An African perspective on aglime

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Abstract

In developed countries agricultural lime is a commodity that is largely taken for granted. In the less developed parts of southern Africa, where agriculture plays a crucial role in daily survival, it is often difficult to get hold of, prohibitively expensive and the 'forgotten input'. This is largely due to the scarcity of production sites, relatively high transport costs and inadequate support for farmers from government agricultural extension services. As part of the UK government-funded research project 'FarmLime' agricultural lime production sites in South Africa and Zambia were studied. The operations in the Western Cape work Precambrian marbles and recent marine limestones using modern plants and operate standard supply chains. In contrast, the operations in Zambia work Precambrian marbles using plant that ranges from the moderately well run to the ad hoc, "home made" variety. The market in Zambia is largely confined to the large commercial farms that can afford to transport and apply their own lime. Small-scale farmers, of which there are upwards of 700,000 in Zambia, struggle with acid soils that they cannot afford to lime with the result that they are trapped in the cycle of poverty. The 'FarmLime' research project has been working on a means of producing affordable agricultural lime from local sources using a redesigned maize mill. It has also demonstrated the benefits of using agricultural lime to farmers by carrying out simple crop trials with groundnuts and maize.

Introduction

Agricultural lime ('aglime') is a commodity taken for granted in most developed countries. Aglime is used in farming as a soil conditioner to prevent acidification, provide a source of plant nutrients (calcium and magnesium) and improve the physical properties of the soil. In the UK it is typically produced in modern processing plants as a co-product with aggregate and other products such as mineral fillers.

As part of a UK Government overseas technical aid project (FarmLime: Low-cost lime for small-scale farming) aglime producers in South Africa and Zambia were visited. The aim of the project was to determine how agricultural lime could be produced on a small-scale and at a price that small-scale farmers in developing countries could afford. The producers were visited as part of the production research.

This research was funded by the UK Government Department for International Development (DfID) geoscience research programme. The aim of DfID research is to "alleviate poverty" through improved access to knowledge and technology, specifically by "enhancing the productive capacity (of less-developed countries) in an environmentally sensitive manner". The basic concept of the FarmLime project was to locate suitable carbonate rocks in the farming districts of Northern Zambia and produce agricultural lime using a low cost method.

The commonly held view is that small-scale farmers do not use agricultural lime because it is expensive, difficult to get hold of and they don't appreciate the benefits. Dolomite suitable for agricultural lime (minimum 80% Neutralising Value and 6% MgO) occurs throughout Zambia including those farming districts with highly acidic soils. It was estimated that a small-scale production method using manual extraction and crushing, and hammer milling could produce aglime for US$20 per tonne. Demonstration crop trials (maize and groundnuts) were set up and these were effective in persuading neighbouring small-scale farmers to use locally produced lime. Where the price of maize is high and the cost of aglime is low the economic benefits of its use are high. However, even if there is a demonstrable economic benefit, the use of aglime will be constrained by the lack of cash in the rural economy.

South African aglime producers

Visits were carried out to four aglime producers in conjunction with the Cape Town office of the Council for Geoscience.

