

Industrial Mineral Resources of Zambia

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Abstract

Zambia has for many years been heavily dependent upon the mining of copper which, combined with cobalt production, represents over 98% of mineral sales and 75% of export earnings (1997 figures). The industrial minerals industry within Zambia has therefore been inevitably tied to the fortunes of these two metals. The recent privatization, and break up, of ZCCM (Zambia Consolidated Copper Mines) has led to a resurgence in investment in the mining sector. Many analysts have predicted that there will be a positive effect on the Zambian economy, stimulating construction and infrastructure development and increasing the demand for industrial minerals. This paper summarises the available information on the industrial mineral resources of Zambia. Ten industrial minerals are described, with reference to some of the work carried out over recent years by the British Geological Survey, in conjunction with the Geological Survey Department of Zambia.

Introduction

Zambia is a landlocked country in central southern Africa which is bordered by Angola, the Democratic Republic of Congo (DR Congo), Tanzania, Malawi, Mozambique, Zimbabwe, Botswana and Namibia (Figure 1). It is a large country (752,614 km²) with a population of about 11 million people, mostly found within the urban centres of Lusaka, the Copperbelt, Kabwe, Kapiri Mposhi and Livingstone. Zambia is divided into nine provinces (Central, Copperbelt, Eastern, Luapula, Lusaka, North-Western, Northern, Southern and Western). It is dissected by four major river systems (Zambezi, Kafue, Luangwa and the Luapula). The road network is limited but well maintained between the main centres and there is a well-established infrastructure of domestic and international telecommunications.

Zambia is internationally recognised as a major producer of copper and cobalt (ranked as the seventh and second highest world producer respectively). It also produces precious metals (gold, silver), gemstones (amethyst, aquamarine, emerald and tourmaline), coal and industrial minerals. The production of industrial minerals is, however, small (Table 1).

