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Review Article

General Review of Industrial Minerals and their Potential, Including for Value Addition

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Abstract

Industrial minerals are geological materials which are mined for their commercial value, non-fuel (fuel minerals or mineral fuels) and are not sources of metals (metallic minerals). They are used in their natural state or after beneficiation either as raw materials or as additives in a wide range of applications.

Typical examples of industrial rocks and minerals are limestone, clays, sand, gravel, diatomite, kaolin, bentonite, silica, barite, gypsum, and talc. Some examples of applications for industrial minerals are construction, ceramics, paints, electronics, filtration, plastics, glass, detergents and paper.

The evaluation of raw materials to determine their suitability for use as industrial minerals requires technical test-work, mineral processing trials and end-product evaluation.

Keywords: Industrial Minerals; Raw Materials; Metallic Minerals

Introduction

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The evaluation of raw materials to determine their suitability for use as industrial minerals requires technical test-work, mineral processing trials and end-product evaluation.

This work is to be carried out as part of the SUMM project during 01 June to 31 August 2017.

This document presents the source of information, background and the objectives, the scopes of the work, the methodologies to be employed, current status of Industrial Minerals in Ethiopia, high priority industrial minerals in Ethiopia, to develop the vision for Minerals Development Institute for Industrial Minerals Technology (MDIIMT).

Source of information

A primary source of information was Mengistu and Fentaw [1] Industrial Minerals and Rocks Resource Potential of Ethiopia and Solomon Tadesse [2], Mineral Resources potential of Ethiopia.

During the preparation of this document, Activity Planning Templates of SUMM Project Components in general and the Activity named; Support for General review of industrial minerals and their potential, including for value addition (Activity 3201.1) [3] and information gathered from group discussions of the team members.

Background and Justification

Supporting the Ministry of Mines (SUMM) project is financed by the Canadian government to assist the Ministry of Mines, Petroleum and Natural Gas (MoMPNG) with ultimate outcome "Increased contribution of Ethiopia's extractive mineral sector to state fiscal revenue, employment and income generation for women and men".

Component three of the project deals with immediate outcome of "Improved capacity to analyze, evaluate and promote the process involved in the domestic use of industrial minerals" and output of "Assessment of priority industrial minerals, their markets, value addition opportunities and economic development potential.

Objective of the Work

To enable both the sector to have a clear road map to use industrial minerals and their potential, including for value addition in a strategic manner and develop framework for the envisaged institute for mineral development.

Scope of the Work

The support will enable MOMPNG to have a clear road map to use industrial minerals and their potential, including for value addition in a strategic manner.

Developing the vision of Institute for Minerals Development for Industrial minerals technology (Mineral beneficiation and agglomeration, chemical and electrometallurgy, pyro- metallurgical process etc.), core mining technology and innovation.

Methodology

I. To undertake a review of the industrial and metallurgical minerals start undertaking the review and propose interventions.
II. Identify use related property identification and processing needs.
III. Coordination and technical backstopping from Canadian experts/Institute.

Current status of industrial minerals in Ethiopia

Regional geology and its relation to occurrence of industrial minerals

The geology of Ethiopia can be grouped into three major units, namely the Precambrian basement, late Paleozoic to Mesozoic sedimentary terrains, and Tertiary-Quaternary volcanics and sediments.

The Precambrian terrains of Ethiopia consist of a wide variety of meta-sedimentary, meta-volcanic and meta-intrusive lithologies, which have been subjected to variable degrees of metamorphism and deformation. These rocks are well exposed in the northern, western, southwestern, southern and eastern parts of the country and cover 17% of the total area of the country. These lithologies host most of the known industrial minerals and rocks of Ethiopia including feldspar, marble, granite, talc, graphite, kyanite, mica, kaolin and quartz.

Late Paleozoic-Mesozoic sedimentary units are widely distributed in Ethiopia as a result of the transgression and regression of the sea from the east in the Ogaden towards the west and north. These rocks cover the northern, central, eastern and southeastern regions and make up 24% of the total country. They are represented by limited glacial deposits including tillites (in the northern and eastern regions), sandstone, limestone, shale, marl and gypsum, and provide sources for mainly cement, glass, and construction raw materials.