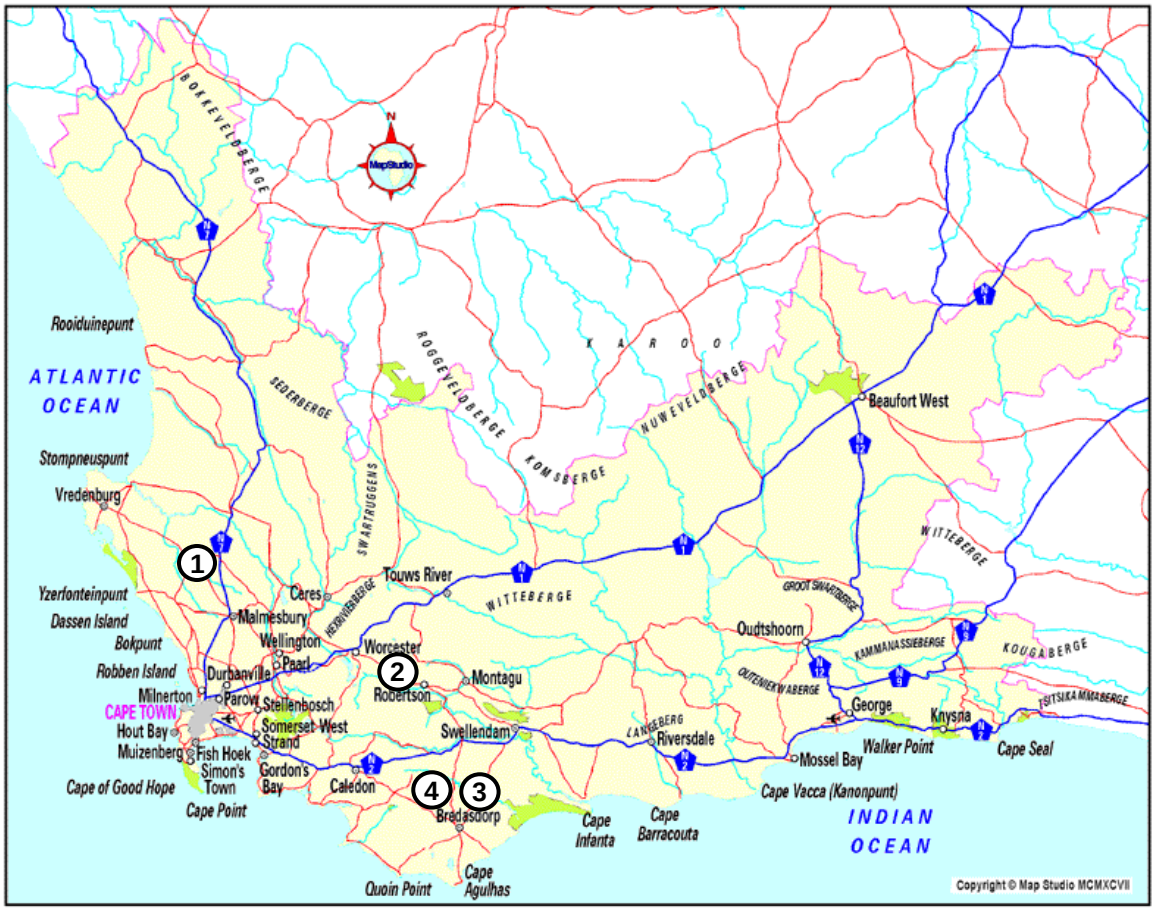

Figure 1 Map of the Western Cape Province, South Africa

① Lime Sales Ltd, Moorreesburg

② Cape Lime Ltd, Robertson

③ P+B Lime Sales, Bredasdorp

④ Nitrophoska (Pty) Ltd, Bredasdorp

Lime Sales Ltd, Bridgetown Dolomite quarry, Moorreesburg, Western Cape

This quarry is situated in a wheat farming area known as the Swartland. It is 25km north-east of Moorreesburg (north of Malmesbury) and is approximately 100km north of Cape Town on the N7 national road. The dolomite occurs as a steeply dipping band in the Bridgetown Formation (Malmesbury Group, Late Precambrian), which consists of greenstone with some chert, dolomite, limestone, shale and phyllite. It is a light-coloured massive fairly pure dolomite containing 31.6% CaO and 21.1% MgO (equivalent to a dolomite mineral content of 96%) with a small amount of silica, alumina and iron (1.3% combined).