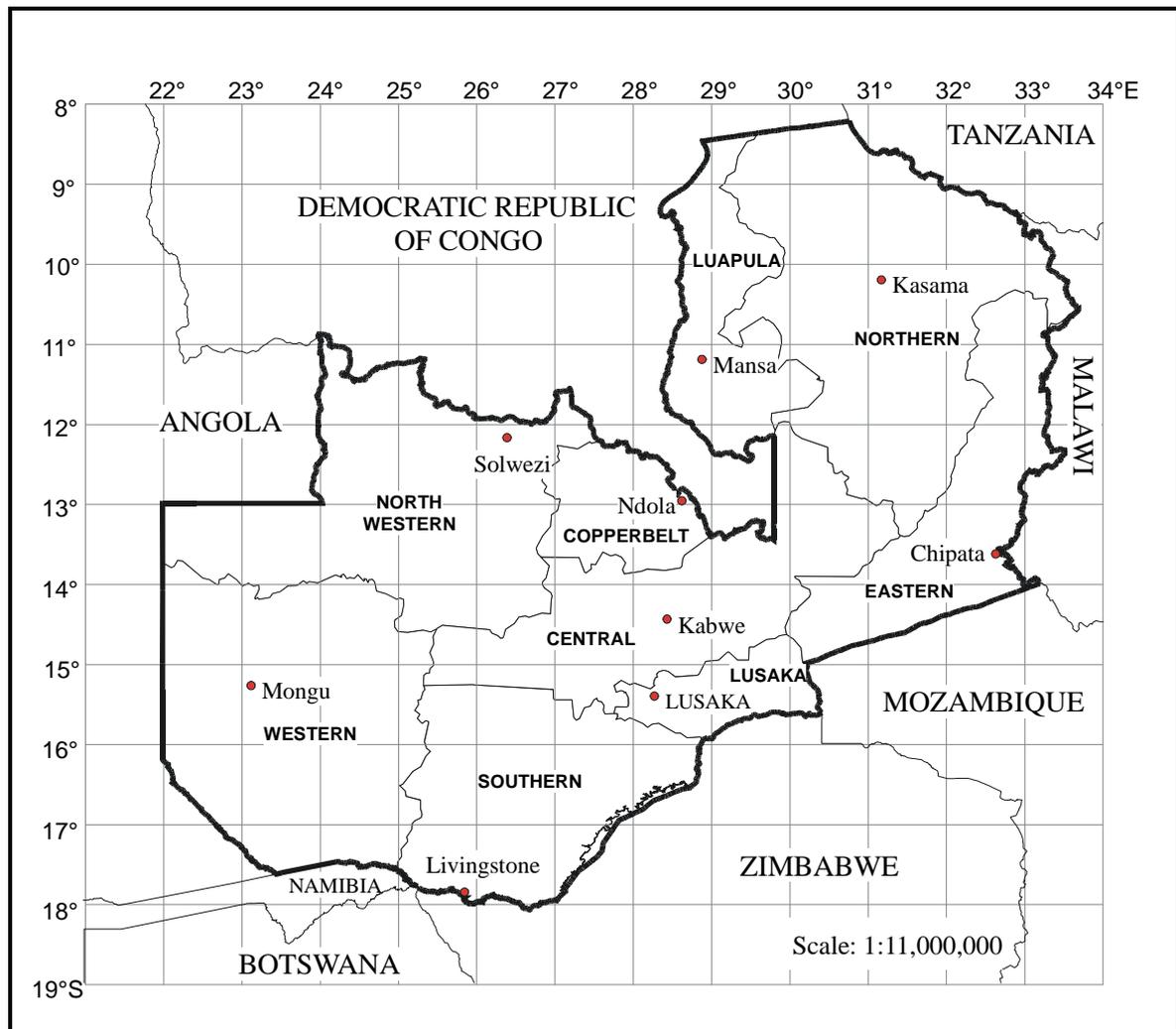


Figure 1. Map of Zambia, with provinces & provincial headquarters

The recent privatisation of the Zambian copper industry, as well as other parastatal businesses, is proving to be an incentive for renewed investment in the mining industry and is generally improving the prospects for the economy. The investment opportunities in the Zambian mining industry are highlighted in the recent promotional and technical documents produced by the Ministry of Mines and Mineral Development (1999). A detailed technical document entitled 'Zambia's Mineral and Energy Resources: Legislation, Resources and Exploration Potential' is also available from the Permanent Secretary, Ministry of Mines and Minerals Development (hard copy and CD-ROM). Also a Geographical Information System (GIS), which enables the occurrences of all Zambian minerals to be readily demonstrated, is in place at the Zambian Geological Survey Department (GSD) in Lusaka. This GIS can accommodate mineral-related queries tailored to individual needs.

This paper describes the geology of Zambia, followed by brief descriptions of ten industrial minerals. It is not an exhaustive inventory of occurrences, as this information can be found in the documents mentioned above or by contacting those people listed at the end of the paper. However, it is intended that this paper should highlight the industrial minerals resources of Zambia and their potential.

Table 1. Production of industrial minerals in Zambia

Industrial mineral / product	Production figure (tonnes)
Aggregate (crushed limestone)	700,000 †
Agricultural lime (2000 estimate)	~20,000 ‡ (~100,000 – 150,000)
Building stone (inc. dimension stone)	700,000 †
Cement	206,266 *
Clay for brick-making	3000 †
Clay for building	30,000 †
Feldspar (last production data 1993)	- (100)
Gypsum	11,000 †
Hydrated lime	16,103 *
Kaolin	200 †
Limestone	412,238 *
Magnetite	1000 †
Pyrite (for H ₂ SO ₄ production)	70,000 †
Quick lime	145,102 *
Sand & gravel	200,000 †
Talc	80 †

NB * 1996 figures (Dolley & Coakley, 1996) , † 1998 figures (Ministry of Mines & Minerals Development, 1999), ‡ 1999 estimate

The Geology of Zambia

The geology of Zambia has largely been shaped by the surrounding cratonic blocks of Kasai (DR Congo), Tanzania, Zimbabwe and Kaapvaal (South Africa). A simplified geological succession of Zambia (after Money, 1986 and Bosse, 1996) is given in Appendix A. The oldest rock sequences in Zambia, the **Basement Supergroup** (the oldest being 3000Ma, but typically most are younger than 2050Ma), occur throughout eastern, central and southern Zambia. These consist mostly of granitic gneisses and migmatites, with marbles, quartzites and meta-pelites. The overlying **Muva Supergroup** (1800 – 1250 Ma) consists of a meta-sedimentary sequence that lies unconformably over the Basement. In central and eastern Zambia the Muva consists of meta-pelites and meta-quartzites, whereas in northern Zambia it consists of 'continental' sediments such as sandstones, quartzites, mudstones and conglomerates.

The **Katanga Supergroup** (1000 – 500Ma) unconformably overlies both the Basement and Muva sequences and occurs throughout the Copperbelt, north-western, northern and central Zambia. The Katanga consists mainly of sedimentary sequences, such as the Mine Series Group that hosts most of the copper-cobalt mineralisation of the Copperbelt within mudstones, sandstones, conglomerates and carbonates.

