To ensure collection of the right revenues and use them to create lasting value for the entire nation.
- To ensure optimum national participation in oil and gas activities.
- To support the development and maintenance of national skills and expertise.
- To ensure that oil and gas activities are undertaken in a manner that conserves the environment and biodiversity.
- To ensure mutually beneficial relationships between all stakeholders in the development of a desirable oil and gas sector for the country.

The Petroleum Exploration Sector Policy objectives are carried out by the Petroleum Exploration and Production Department (PEPD) of the Ministry of Energy and Mineral Development, which promotes petroleum exploration in the country by attracting oil companies to invest in the sector.

The objectives of PEPD are:

- To monitor and regulate petroleum exploration and development operations undertaken by oil companies.
- To build local capacity in manpower and infrastructure for petroleum exploration, development and production.
- To carry out geological and geophysical surveys in various sedimentary basins of the country in order to assess their hydrocarbon potential.

4.2.1 Licensed Areas

Within the basins are the exploration areas (EA) or blocks that have been licensed in the Albertine graben. Today, there are 9 exploration areas (EA) and they include:

Pakwach Basin (Exploration Area 1). It is a half graben and lies in three districts of Amuru, Nebbi and Buliisa. It is part of the northern domain of the Albertine graben. The biggest part of this basin is covered by Murchison Falls National Park which is a habitat to a number of wild animals. This area has huge environmental issues as compared to other exploration areas. It is licensed to Tullow Oil (and formally also to Heritage Oil and Gas (U) limited). So far 3 exploration wells have been drilled in the basin (Rii 1, Jobi 1 and Ngiri 1 in 2008) and all have made discoveries. Jobi and Rii are thought to be on the same structure and estimated to have 500 million barrels of oil (P50). According to Heritage Oil and Gas Ltd, this is among the biggest onshore discoveries in Sub-Saharan Africa in recent times. This was followed by Ngiri-2 in 2010, and Jobi-East-1 and Mpyo appraisal wells in 2011. Up to 4 Jobi-East appraisal wells were planned for 2011. The environment has been restored in drilled areas.

Northern Lake Albert Basin /EA 2/ Block 2: Tullow Oil operates this block with 33.33% interest and with partners CNOOC and Total also having 33.33% interest each. It covers an area of about 3900 km².

In Kaiso-Tonya area a number of wells have been drilled. They include: Mputa wells (1, 2, 3, 4 and 5), and Ngassa-1 and 2. Apart from Ngassa-1 the rest were discovery wells.

In Butiaba-Wanseko area there are a number of well sites including:

Waki-1: This was drilled in 1938 and encountered hydrocarbons towards the base of the well.

Taitai-1- This is a discovery well drilled in 2008 and had oil shows within the Basement at 1016 mTD.

Wairindi-1- A shallow well drilled to 790m depth.

Kasemene- This well has oil with a gas cap and flowed at 3500 bopd when tested. It is one of Tullows best wells and is proposed for the early production scheme after Mputa-1.

Kigogole-1- It has a TD of 616 m and flowed at 300 bopd. It is the lightest crude so far in the Albertine graben with API of 33.

Other wells include Nzizi-1 and 2- (encountered both oil and natural gas, Karuka-2, Nsoga-1, Kigogole-3, and Ngara-1. More wells have been planned for drilling.

Southern Lake Albert Basin (Exploration Area A)

The area was first licensed to Heritage Oil and Gas Ltd in 1997 but it was re-licensed to Heritage Oil and Tullow Oil in 2004. Seismic data were acquired over the lake, land and transition zones. Several prospects were identified and the first well Kingfisher-1 was drilled on the shores of Lake Albert.

Semliki Basin (Exploration areas 3 (B, C and D): The Ugandan portion of the Semliki Basin covers the southern part of Lake Albert and the landward area to the south of the lake including eastern part of the flood plain of the Semliki River and Lake Albert (Semliki flats) as well as the adjacent Toro plain.