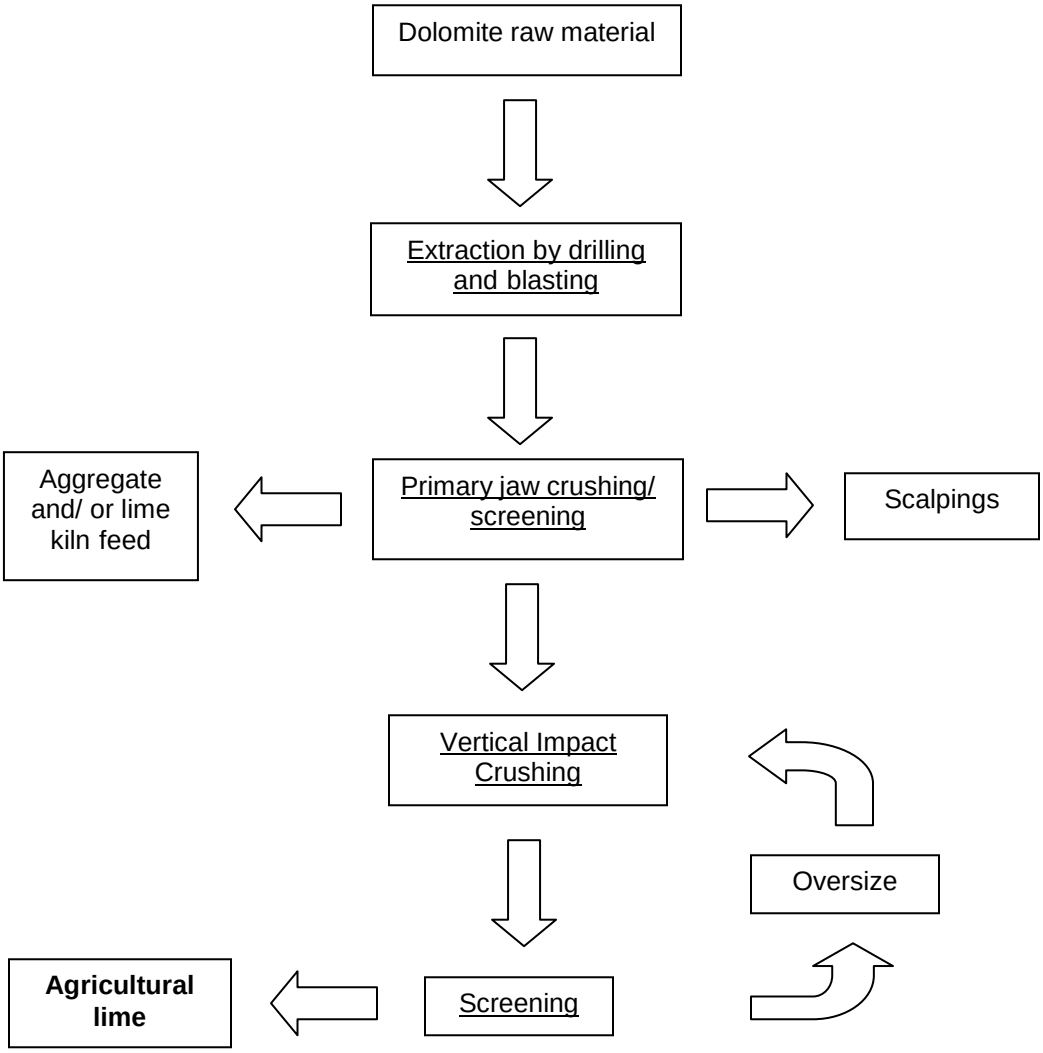

Figure 2. Process for the production of agricultural lime from hard rock dolomite, Western Cape, South Africa

The agricultural lime is generally produced from the clay-rich overburden, overlying the pure dolomite, which contains a significant proportion of fine-grained dolomite. The pure dolomite is extracted and processed separately to produce metallurgical grade material for use in steel production. The agricultural lime production process is given in Figure 2. The raw material is jaw crushed and screened to remove the scalpings (fine-grained and clay-rich material) and aggregate-grade dolomite (in the size range 10 to 25mm). The dolomite coarser than 25mm is crushed using a vertical impact mill to produce agricultural lime 100% finer than 1.7mm with 40 to 50% finer than 50 microns. The oversize is recirculated to the mill. If there is the demand, agricultural lime can also be produced by crushing the aggregate. The company is also considering installing equipment to produce agricultural lime from the clay-rich scalpings.