The rocks of the **Karoo Supergroup** (late Carboniferous to Jurassic) occupy the rift troughs of the Zambezi, Luangwa, Luano-Lukusashi and Kafue valleys, and also outcrop in western Zambia. These consist of conglomerates, sandstones, carbonaceous siltstones and mudstones. The Batoka basalts occur in western Zambia and the Zambezi valley (forming Victoria Falls). Aeolian sands of the Kalahari Group (Tertiary) cover much of western Zambia.

INDUSTRIAL MINERALS OF ZAMBIA

Feldspar

Feldspar occurs in pegmatites hosted within the granitic gneisses and schists of the basement. Pegmatite groups occur extensively within the basement of Central Province (e.g. Serenje, Mkushi and Mita Hills areas) oriented roughly parallel to the regional north easterly strike. Several have been worked recently for use in glass and ceramics production. Feldspar-bearing pegmatites have also been recorded in Northern (Shiwa N-gandu), Eastern (Lundazi) and Southern (Mazabuka and Siavonga) provinces (Table 2).

The **Shipungu pegmatite** occurs in Central Province (7km south of Kapiri Mposhi) and has been developed to supply feldspar for glass production at Kapiri Glass Products (which recently closed its works, possibly indefinitely). The pegmatite contains partially kaolinized alkali-feldspar, with intergrown quartz and abundant mica, of apparently mediocre quality.

The **Siavonga-Kariba (Namukombo) pegmatite** occurs in Southern Province (10km north of Siavonga) and was worked by hand on a demand basis to supply ceramic producers based in Lusaka (for example Moore Pottery). The pegmatite consists of pale pink alkali feldspar (Table 2) with minor muscovite mica and quartz.

The **Chilulwe pegmatite** occurs in Central Province (40km south-east of Serenje) and has been worked on a similar basis to the Siavonga-Kariba pegmatite. The pegmatite consists mainly of white K-feldspar (Table 2) with a minor amount of kaolinite and muscovite mica. The feldspar was evaluated as part of a kaolin investigation and was found to have a whiteness (ISO brightness) of 86% and chemical composition suitable for use as a ceramic raw material (Mitchell, 1994).

Table 2. Chemical composition of Zambian feldspar

Locality	SiO ₂ Wt %	Al ₂ O ₃ Wt %	K ₂ O Wt%	Na ₂ O Wt %	Fe ₂ O ₃ Wt %
Siavonga – Kariba ¹	na	18.7	11.6	2.6	0.1
Chilulwe feldspar ²	64.32	19.14	15.27	0.71	0.04
Mita Hills feldspar ³	69.95	15.2	11.8		0.21
Shiwa Ng'andu ³	64.5	na	12.5 – 13.1	3.2	na

1. Briggs & Mitchell, 1991; 2. Mitchell, 1994; 3 Muibeya, 2000; na = not available.

Silica sand

Silica sand of varying quality occurs throughout Zambia but no resource information exists except for that on the silica sand deposits near Kapiri Mposhi (which was the source of raw material for glass manufacture by Kapiri Glass products Ltd) and Rufunsa

The **Kapiri Mposhi silica sand deposit** occurs 10km to the north of Kapiri Mposhi, Central Province. This high-grade silica sand deposit was formed by *in situ* weathering of the Muva-age quartzites and subsequent leaching to remove iron and clay minerals. The unprocessed silica sand (Table 3) contains 99% quartz with the remainder consisting of zircon, garnet and iron oxides. After processing (screening and froth flotation, as carried out in the glass works) the amount of impurities present may be reduced and most of the sand particles are then between 1 mm and 63 μ m in diameter (Briggs & Mitchell, 1991).

The **Rufunsa silica sand deposit** occurs 30km to the west of Rufunsa on the Great East Road. The silica sand (Table 3) has formed by weathering of the Rufunsa Quartzites and deposition in a dambo. There has been no significant extraction of silica sand from this deposit.