Well sites – They are the Turaco wells 1, 2 and 3 all of which are situated on Mokondo fault. Turaco-1 was drilled in 2002 by Heritage Oil and Gas Ltd but could not reach total depth due to technical problems. Turaco-2 drilled in 2004 had oil shows but was not tested. Turaco 3 was drilled successfully but on testing it was found to be heavily contaminated with carbondioxide. EA 3 is still up for licensing and possibly locations without carbondioxide will be identified for future exploration.

Lake Edward-George Basin (Exploration area 4B): This is surrounded by Rwenzori Mts to the north, Bushenyi, Rukungiri and Kanungu to the east and south, and DRC in the west. This basin lies within Queen Elizabeth National Park except in the southern part and is licensed to Dominion Petroleum Ltd. The first well (Ngaji-1) was drilled in 2010 but did not encounter any significant hydrocarbons in it. Exploration work is still continuing.

Rhino Camp Basin (Exploration area 5): This is the northernmost part of the Albertine graben. It stretches from Wadelai in the south and intersects the Aswa Shear Zone around Nimule at the Uganda-South Sudan border where it terminates. The license area covers 6040 km². This Area is licensed to Neptune Petroleum (Uganda) Limited.

Drilling sites- Iti-1 was drilled in May 2009 to 592 m where a basement was encountered without encountering any hydrocarbon shows i.e., it was a dry well. The well was then plugged and abandoned in June 2009. Avivi-1 was spudded in 2010 and also failed to encounter hydrocarbons. At Sambia site, the drilling is suspended until enough data is acquired to confirm any further drilling.

The other blocks (3B, 3C, 3D and 4A) are due for licensing by Government. The government is planning a new licensing method based on the reduced business risk in the Albertine graben.

The discovery wells drilled in the Albertine Graben have confirmed the existence of a working petroleum system. In Kaiso-Tonya (5% of the Albertine Graben), over 300 million barrels of oil are estimated to be in place where the Waraga, Nzizi and Mputa discoveries have been made. High flow rates of many of the wells in Kaiso-Tonya also confirmed the existence of significant petroleum accumulations (e.g., over 12,000 barrels of oil per day (bopd) from three zones in Waraga-1, 1,100 bopd from two zones in Mputa-1, 14mmscf/d of natural gas from one zone in Nzizi-2, 1,800 bopd from one of the three potential zones of Mputa-3 and over 14,000 bopd from three zones in Kingfisher-1).

A working petroleum system consists of **source rocks** which on **maturation** generate and expel oil and/or gas, **migration** pathways, **reservoir rocks** which store gas and/or oil, **traps** and **seals** which stop the petroleum from migrating/escaping leading to accumulation, and proper **timing** of these elements.

In the graben over 50 oil seepages are documented but 10 are confirmed in and around Lake Albert. The seepages in the graben together with the shale sequences encountered during geologic mapping and in the wells drilled confirm the presence of high quality mature source rocks. Also, thick sequences of good quality reservoir sands (with sufficient porosities of

>20% up to 40% and permeabilities ranging from 32 to 6000 md) have been mapped at several locations in the graben. Fractured basement reservoirs have also been found to have high potential for commercial oil and gas. The Albertine Graben consists of full grabens and half grabens separated by accommodation zones. Areas around the accommodation zones and along the major basin bounding faults have provided good structural traps in which petroleum has accumulated. Tectonic activity also created a range of potential structural traps including tilted fault blocks, anticlines and flower structures. Clay sequences of over 100m thick have been encountered in outcrops and in the drilled wells. These sequences provide the seals required to hold hydrocarbon accumulations in the subsurface.

4.2.2 Geologic setting of the Albertine graben

The Albertine Graben is bordered on either side by the gneissic-granulitic complex which forms the escarpments and plateaux overlooking the downthrown graben. The escarpments rise up to 2000m above the mean sea level in places and the down thrown graben reaches as low as 620 m in altitude.