Formerly part of Iscor Lime Division, Lime Sales Ltd mainly supplies the Saldanha Steel works (11 – 13,000 tonnes per month in 1999). Its other products include agricultural lime (50,000 tonnes per annum) and aggregate (3000 tpa). The agricultural lime is sold to the local farmers via agents/ co-operatives at 60 Rand per tonne ex-works (which equates to approximately US$11 in 1999 prices). Farmers do not buy directly from the quarry, as they do not have the necessary lime

spreaders. The demand for agricultural lime has been suppressed in recent years due to the poor rains; it is the first input that most farmers would drop if times were hard. The quarry has a good relationship with the farmers immediately surrounding the quarry. The only complaints relate to the noise of blasting, whereas dust is apparently not an issue that concerns local people.

Cape Lime Ltd, Langvlei dolomite quarry, Robertson, Western Cape

Langvlei dolomite quarry is situated 11km north-west of Robertson in the Breede river valley and is about 150km east of Cape Town. The dolomite is similar to that at Bridgetown quarry and occurs as a nearly vertical lens within the Malmesbury Group phyllite. The dolomite is relatively pure (82 to 98% dolomite) and occurs as a light grey, massive rock. The only significant impurity is silica, occurring as thin layers of quartz (originally chert).

The dolomite is extracted by drilling and blasting of the quarry benches. It is then jaw crushed and screened. At this stage aggregate and feed for the lime kilns is produced. The aggregate is in single sizes from 20mm and finer. The lime kiln feed (100 to 200mm diameter) is calcined using vertical lime kilns and hydrated using either pressurised or normal hydrators (depending upon the quality of the hydrated lime required). Dolomite in the size range 20 to 30mm is crushed using a vertical impact crusher and screened to produce agricultural lime. The oversize is recirculated back into the mill. If there is the demand, agricultural lime can also be produced by crushing the aggregate.

This operation produces a range of products including agricultural lime, aggregate, quick lime and hydrated lime. In the period April to September 1999 16,724 tonnes agricultural lime and 4200 tonnes of building lime were sold, at 72.10 (US$13) and 300 (US$53) Rand per tonne respectively. The agricultural lime is supplied over an 80km radius from the operation. The busy time of year is between April to June/ July when typically 40 to 50 lorries are dispatched over a weekend. The main purchasers are the fertiliser companies such as Nitrophoska, Kynoch, Omnia and Sasol who provide an integrated fertiliser-agricultural lime packages to their customers. Also they produce mining explosives by combining limestone with Ammonium Nitrate to produce LAN (Limestone Ammonium Nitrate). This reduces the nitrate content from 32 to 28%, rendering it ‘safe’ from being used as a conventional explosive.

P+B Lime Sales, Bontebok Limeworks and limestone quarry, Bredasdorp, Western Cape

Coastal limestones occur intermittently along 1200 km of the South African coastline between Saldanha in the Western Cape and East London in the Eastern Cape. This marine limestone occurs as beds of variable thickness, usually less than 10m thick, in a narrow belt that extends from 10 to 50km inland from the coast. It is often poorly exposed being overlain by sand, calcrete and a poorly indurated limestone (which is a partially cemented dune-type limestone, locally up to 150m thick). It is Upper Cretaceous to Recent in age; mostly Miocene and Pliocene.

Bontebok Limeworks is located 3km north-east of Bredasdorp in the Overberg region of the Western Cape. This is literally ‘over the mountain’ from Cape Town (which is 170km to the East) and is the centre of the dairy, wool and wheat farming region.

The limestone at Bredasdorp has been deposited onto the eroded surface of the older basement rocks (Malmesbury Group). It is a weakly indurated, sandy limestone that consists mainly of the broken fragments of marine, estuarine and terrestrial shells. It is overlain by calcrete and dune sand. Locally the limestone is more indurated with karstic features, such as caves and potholes, having developed. The limestone typically contains 88% calcite, less than 5% dolomite and up to 8% silica (as quartz). Material worked from the Bontebok Limeworks quarry includes calcrete, primary limestone and indurated zones within it. The calcrete is worked for production of hydrated lime and the indurated limestone as a metallurgical flux. The primary limestone, which is yellowish in colour, is worked for the production of agricultural lime. As the limestone is soft it can

be extracted using a 'ripper', which is a large metal hook fixed on the back of a bulldozer that is used to gouge out the limestone. The limestone is then jaw crushed and milled to produce agricultural lime (Figure 3). This is 97% finer than 1.7 mm and 48% finer than 250 microns.