Table 3. Chemical composition of silica sand in Zambia (from Mambwe, 1992)

Locality	SiO ₂ Wt %	Al ₂ O ₃ Wt %	K ₂ O Wt %	Na ₂ O Wt %	Fe ₂ O ₃ Wt %	Remainder Wt %
Kapiri Mposhi						
unprocessed	96.1	3.45	na	na	0.17	na
processed	98.8	0.78	na	na	0.035	na
Rufunsa	97.63	1.28	0.21	0.09	0.10	0.29

na = not available

Talc

Talc occurrences have been recorded in the Lusaka, Central, Copperbelt, North-Western and Eastern Provinces of Zambia. The talc deposits can be classified into two broad genetic groups. The first (which covers the majority of occurrences) were formed by the regional metamorphism of siliceous dolomites of Katangan age and the second were formed by the hydrothermal alteration of basic intrusions associated with dolomites.

The **Lilayi talc deposit** occurs 5km to the south of Lusaka and consists of lenses of massive talc (steatite) up to 6m in thickness within a dolomite host. The steatitic talc consists of white, relatively pure material (containing 90% talc with traces of dolomite and chlorite) and has been extracted on a small-scale by Crushed Stone Sales Limited (a subsidiary of Indeco) for many years. Another talc deposit was discovered 25km to the southeast of Lusaka at **Chipapa**, which after subsequent evaluation was found to consist of equal proportions of pyrophyllite and talc (Muibeya, 2000).

During the period 1920 to 1950 and the regional geological exploration that accompanied the establishment of the Copperbelt, talc was often found in the copper-ore bearing horizons of the Upper Roan Formation. Talc deposits were found to occur at many of the well-known copper mining localities including Bwana Mkubwa, Nkana, Nchanga and Mufulira. Despite extensive technical evaluations the only recorded extraction of talc occurs at **Mishishi** ('Mushishi'), a western suburb of Ndola where it was worked on a small-scale by Talc Zambia Limited. The grades produced by selective mining were as follows; yellow, off-white and white (Table 4).

Table 4. Properties of the Mishishi talc, Zambia (from Briggs & Mitchell, 1991)

Property	Yellow	Off-white	White
<u>Raw material</u>			
- talc content	91	97	93
- brightness	43	75	76
- particle-size			
- +1 mm	3.4	16.4	12.0
-1mm +125 µm	30.5	23.5	27.0
-125 µm	66.1	60.1	61.0
<u>After flotation</u>			
- talc content	95	99	97
- brightness	54	78	76

NB Talc content and particle size are weight percentages; brightness is a percentage relative to a calibration standard (DIN 5033 BaSO₄).

Talc occurrences are also known to occur in the provinces of Central (Mkushi), North-Western (Chisasa & Ntambu) and Eastern (Kalinku) Zambia. An interesting possibility that may warrant further investigation is the talc-rich by-products associated with the extraction of gemstones in the Kafubu Emerald belt. Talc-magnesite and talc schists are extracted, washed and screened as part of the emerald production operation.

Barite

Occurrences of barite have been recorded throughout Zambia but none have been worked to date. The most well known deposit occurs close to **Chibote Mission**, 75 km north of Luwingu and consists of lenticular beds of coarse tabular barite crystals (grade 90% BaSO₄) associated with the red shales, sandstones and chert of the Plateau Series. The **Chasefu deposit** occurs 55km to the north of Lundazi, eastern Zambia and consists of a white, coarsely crystalline high-purity barite (Table 4). The **Ndabala** deposit, Mkushi district, central Zambia, consists of heavily stained barite with iron and manganese oxides (Table 5).

Barite has also been reported to occur in the Zambian provinces of Eastern (Chasefu), Central (Chiweuwe, near Mkushi), Luapula (Chipili, near Mansa), Northern (Lutoka Hill, near Senga Mission) and Southern (Kafue; Chirundu).

Table 5. Properties of barite from Zambia (from Briggs & Mitchell, 1991)

Sample	BaSO ₄ Wt%	Fe ₂ O ₃ Wt%	SrO Wt%	Brightness %
Chasefu	95	0.1	0.6	76
Ndabala	90	0.2	1.0	nd

nd = not determined

Phosphate

The phosphate resources of Zambia have over the years attracted a great deal of attention as a possible source of fertiliser raw materials. Research has focused upon five igneous deposits, where the main phosphate mineral (apatite) occurs in carbonatite or syenite, or in associated pegmatites.