The Tertiary to Quaternary volcanics are associated with the evolution of the Main Ethiopian Rift Valley (MER), the Afar Depression, and highland volcanism. The main rock types are basalts, trachytes and associated dyke swarms, andesites, rhyolites, ignimbrites and pumiceous ash and covers some 40% of the total country of which Tertiary plateau basalts cover Twenty-five percent of the area. Tertiary sediments are known in the Ogaden, in the Danakil Depression, and in the lower Omo River Valley, and make up about 8% of the country. These sediments include sandstone, limestone, conglomerate, mudstone, shale, gypsum, anhydrite, and other evaporites. Quaternary sediments occur throughout the country and were formed as lacustrine as well as marine formations. They comprise limestones, clay, siltstone, sand, volcanoclastic, and others, and cover about 11% of the total area of Ethiopia. The economic importance of the Cenozoic sediments and volcanic rocks as industrial minerals resources is demonstrated by the presence of various construction materials, potash, rock salt, gypsum, bentonite, diatomite, pumice, sulfur, etc.

In addition, there are alkaline and acidic intrusives (alkaline granite, syenites, and phonolite plugs and flows), which range in age from Mesozoic to late Tertiary. They occur in areas underlain by Precambrian rocks as well as in the rift floor of the Ethiopian Rift Valley. Genetic classification of industrial minerals and rocks has been adopted in the following discussions [4].

High potential and prioritized minerals

- Industrial minerals: Graphite, Kyanite, Bentonite, Diatomite and Kaolin.
- Among Metallic Minerals: Tantalum (Niobium, REE, Lithium, Beryllium) deposit.

Graphite

Natural graphite is an excellent conductor of heat and electricity, stable over a wide range of temperatures; highly refractory with a high melting point (3,650°C); compressible and malleable; resists chemical attack, thermal shock, shrinkage, wetting by metals, and oxidation, has a low absorption coefficient of X-ray and neutrons and a low coefficient of friction (good lubricity).

Flake graphite provides good oxidation, corrosion resistance and structural strength in various carbon-based refractory products. Because of its high lubricity and resistance to heat up to 310°C, graphite is used in many forms as lubricants (automotive and mechanical devices). Graphite impregnated organic friction materials assist with heat stability and reduce wear in friction materials (brake and clutch linings). Because of its jet color, and opaqueness, graphite has long been used in pencils. Good electrical conductivity allows graphite to be used where small currents are required over a long period of time (battery). It has also application in foundries, carbon brushes, explosive, graphite foils etc.

Some meta-sedimentary rocks in the Sidamo, Hararrghie, Wollega and Tigray, are the potential source rocks for graphite. A series of long belts of graphitic schist extends for tens of kilometers through the Kenticha and Kibre-Mengist areas of the Adola Belt in Sidamo. Graphite content is moderate, but the graphite is generally fine-grained. Well-crystallized and flaky graphite occur in the quartz-feldspar-mica schist in the Moyale61 area near to the Ethio-Kenya border.

The Precambrian metamorphic rocks of southern Ethiopia, which belongs to the Pan-African (Mozambique Belt), host the Moyale graphite deposit. The principal rock types are amphibole schist, quartz-feldspar-mica schist, grano-diorite, and quartzite. The graphite in Moyale area are hosted by quartz-feldspar-mica schists and quartzite, which generally form continuous bodies extending for hundreds of meters. Regional variation in grade and flake size of the graphite is a common feature. Based on the mode of occurrence, rock assemblage, and aerial extent of the graphite bodies it is likely that the graphite is of sedimentary origin.

According to the results of image analysis and carbon analysis by loss of ignition method the average volume/weight percentage of the graphite is about 8%. Preliminary trial to concentrate the graphite by flotation results in a grade of 70% with a recovery of > 90% for a material which passes the 400μm. Stepwise grinding and successive flotation will increase the grade of the concentrate. The Moyale graphite deposit has an estimated reserve of 460,000 tons of graphite [4].

Kyanite

Kyanite is found in most of the metamorphic rocks of southern Ethiopia. The kyanite deposit of Chembi is hosted in the northeast part of the Adola Belt, in a thin belt of kyanite-quartz schist, which extends continuously for more than 30 km. Mineralogical analyses of samples collected from trenches indicates a modal composition range between 21 - 26%, kyanite, 71 - 75%, quartz, and 2 - 5% other minerals (kaolinite, mica, rutiles). Preliminary attempts to concentrate the kyanite by flotation resulted in a grade higher than 94% kyanite and a recovery well above 85%. Kyanite concentrates have an alumina content well above 61 wt% with total alkali and iron less than 0.2 wt% and 0.6 wt%, respectively (Fentaw, 2000a). The chemical composition of the kyanite ore is shown in table.