Rifting that led to the formation of the Albertine graben commenced in Tertiary times, probably during Oligocene or Early Miocene (Abeinomugisha and Kasande, 2008). The Albertine graben is defined by discrete basin bounding faults with similar amounts of displacement giving it a full graben structure in contrast to Tanganyika and Malawi rifts which are half grabens. Tectonic forces in the graben are overwhelmingly extensional (Kiconco, 2005), although some lateral movements show some later compressional episodes as evidenced by positive flower structures in some parts of the sedimentary basins. The main boundary faults trend mainly in NE-SW, demarcate the extent of the rift valley and are normal faults. Faults trending E-W and occurring between the boundary faults are called transfer faults typical of extensional rift basins. They form as a result of interaction between two normal faults during their growth.

The stratigraphic succession of the Albertine graben consists of both the pre-rift and syn-rift sections. The pre-rift section is composed of the Basement Complex rocks whereas the syn-rift section consists of the sediments accumulated in the graben as the hanging wall subsided. Some tiny pockets of Karoo shale exist in the south-eastern part of the graben indicating that the Permo-Triassic deposition of Sothern Africa must have reached Uganda (PEPD, 2005).

The syn-rift sediments are dominantly fluvial and lacustrine deposits. The stratigraphy has been divided into formations by PEPD based on sediment characteristics such as the fossil content, unconformities, grain size, sedimentary structures and degree of consolidation of the sediments. These Formations are named after prominent rivers and localities.

4.2.3 Production

Early extraction of crude oil is projected at 4,000-5,000 barrels per day with production anticipated to begin by 2013. The production is expected to increase to 125,000 barrels per day or more after five years and continue at the top rate (125,000) for more 15-20 years. This

would accelerate growth, diversify the economy and also drastically reduce Uganda's petroleum import costs which currently stands at a minimum of \$600 million annually.

The government has negotiated initial plans with oil companies for petroleum development, but activity has not yet begun. An early production scheme in 2009 was indefinitely postponed due to different reasons including the recent volatility of gas prices and the global financial downturn. The credit crunch and other uncertainties led to changes in the assignment of oil blocks, when Tullow Oil took over Heritage Oil's stake in two blocks and signing partnerships with larger oil players Total and CNOOC (Chinese company) who have acquired a third of the Tullow interest each. Other oil companies operating in other parts of the Albertine graben are Neptune Petroleum (Uganda) Limited and Dominion Petroleum Ltd. Over forty new companies have applied for exploration licenses in the Albertine graben.

The Government of Uganda is investing in a refinery so that it produces oil for the local market and the region. However, according to the World Bank and IMF, this is a financially challenging and inefficient option with estimated costs exceeding \$4 billion. The oil companies favour a pipeline that could serve the international market, but a pipeline will not be profitable unless production increases beyond national demand and current estimated production levels. The third option is export via railway which would have the additional benefit of improving overall infrastructure.

Petroleum production in the Albertine region also raises concerns about environmental impact and effects on the existing tourist industry, which is currently a major source of foreign exchange. Uganda also shares the reserves with the DRC, creating the potential for conflict if both countries do not live up to their joint agreement for exploration and exploitation.

5. AVAILABLE SKILLS

The Geological Survey and Mines Department (GSMD) is being funded to undertake surveys aimed at providing the needed database to encourage investment in the mineral sector, as well as the training of relevant personnel. The Department also has a cross section of professional staff that may be seconded on request, to companies wishing to commence new exploration programmes.

The Petroleum Exploration and Production Department (PEPD) has a number of trained personnel in the petroleum sector and it promotes petroleum exploration in the country. Makerere University in Kampala, offers degree courses in Geology, Petroleum Geoscience and Production, Masters in Petroleum Geoscience and various disciplines of engineering while a number of technicians are trained locally at Kyambogo University, Petroleum Institute in Kigumba and other Technical Institutes spread across the country.

6. CONCLUSIONS

- Uganda has a good mineral potential and the ongoing sector interventions have positioned the country favourably for investment in mineral exploration and development.
- Acquisition of new geoscientific data and information from the Sustainable Management of Mineral Resources Project (SMMRP) will bring new opportunities for mineral discoveries.
- The Government of Uganda is committed to providing investor friendly policies in the mining and energy sector and encourages research and development in these sectors.

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Appendix I: Map of Uganda showing mineral occurrences (Department of Geological Survey and Mines, GSMD).