The **Nkombwa Hill carbonatite** occurs 25km to the east of Isoka in Northern province and has been extensively researched since the 1950's; it even has its own unique phosphate mineral, isokite (CaMgPO₄F). The carbonatite forms part of a late proterozoic alkaline province intruded through the basement. It has a complex assemblage of dolomitic and ankeritic carbonate 'zones' that contain four phosphate-bearing minerals, namely apatite, isokite, monazite and daqingshanite (carbonate-phosphate with Sr, Ba, Ca & rare earth elements). The carbonatite has an average surface grade of 4 – 5% P₂O₅. However, beneficiation to produce a phosphate-rich concentrate would be difficult due to the complex mineralogy. The potential of Nkombwa Hill may only be realised if a variety of products are generated such as construction raw materials and agricultural lime, as well as phosphate, niobium and rare-earth elements.

Other phosphate deposits are known to occur in the Zambian provinces of Northern (the Chasweta, Mwambuto, Nachomba and Kaluwe Hill carbonatites in the Luangwa-Rufunsa area), Eastern (Chilembwe, near Petauke), Lusaka (Sugar Loaf, near Mumbwa) and Southern (Keshya ravine carbonatite, Kafue). Currently research is underway by Professor Stephen Simukanga at the School of Mines, University of Zambia in Lusaka to produce Partially Acidulated Phosphate Rock (PAPR) for use as a direct application fertiliser.

Limestone & dolomite

Carbonate rocks are known to occur throughout Zambia, especially along the line of rail from Livingstone to North-Western Province, as well as in Luapula, Northern and Eastern provinces. Most of the carbonates occur in the clastic sequences of the Katanga Supergroup, with a smaller proportion in the older underlying Basement Complex and younger Karoo sequences. The CaO and MgO contents of several carbonates are given in Table 6.

Table 6. Chemistry of some Zambian carbonates (Mitchell *et al*, 1997)

Stratigraphy	CaO Wt %	MgO Wt %
Basement Complex		
Sasare Group	38.1*	12.6*
Lower Katanga Supergroup		
Mujimbeji Marble, Monze Group, - calcitic marble	48.1	4.0
Mampompo Limestone, Broken Hill Group (Lusaka)	53.0	1.5
Upper Roan Formation, Mine Series Group	28.62 – 55.86*	0.4 – 27.72*
Upper Katanga Supergroup		
Kakontwe Limestone, Kundelungu Group	52.2	1.6
Muchinda Limestone, Kundelungu Group	30.1*	16.0*
Luapula Beds, Kundelungu Group!	28.6	17.8
“Mkushi Dolomite”, Kundelungu Group	28.2	20.6
Undifferentiated Katanga Supergroup		
Mapanza Carbonate Formation	49.3	0.5
Mvuvye Marble, Mvuvye Group - calcitic marble	41.8	2.0
- dolomitic marble	28.1	27.5
Nkombwa Hill (Dolomitic Carbonatite)	24.0	19.0

NB Values are averages unless marked with *

Chilanga Cement Ltd exploits the calcitic marble of the **Mampompo Limestone** for the production of cement. The Mampompo Limestone is also exploited by Crushed Stone Sales Ltd, United Quarries Ltd and Mindeco Small Mines Ltd for the production of ground limestone. The calcitic marble of the **Lower Kundelungu Formation** is exploited by Ndola Lime Ltd for the production of burnt lime and by Chilanga Cement (Ndola) Ltd for the production of cement. Typical chemical analyses are given in Table 7.

Table 7. Chemistry of Zambian carbonates used commercially (Mitchell *et al*, 1997)

Company	CaO Wt %	MgO Wt %	SiO ₂ Wt %	Fe ₂ O ₃ Wt %
Chilanga Cement	48.6	1.0	7.6	1.4
Ndola Lime ¹	53.3	0.5	1.2	0.3
Crushed Stone Sales Ltd				
- calcitic	47.4	2.8	6.4	0.5
- dolomitic	44.0	11.0	0.9	0.4
United Quarries Ltd	52.0	2.4	2.2	0.1
Lilyvale Farm, Kabwe	na	25.8	na	na
Mindeco Small Mines Ltd	50.4	1.8	na	0.1

1 = The carbonate used by Ndola Lime is also used by Chilanga Cement to produce cement for the Copperbelt.

Carbonates potentially suitable for use as agricultural lime have recently been evaluated by the BGS in a collaborative project with the Zambian GSD (Mitchell *et al* 1997). The most important criteria for the assessment of carbonates for use as agricultural lime are the neutralising value, plant nutrient content (CaO and MgO), reactivity and grindability. Those samples with a neutralising value higher than 80% CCE and a magnesium oxide content higher than 6% were considered to have potential for use as aglime (Table 8).