On the basis of optical studies performed to determine the degree of liberation, nearly all the materials at a grain size < 830 um are free from interlocked grains. Conservative reserve estimation based on detail mapping and reasonable geologic inference suggests that there is more than ten million tons of kyanite in Chembi area [4].

Bentonite

Bentonite is clay consisting of smectite minerals, in particular montmorillonite. Bentonite has exchangeable Na, Ca, or Mg cations, and exhibits far greater ion-exchange worldwide capacity than any other mineral except for zeolite. Na-bentonite has high swelling capacity and ca-bentonite has a relatively low swelling capacity.

Ca-bentonite has wide application as absorbent, animal feed, foundry sand, catalyst (oil refining), waterproofing and sealing, etc. In addition to these applications, Na-bentonite is also widely used for iron ore pelletizing, foundry sand, drilling mud, adhesive, paint, landfill, bonding, plasticizer, etc.

Bentonitic clay resources are found in the Afar region. They are easily accessible, as they are located near the main road. The main occurrences are at Ledi, Gewane and Warseisa. The bentonitic beds are part of a thick sequence of lacustrine sediments, which consists of clays, silts, sands, calcareous grits, gravels, conglomerates, basaltic flows, and ashes. These sediments were deposited near the western margin of the central part of the Afar depression, which through-out the Tertiary and Quaternary was an area of subsidence and intermittent volcanism. The bentonitic clays are probably the result of alteration of glassy igneous materials [5]. The total resource in the Afar region is estimated to 170 million ton and the chemical composition is shown in table. The bentonitic beds are well exposed and the overburden consists of loamy gravel and sandy clay. Tests conducted so far confirm that some beds could be used for the preparation of drilling mud and iron ore pelletization and if upgraded, may have foundry application as well.

The Gidicho Island in Lake Abaya in the rift valley is another source of bentonitic clay. This occurrence is of Pleistocene lacustrine origin and occurs in association with diatomite, silt and diatomaceous earth. The preliminary resource estimate is 5 million ton of material suitable, after upgrading, for the preparation of drilling mud [4].

Diatomite

Diatomite is a soft, pale-colored sedimentary rock composed chiefly of the skeletal remains of diatoms-minute aquatic algae, commonly 20 - 200 μm in diameter. Diatomites are found as thin beds within marine and lacustrine sedimentary sequences and usually in close proximity to active volcanism, which provides the abundant soluble silica necessary to build the diatom skeletons. Its chemical composition is similar to opal or hydrous silica. The nature of particulate structure combined with chemical stability and inertness make diatomite an ideal filter aid (beer, liquor, raw sugar, lubricating oil, swimming pool, water treatment etc.) Diatomites brightness of up to 90%, refractive index of 1.42 - 1.49, low bulk density, inertness and moderate refractoriness, high absorptive capacity, and high surface area allows it to be used as filler (paint, pulp, rubber, pharmaceuticals etc). Diatomite may be used as mild abrasive (toothpaste, polish). Based on its inertness, high surface area, low bulking value, diatomite can absorb 2 to 3 times its own weight of liquid and thus act as carrier (pesticide), absorber (per litter, waste treatment), and catalyst carrier.

More than 12 diatomite occurrences are identified in Ethiopia. Most of them are located in the Main Ethiopian Rift and in the Afar depression. Deposits of relatively better quality are restricted to the central part of rift and include the Gade Mota, Adamitulu, Chefe Jilla and Abiyata deposits. All known deposits are of lacustrine origin and of Tertiary to Pleistocene in age.

The Main Ethiopian Rift due to its wide spread silicic volcanism and lacustrine basins were the most favorable site for the accumulation of fresh water diatomite deposits. Rift volcanism associated with sediment supply and basin formation, ground water chemistry and hydrothermal activity, caldera collapse and formation of lacustrine basin may provide suitable environment for the formation of diatomite. High level of dissolved silica and abundant nutrient in the lake water give rise to conditions, which favor rapid growth and accumulation of diatomaceous oozes, which compact and dewater to form diatomite.

The Gada Motta caldera, for instance, is a semi-circular volcano-tectonic structure of about 15 Km diameter. The rim of the caldera rises up to 400m above the surrounding plain. It is mainly composed of rhyolite and consolidated water-lain tuffaceous silt stones of lower Pleistocene age. The whole sequence is overlain by brecciated pumice and pumiceous ash and glassy ignimbrite.