Bontebok Limeworks produces 300 to 500 tonnes per day of agricultural lime and approximately 10 tonnes per day of hydrated lime. The agricultural lime is sold to six local agricultural co-operatives in the Western Cape area (23 Rand/ US$4 per tonne), e.g. Bredasdorp Agricultural Co-operative, who sells it onto the farmers (for 27.5 Rand/ US$5 per tonne). The hydrated lime is sold for 400 to 500 Rand (US$71 to 89) per tonne and the quick lime for 29 Rand (US$5) per 20kg box. A specialist waterproofing powder ('Concrim') produced by slaking the quick lime with a proprietary reagent is sold for 65 Rand (US$12) per 20kg box. The main lime spreading season is from January to April. Typically, a local contractor using a tractor and spreader applies 1.5 to 3.5 tonnes per hectare (in extreme cases 10 tonnes per hectare). The lime application rate is usually determined as part of the soil testing carried out for fertiliser addition ('nutrient demand').

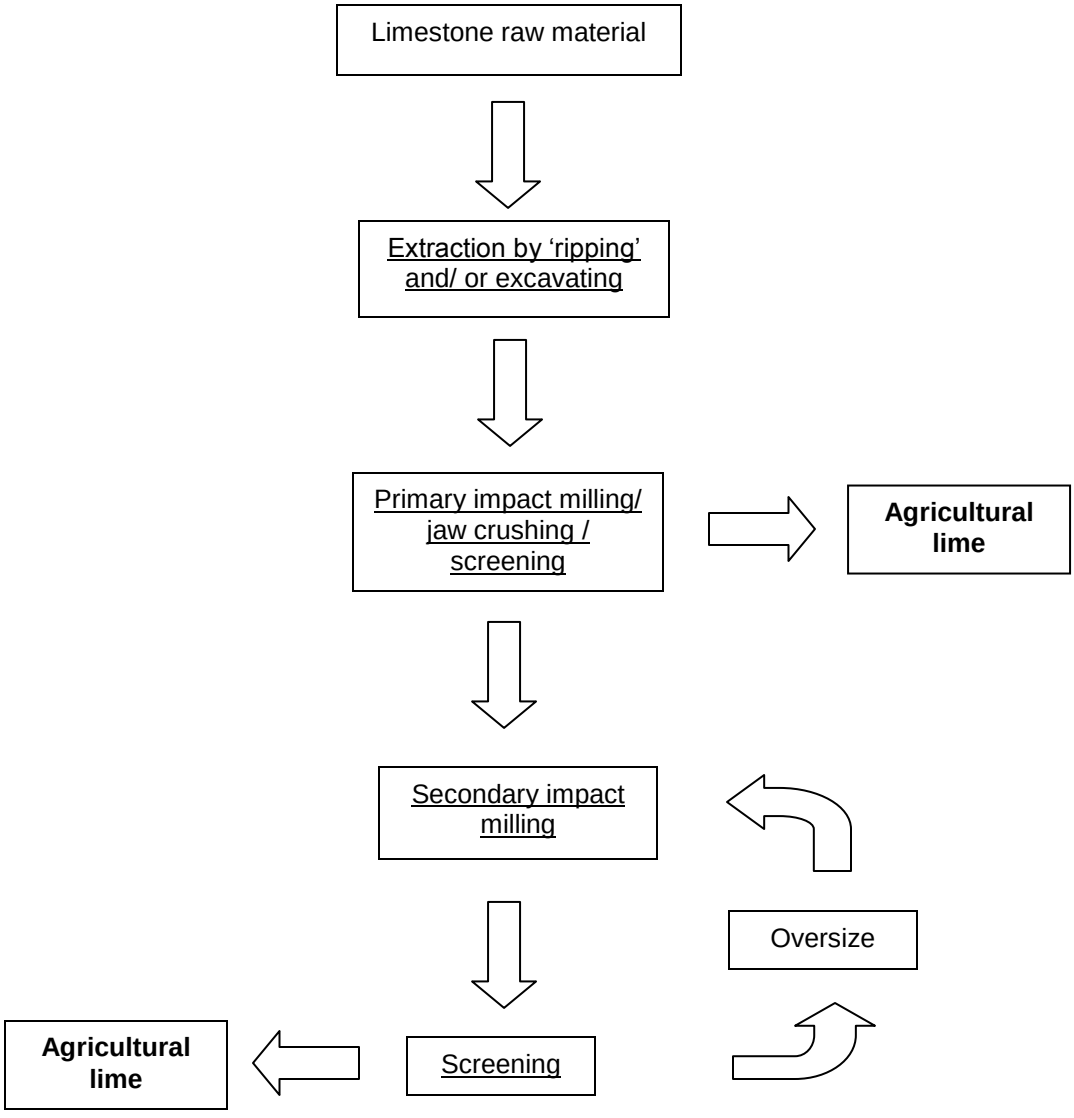

Figure 3. Process for the production of agricultural lime from soft rock limestone, Western Cape, South Africa

Nitrophoska (Pty) Ltd, Karsrivier Kalk limestone quarry, Bredasdorp, Western Cape

Karsrivier Kalk limestone quarry is located approximately 7km to the north-west of Bredasdorp, 3km off the main tar road to Swellendam. The limestone is identical to that worked at Bontebok limeworks. The limestone is excavated using a front-end loader and fed directly into a primary impact mill (Hazemag APR 1010). The crushed material (less than 40mm) is screened on 1mm to produce the first agricultural lime product; this represents approximately 50% of the mined material. The oversize is fed into a secondary impact mill (Hazemag 806) and the crushed material screened on 1mm to produce the second agricultural lime product. The oversize represents 70% of the secondary mill output and is recirculated to the mill for regrinding. The agricultural lime product has 99% finer than 1.7mm and 75% finer than 250 microns.