Table 8. Some Zambian carbonates with potential for agricultural lime (from Mitchell *et al* ,1997)

Sample	Neutralisation Value % CCE ¹	Plant nutrient content		Reactivity % ²	Grindability % < 75 µm ³
		MgO	CaO		
		Wt %	Wt %		
Chivuna Limestone, Chivuna	106	21.83	30.24	65.9	64.0
Mujimbeji Marble, Solwezi	107	21.86	30.96	70.4	41.1
Upper Roan Fm, Mpongwe	105	18.59	43.4	89.3	97.1
Muchinda Limestone, Lilyvale Farm, Kabwe	106	21.55	31.22	84.2	97.2
Lower Roan Fm, Mkushi	104	21.25	30.04	68.4	98.6

NB 1 = Neutralisation values (NV) are expressed as the percentage Calcium Carbonate Equivalent (CCE). 2 = Percentage reactivity is a measure of the 'agronomic effectiveness' of the agricultural lime. 3 = Grindability (ease of pulverisation) is expressed as the weight percentage of material finer than 75 microns after standard milling conditions.

The gradual decline in agricultural lime production and use over the last twenty to thirty years has recently shown some evidence of reversal. New agricultural lime production operations have opened up over the past 18 months. The most significant of these are HiQwalime (with plants in operation, or planned, in Mkushi, Kabwe and Mazabuka) and Uniturtle (Lusaka). Agricultural lime production was up until 1999 lower than 20,000 tonnes pa whereas recent estimates have placed the 2000 production between 100,000 and 150,000 tonnes pa (Table 1).

Kaolin

Kaolin occurrences in Zambia are associated with pegmatites (see earlier section on feldspar) and have formed by the weathering or hydrothermal alteration of feldspar.

The **Chilulwe kaolin** occurs in Central Province (40km to the south east of Serenje) and has been worked on a low volume demand-basis to supply the ceramic plants in Lusaka and Kitwe. The kaolin occurs in a hydrothermally-altered pegmatite hosted within a sequence of granulites, schists and quartzites that form the basement. Exploration by the former Mining Exploration department (Minex) established that the pegmatite is at least 1km long (striking north easterly), 15m deep and 10-15m wide. A laboratory

evaluation (Mitchell, 1994) determined that the kaolin-rich part of the pegmatite consists of 80% microcline feldspar, 17% kaolinite and a small amount of muscovite mica, beryl and tourmaline. Wet processing trials, involving a two-stage hydrocyclone separation, produced a kaolin product with a high kaolinite content, a fine particle size and a moderately high brightness (Table 9).

Other kaolin deposits are known to occur in Central Province at Chibolele (east of Chilulwe), Lukusashi, Kasanka, Chalata, Chibote and Kapiri Mposhi. Outside of Central Province there are recorded occurrences of kaolin in the Zambian provinces of Copperbelt (Twapia, near Ndola) and Southern (Masuku, 45km to the south east of Choma) (Mitchell *et al*, 1992). Interestingly, local women eat a small amount of the Twapia kaolin to help relieve the chronic indigestion they experience during the later stages of pregnancy! Laboratory evaluation and processing trials have been carried out on some of these kaolin deposits (Table 8).

Table 9. Properties of selected Zambian kaolins (from Briggs & Mitchell, 1991; Mitchell, 1994)

Kaolin deposit	Kaolinite content Wt % ¹	Particle-size Wt % <2 μ m ²	Brightness % ³	Fe₂O₃ Wt % ⁴
Chilulwe				
- Raw material	17	6	nd	nd
- Kaolin product	87	58	76	0.23
Choma				
- Raw material	33	5	nd	nd
- Kaolin product	88	49	82	0.18
Twapia				
- Raw material	36	7	nd	nd
- Kaolin product	76	57	64	2.23
Kapiri Mposhi				
- Raw material	32	11	nd	nd
- Kaolin product	88	85	71	1.74

1. Kaolinite content was determined by thermogravimetric analysis (TGA). 2. Particle-size was determined by X-ray Sedigraph analysis. 3. Brightness was determined by reflectance spectrophotometric analysis (ISO2469). 4. Fe₂O₃ content was determined by X-ray fluorescence spectrophotometric analysis (XRF). Nd = not determined

Graphite

In Zambia, graphite has been exploited, albeit on a small-scale, by local communities for generations. It has been used mainly to add a black sheen to water pots, especially in the Luangwa valley and Mvuvye, Eastern Province. In Zambia most of the known occurrences are flake-graphite, hosted within schists and gneisses, although a few occurrences of amorphous graphite have also been reported. Graphite occurrences are recorded in the Zambian

provinces of North Western (Mwinilunga & Solwezi), Central (Mkushi) and Eastern (Petauke & Lundazi).