The high-grade ores of Chefe Jilla, Adami Tulu and Gada Motta have SiO_2, Al_2O_3, Fe_2O_3 and CaO in the range of 84.5 - 86.5%, 3.1 - 3.7%, 1.5 - 2.4%, and 0.1 - 1.9%, respectively. Slightly higher values of alumina, iron and calcium can be ascribed to the association of volcanic ash, clay and calcareous concretions. According to their physico-chemical characteristics the high quality diatomite can be used for filtration and as catalyst carrier in chemical industry. The relatively lower quality diatomites can also be used as pesticide carrier, filler, thermal insulating material and lightweight bricks [6].

The total resource of Gade Motta, Adami Tulu, Chefe Jilla and Abiyata diatomite is more than 40 million tons of which about 85% is contributed by Gade Motta diatomite [4].

Kaolin

Kaolin is white, soft plastic clay mainly composed of fine-grained platy mineral kaolinite. Individual kaolins vary in many physical respects, e.g. degree of crystallinity, which influences brightness, whiteness, opacity, gloss, film strength, and viscosity. Kaolin is a mineral filler that is inert over a wide pH range, nonabrasive, with a fine but controllable particle size, low heat and electrical conductivity, and with good brightness and opacity (hiding power) used in paper, plastics, paint, rubber, adhesives etc. The same properties plus particle shape, rheology, viscosity, and pH allow kaolin to be used as a paper coating pigment, which contributes brightness, gloss, smoothness and ink reception to paper surface. Kaolin, ball clay, and halloysite supply chemical components (SiO_2 and Al_2O_3) to ceramics as well as plasticity, workability, and strength in the pre-fired state; and strength and a light color in the fired body. Kaolinite contains alumina and silica (cement additive; aluminum sulfate;

and zeolites production; fiberglass manufacture; catalyst carrier) and good bonding and absorption properties (cosmetics, pharmaceuticals; insecticide carrier; animal feed).

Kaolin commonly is the weathering product of feldspar-bearing rocks, such as granites, pegmatites, gneisses or sandstones. It is also the result of hydrothermal alteration and weathering products of acidic to intermediate volcanic rocks (in the case of Ethiopia Tertiary or younger age). The main sources of kaolin for the ceramic industry in Ethiopia are the weathering products of granites and pegmatites. Economically exploitable kaolin resources of sedimentary origin have not been reported to date. Acidic volcanics rocks (such as rhyolite or trachyte) in central and northern Ethiopia, and the coal related clay sediments of northwest Ethiopia, near Chilga, are future sites for prospecting.

Exploration in Bombowha (Sabov, 1983) and Kombelcha [1] areas proved about 300,000 tons of kaolin at each of these localities. Moreover, recently it is reported that several hundred thousand tons of good quality kaolin is known to be hosted by the kaolinized granites of Bombowha area (Said, 2000).

Kaolinite is the predominant clay mineral of the Kombelcha and Bombowha areas with quartz-feldspar and illite/muscovite occurring as subordinate minerals. Other than kaolinite, halloysite and gibbsite characterize the Bombowha kaolin deposit. Alumina is generally above 35% in the Bombowha kaolin with impurity elements such as iron (< 1%) and total alkali and titanium accounting for less than 3%. On the other hand, the Kombelcha kaolin bears a relatively lower alumina (33.24%), and higher total alkali and iron, averaging 2.54% and 2.63% respectively. The Kombelcha kaolin shows high shrinkage and low porosity values at lower temperatures mainly due to its higher alkali and iron contents. From firing properties, the vitrification temperature can be inferred to as 1150°C for the Kombelcha kaolin while the Bombowha kaolin tend to remain refractory until 1250°C. Field evidences supported by granulometric and chemical analyses suggest that kaolin is a product of an *in situ* weathering of granite in the Kombelcha area. The Bombowha kaolin tends to be a product of both hydrothermal and *in situ* weathering of pegmatite and granites (Fentaw, 1998). The Tabor Ceramics and Nazareth Aluminum Sulphate Industries are the main consumers of Bombowha kaolin in Ethiopia [4].

Tantalum (Niobium, REE, Lithium, Beryllium) deposit

- Primary ore, tantalite bearing granite-pegmatite with complex Ta-Nb-Li-Be mineralization;
- Lateritic type ore, the mantle of weathering developed over pegmatite and granite;
- Eluvial-deluvial and alluvial placer.

The weathered ore developed over the primary ore of pegmatite represents the huge rare metal resources of the Kenticha deposit. This deposit is marked with high quality Ta-Nb and made it one of the best of the like of deposits elsewhere in the world [2].

The primary ore with a probable reserve of 17,000 tones concentrate containing 0.017% Ta_2O_5.

The weathered zone plus part of primary zone is calculated to be 4700 tones Ta_2O_5 proved reserve, with an average grade of 0.015% Ta_2O_5 [7].

Geology and its relation to occurrence of industrial minerals of Ethiopia

I. The Precambrian basement;
   i. Gold and Base metal, PGE, Rare metals,
   ii. Refractory Raw materials (Graphite, Kyanite and Talc),
   iii. Construction Raw materials (Marble, Dolomite and Granitic Gneiss)
   iv. Ceramic Raw materials (Kaolin-as alteration of weathered pegmatite and granitic gneiss)

II. Late Paleozoic to Mesozoic sedimentary succession;
   i. Coal,
   ii. Cement Raw materials (Limestone, Gypsum and Clay)

III. Cenozoic (Tertiary-Quaternary) Volcanics and Sediments;
   i. Diatomite, Potash, Bentonite, Salt, Sulfur, Silica Sand and Soda ash
   ii. Gemstone, Geothermal Resources

IV. Intrusives and Pegmatites.

<table>
<tr><th>Geological association</th><th colspan="2">Type of mineral</th><th>Region</th><th>Resources (M tons)</th></tr>
<tr><td rowspan="3">Mineralization Related to Precambrian basement</td><td colspan="2">Refractory Raw materials (Kyanite, Graphite, Talc))</td><td>Southern Greenstone belts (Chembi and Moyale)</td><td>12.00</td></tr>
<tr><td colspan="2">Construction Raw materials (Marble, Dolomite)</td><td>Southern, Western and Northern greenstone belts (Metekel Zone, Daleti, Wonchit and Jemma)</td><td>> 210.00</td></tr>
<tr><td colspan="2">Ceramic Raw materials (Kaolin)</td><td>Southern and Centaral Ethiopia (Bombowha and Kombelcha)</td><td>2.00</td></tr>
<tr><td rowspan="3">Mineralization Related to Paleozoic-Mesozoic sediments</td><td colspan="2">Coal</td><td>South western, Northern Ethiopia</td><td>500.00</td></tr>
<tr><td colspan="2">Cement Raw materials (Limestone, Gypsum, Clay)</td><td>Abay River Basin, Western Harrerghe and Tigray Region</td><td>3,600.00</td></tr>
<tr><td colspan="2">Gypsum</td><td>Abay River Basin, and Tigray Region</td><td>>100.00</td></tr>
<tr><td rowspan="11">Mineralization Related to Cenozoic volcanics and Sediments</td><td colspan="2">Diatomites</td><td>Rift valley Region</td><td>46.53</td></tr>
<tr><td colspan="2">Potash</td><td>North-extreme (Dallol) Region</td><td>160.00</td></tr>
<tr><td colspan="2">Bentonite</td><td>Afar Southern Region</td><td>141.00</td></tr>
<tr><td colspan="2">Sulfur</td><td>Afar Southern Region</td><td>Not determined</td></tr>
<tr><td colspan="2">Salt</td><td>Afar and Somali Region</td><td>300.00</td></tr>
<tr><td colspan="2">Glass Raw Materials (Silica - Sand, Feldspar, Qurtz, Calcitic marble)</td><td>Central, Southern and Eastern Ethiopia</td><td>6.00</td></tr>
<tr><td rowspan="2">Gemstone</td><td>Opal</td><td>Central and Northern Ethiopia (Wegel-Tena, Mezezo)</td><td></td></tr>
<tr><td>Garnet, Sappire, Tourmaline</td><td>Southern Ethiopia (Borena andGuji zone)</td><td></td></tr>
<tr><td colspan="2" rowspan="3">Geothermal Resource