The **Njoka graphite deposit** occurs in Eastern Province (53km west of Lundazi). The graphite occurs as flakes up to 4mm long (typically 0.4-2mm) in a quartz-albite schist, with an average grade of 12% flake graphite. Laboratory processing trials, involving single stage froth flotation, produced concentrates with up to 78% graphite at a recovery of 70%. The **Petauke graphite deposit** also occurs in Eastern Province (Mkonda, North of Petauke) and consists of gneiss with a grade of 15% flake graphite. Similar processing trials, as for the Njoka graphite, produced high grade concentrates (up to 87% flake graphite) but with relatively poor recovery (39%). This was found to be due to the intimate association of mica with graphite; the two platy minerals are intercalated and are hence difficult to liberate (Mitchell, 1992).

Gypsum

There are only three notable occurrences of gypsum in Zambia. **Lochinvar gypsum** occurs as gypsum nodules embedded in a clay-rich dambo within the Kafue Flats of Lochinvar National Park (Southern Province). This was worked in the past to provide gypsum for cement production (since replaced with cheaper by-product gypsum from copper processing). Mindeco Small Mines formerly worked the dambo on a small-scale for the manufacture of school chalk and plaster moulds for ceramic production. A spot sample of dambo clay was found to contain 46% gypsum, over 90% of which is coarser than 2mm in diameter (Briggs & Mitchell, 1992). The gypsum was concentrated using a simple washing and screening process.

The remaining occurrences of gypsum occur as relatively thin beds and veins within Karoo age sedimentary rocks that occur in the Chifungwe plain of Northern Province.

Fluorite

Fluorite occurs mainly in the Southern Province of Zambia, typically as hydrothermal vein and replacement deposits associated with Karoo age sedimentary sequences. The **Sianyolo fluorite (Gwembe district) deposit** consists of steeply dipping veins hosted within quartzites and schists. Resource calculations (only including veins over 1m thick) indicate 1.7 million tonnes at 85% CaF₂. Three major fluorite occurrences occur in the Siavonga district and resources have been conservatively estimated to be 500,000 tonnes at 50% CaF₂.

Other industrial minerals

The industrial minerals inventory of Zambia includes many others beyond those outlined in this paper. Some of the more significant occurrences are listed in Table 9.

Table 9. Significant occurrences of other industrial minerals in Zambia

Industrial Mineral	Locality	Comments
Asbestos	Chinkombe & Mwatezi area, Eastern Prov.	Pods, veins and lenses within amphibolite.
Clay: Ball clay	Chamba Valley, Lusaka Prov.; Solwezi, NW Prov.; Loshi, Luapula Prov.	River and dambo clay deposits of variable plasticity & fired colour.
Clay: Bentonite	Luano Valley, Central Prov.	Low quality bentonitic clays associated with mudstone, Lower Karoo.
Clay: Brick clay	Dambo clay throughout Zambia	Large volume resource, however little information on firing properties.
Clay: Fireclay	Maamba colliery, Southern Prov.	Fireclay hosted in mudstone associated with Karoo age coal measures.
Corundum	Rufunsa, Lusaka Prov.	Corundum occurs within pegmatites & mica schists.
Dimension stone: Black granite	Chipata, Eastern Prov.; Lusaka, Lusaka Prov.	Occurrences of gabbro and meta-gabbro.
Dimension stone: Marble	Carbonate deposits across Zambia.	Occurrences of limestone & dolomite.
Dimension stone: Syenite	W of Solwezi & Mumbwa, Central Prov.	Solwezi occurrence consists of sodalite-bearing syenite.
Kyanite	Kafue, Leopards Hill, Mwembeshi River & Chalenga River, Lusaka Prov.	Kyanite schists with large resources of high purity kyanite (up to 61% Al ₂ O ₃).
Magnesite	Leopards Hill, Lusaka Prov.	High purity magnesite, although low volume.
Mica	SE of Serenje, Central Prov.; Lundazi, Eastern Prov.; SE of Choma, Southern Prov.	Coarse muscovite mica in pegmatites associated with granitic gneisses.
Salt	Northern, Luapula, N. W., Western & Southern Provinces.	Salt pans assoc. with spring water.
Vermiculite	Kankomo dambo, Kalulushi, Copperbelt Prov.	Weathered shale and clay deposits.
Zeolite	Dombwe Hill, Kafue & Singwe Gorge, Livingstone, Southern Prov.; Mongu, Western Prov.	Stilbite & heulandite occur as vesicular infilling in Karoo basalts.