Tendaho Geothermal field

Korbeti,Abaya, Tulu-Moye and Dofan</td><td>Aluto Geothermal field</td><td>Under Construction (75 Mega-Wat)</td></tr>
<tr><td>100 (Mega-Wat)</td><td></td></tr>
<tr><td>Reconnaissance to Semi-detailed surveys carried</td><td></td></tr>
<tr><td rowspan="3">Mineralization Related to Intrusives and Pegmatites</td><td colspan="2">Phosphate</td><td>Western (Bikilal) and South eastern (Melka-Arba) Ethiopia</td><td>340.00</td></tr>
<tr><td colspan="2">Iron</td><td>Western (Bikilal), South eastern (Melka-Arba) Ethiopia and Northern Ethiopia</td><td>125.00</td></tr>
<tr><td colspan="2">Tantalum Niobium (Lithium as an associate mineral)</td><td>Southern Ethiopia (Kenticha)</td><td>17,000T with a grade of 0.017%Ta_2O_5</td></tr>
</table>

Table 1: Geology and its relation to occurrence of industrial minerals of Ethiopia.

High priority industrial minerals in Ethiopia and processing techniques required

The prioritized Industrial minerals are; Graphite, Kyanite, Bentonite, Diatomite and Kaolin. The following activities are recommended to be carried out, namely:

- Activity 1: Evaluation and Beneficiation
- Activity 2: Chemical processing
- Activity 3: Hydrometallurgy
- Activity 4: Thermal route
- Activity 5: Environmental aspect.

Supporting for general review of industrial minerals and their potential, including for value addition.

Activity 1: Evaluation and Beneficiation: The science and technology of minerals evaluation; beneficiation (upgrading) will include:

- Evaluate ores and minerals with different recent techniques of characterization.
- Beneficiate and upgrade ores and minerals with both conventional and recent technologies of physical separation.
- The fundamental principles as well as the recent advancements of mineral processing technology starting from evaluation and characterization of ores, to beneficiation using conventional technologies,
- In mineral evaluation, characterization of minerals with different techniques such as X-ray diffraction (XRD), X-ray fluorescence (XRF), thermal analysis, size analysis, applied mineralogy, scanning electron microscopy (SEM), and transmission electron microscopy (TEM).
- In mineral beneficiation and upgrading, all aspects of science and technology of mineral processing with conventional physical treatment in addition to the most up-to-date available technologies in the world to treat and upgrade minerals will be covered.
- Minerals liberation through crushing and grinding (in open and closed circuits) with different mills in dry or wet environment, followed by classification techniques using screening, spiral classifiers, and/or hydrocyclones will also be done
- Different aspects of minerals beneficiation by different gravity separation techniques (e.g. Jig, Shaking Table, Falcon Concentrator), magnetic separation (e.g. low vs. high; dry vs. wet), flotation science and technology, and dewatering and drying as well as agglomeration techniques will be emphasized. Determination of energy consumption during the grinding processes will also be considered.

Activity 2: Chemical processing: It will also be emphasized the different available routes for chemical processing of the minerals to produce value-added products. This can include: chemical processes; thermal and electro-chemical processes as well.

Activity 3: Hydrometallurgy will cover a wide scope of processes such as extraction and leaching of minerals (e.g. pressure leaching, atmospheric leaching and bioleaching), dewatering through flocculation and filtration, purification processes by precipitation, solvent extraction, ion exchange and crystallization, and drying methods.

Activity 4: The thermal route includes processes such as calcination, roasting, reduction, chlorination and sulphatization. Electro-winning and refining techniques will also be considered.

Activity 5: Environmental aspect:

- Comply the beneficiation and chemical processing impacts with the environmental regulations.
- Be familiar with the economic impact of upgrading and chemical processing of minerals to produce value-added products.
- In addition, the environmental aspects of mineral processing in terms of water treatment and recycle of valuable products from wastes. This could include conventional methods of waste treatment, and bioprocesses.
- Mass-balance calculation as well as flow sheets design for both beneficiation and chemical processes will also be included.

To develop the vision for minerals development institute for industrial minerals technology

Ethiopia is endowed by huge reserves of different minerals and rocks. Considerable resources of industrial minerals are present such as limestone, dolomite, magnesite, graphite, Kyanite, diatomite, silica sand, feldspars, kaolin, clays, bentonites, tantalite, trona (soda ash), and energy ores such as coal and oil shale. Although such mineral wealth is present their contribution to the Gross Domestic Product (GDP) of these countries is, generally low. This is because most of these ores and minerals are in a raw form, not processed or value added. In most of the cases without treatment or upgrading, and costs very low prices. The contribution of such mineral resources to the national income can, indeed, be improved if such minerals and ores are upgraded and processed to produce value-added products rather than selling run-of-mine ores.

Objectives of the minerals

Development institute for industrial minerals technology (MDIIMT)

The main objective of the proposed MDIIMT:

- Evaluate ores and minerals with different recent techniques of characterization.

- Beneficiate and upgrade ores and minerals with both conventional and recent technologies of physical separation.
- Apply the different routes of chemical processing to produce value-added products from minerals.
- Calculate mass-balance and energy-balance as well as developing flow sheets for treating minerals.
- Comply the beneficiation and chemical processing impacts with the environmental regulations.
- Be familiar with the economic impact of upgrading and chemical processing of minerals to produce value-added products.

The Institute is aimed the fundamental principles as well as the recent advancements of mineral processing technology starting from evaluation and characterization of ores, to beneficiation using conventional technologies in addition to the most up-to-date available technologies in the world to treat and upgrade minerals and as well as different routes of chemical processing (e.g. chemical, electro, thermal) to produce value-added products from the minerals.

In mineral evaluation aspect, it will cover characterization of minerals with different techniques such as X-ray diffraction (XRD), X-ray fluorescence (XRF), thermal analysis, size analysis, applied mineralogy, scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

In mineral beneficiation and upgrading, all aspects of science and technology of mineral processing with conventional physical treatment in addition to the most up-to-date available technologies in the world to treat and upgrade minerals. It will also carry out minerals liberation through crushing and grinding (in open and closed circuits) with different mills in dry or wet environment, followed by classification techniques using screening, spiral classifiers, and/or hydrocyclones. Different aspects of minerals beneficiation by different gravity separation techniques (e.g. Jig, Shaking Table, Falcon Concentrator), magnetic separation (e.g. low vs. high; dry vs. wet), flotation science and technology, and dewatering and drying as well as agglomeration techniques will be emphasized.

The Institute will also emphasize the different available routes for chemical processing of the minerals to produce value-added products. This can include: chemical processes; thermal and electro-chemical processes as well. It will also conduct wide scope of processes such as extraction and leaching of minerals (e.g. pressure leaching, atmospheric leaching and bioleaching), dewatering through flocculation and filtration, purification processes by precipitation, solvent extraction, ion exchange and crystallization, and drying methods. The thermal route includes processes such as calcination, roasting, reduction, chlorination and sulphatization. Electro-winning and refining techniques will also be considered.

In addition, the Institute will carry on the environmental aspects of mineral processing in terms of water treatment and recycle of valuable products from wastes. This could include conventional methods of waste treatment, and bioprocesses. Mass-balance calculation as well as flowsheets design for both beneficiation and chemical processes.

Therefore, it is vital to develop the vision of Institute for Minerals Development for industrial minerals technology (mineral beneficiation and agglomeration, chemical and electro metallurgy, pyro metallurgical processes etc.), core mining technology and innovation [8].

Conclusion and Recommendations

I. It is hereby recommended to develop the vision of Institute for Minerals Development for industrial minerals technology (mineral beneficiation and agglomeration, chemical and electro metallurgy, pyro metallurgical processes etc.), core mining technology and innovation.
   a) In mineral evaluation, characterization of Industrial minerals with different techniques such as X-ray diffraction (XRD), X-ray fluorescence (XRF), thermal analysis, size analysis, applied mineralogy, scanning electron microscopy (SEM), and transmission electron microscopy (TEM).
   b) In mineral beneficiation and upgrading, all aspects of science and technology of mineral processing with conventional physical treatment in addition to the most up-to-date available technologies in the world to treat and upgrade minerals will be covered.

II. Ethiopia is endowed with a variety of industrial minerals and rocks some of which are available in large quantities and are of very good quality. Minerals such as kyanite, apatite, ilmenite, diatomite, graphite, and potash occur sufficiently to warrant medium-to-large-scale mining. With the development of new industries the demand for industrial minerals is increasing. In the view of the existing/known resources, the glass, cement, ceramics, refractory, and fertilizer industries appear to be the most promising sectors for development, also in the interest of the country's future development.

III. As Lithium and its compounds have several industrial applications, including heat-resistant glass and ceramics, lithium grease lubricants, flux additives for iron, steel and aluminium production, lithium batteries, and batteries, thus it is recommended to focus on Kenticha Tantalite deposit where lithium is associated.

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