Exploration potential

The industrial minerals potential of Zambia has largely been untouched. Most development has been related to the copper industry (e.g. limestone and pyrite used to produce lime and sulphuric acid, respectively, for copper processing) and basic infrastructure requirements (e.g. aggregates & building materials). However, it would be fair to assume that, with the likely economic growth linked to the privatisation of the copper industry, future demand for a variety of industrial minerals will increase. This in turn will stimulate exploration to identify appropriate industrial minerals resources. The following statement on exploration for industrial minerals has been reproduced from the Ministry of Mines & Minerals Development investment brochure.

“Zambia is favoured with considerable resources of feldspar (Pan-African pegmatite bodies), silica sand (Muva-age quartzites), limestone (mostly lower Katanga), and a variety of rock types potentially suitable for dimension stone. Numerous occurrences of ball clay and brick clay are evident throughout the country but the quality of the clays has rarely been thoroughly investigated. Good quality talc has yet to be discovered but the focus of interest would be on hydrothermally altered ultramafic rocks and on metamorphosed dolomites in the Lusaka and Copperbelt areas. Major targets for barite exploration would be vein and replacement deposits in the Luongo Fold and Thrust Belt of the Bangweulu Block. Any search for phosphate (apatite) would necessitate re-evaluation of the carbonatite-hosted deposits associated with the Karoo-age rifts of southern, central, and eastern Zambia. Medium- to high-grade graphite deposits are confined to the high-grade metamorphic terrains of eastern Zambia.”

(Ministry of Mines & Minerals Development, 1999)

Conclusions

The industrial minerals industry of Zambia has always been overshadowed by the metals industry, especially the production of copper and cobalt. Currently, there has been little in the way of industrial mineral production outside that used to supply the copper industry and for basic infrastructure development. The recent privatisation of the copper & cobalt industry will almost certainly stimulate long-term growth of the Zambian economy. This will spur on construction and infrastructure development and as a consequence increase the demand for industrial minerals. Zambia has the potential to meet this increased demand. However, development of other industrial minerals such as barite, feldspar, silica sand, kaolin, graphite, gypsum and fluorite will depend upon local industrial production of glass, ceramics, refractories, paint, paper, plastic and industrial chemicals.

The industrial minerals resources of Zambia are well documented and their occurrence can be easily located via the use of the GIS newly established at the Geological Survey Department. However, there remains a need to establish the suitability of these resources for use as industrial raw materials. This need includes characterisation to determine the mineralogical, chemical and physical properties, plus mineral processing trials and end-use property testing. Such work has been carried out over the years, chiefly by the Geological Survey Department, the University of Zambia (UNZA) and the Zambian National Council for Scientific Research (ZNSCR), but has lacked co-ordination and focus on priorities. What is needed is the establishment of an industrial minerals evaluation programme, with a suitably equipped laboratory and trained staff, at the Geological Survey Department.

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APPENDIX A. SIMPLIFIED GEOLOGICAL SUCCESSION OF ZAMBIA

(After Money, 1986; Bosse, 1996)

Lithostratigraphy	Description	Age
Kalahari Group Zambezi Formation Barotze Formation	Sand, ferricrete, silcrete, calcrete and evaporite Clastics (quartzites, sandstones and conglomerates) and carbonate	Late Tertiary to Recent
Karoo Supergroup Upper Karoo Group Lower Karoo Group	Arkoses and basalts Tillites, clastics (sandstones, mudstones and shale), coal and carbonates	Carboniferous to Lower Cretaceous
Lower Palaeozoic	Quartzites, shales and arkoses	Lower Palaeozoic
Katanga Supergroup Upper Katanga Middle Katanga Lower Katanga	Sandstones, (dolomitic) shales, marbles, arkoses and quartzites Shales, sandstones and conglomerates, plus dolomitic carbonates, ironstones and fluvioglacial deposits Basal conglomerate, quartzite, arkoses and sandstone overlain by dolomitic carbonates and shales	Upper Precambrian
Basement Complex Muva Supergroup Lufubu	Basal conglomerates, metavolcanics, quartzites, sandstones, slates and phyllites Migmatites, gneisses, ironstones, quartzites, marbles, amphibolites, metavolcanics, syenites and granites	Lower Precambrian