Nitrophoska is primarily a fertiliser company but is involved in production of agricultural lime in order to provide its customers with a comprehensive 'precision farming' package. The farmer pays for a GPS-based soil survey of his land (which includes soil testing for pH and nutrient content). The soil map produced is used to identify the most appropriate type of agricultural lime to use (dolomitic or calcitic) and the application rate. The data is used to drive a GPS-referenced lime spreader, which controls the application rate according to the varying requirements across a farmer's land. The agricultural lime is currently sold for 40 Rand (US$7) per tonne. It was noted that the local market price is currently depressed by the low prices offered by Bontebok Limeworks.

Zambian aglime producers

Visits to the aglime producers in Zambia (Figure 4) were carried out in conjunction with the Geological Survey Department (GSD) of Zambia.

Figure 4 Map of Zambia

1. Lilyvale Farm, Kabwe
2. Mindeco Small Mines Ltd, Lusaka
3. Ndola Lime Ltd, Ndola
4. Uniturtle Industries (Z) Ltd, Lusaka
5. Hi-Qwalime Mining Ltd, Mkushi
6. FRECA Mining & Manufacturing Ltd, Solwezi

Lilyvale Farm Ltd, Lillyvale Farm dolomite quarry, Kabwe, Central Province

Lilyvale Farm is located 24km to the west of Kabwe and approximately 140km north of Lusaka. It is primarily a coffee plantation with occurrences of dolomite and limestone that are worked for production of agricultural lime and stock feed supplements respectively.

The dolomite and limestone occur within the Muchinda Limestone unit (Nyama Formation, Kundelungu group, Katanga). The dolomite is a buff to grey hard marble that consists of very fine-grained granular dolomite, irregular patches and veins of coarser-grained dolomite and a small amount of pyrite. The limestone is a dark grey hard laminated marble that consists of fine- to coarse-grained calcite with a small amount of feldspar, quartz and pyrite.

The dolomite and limestone is extracted by quarrying. The overburden is removed manually; it takes 6 men 3 days to clear a 12 by 12 metre area of overburden from 0.5 to 1 metre in depth. The rock is drilled and blasted. The blocks are removed, using crowbars, picks and sledgehammers (to break up blocks larger than 50cm), and loaded manually into a 2 tonne capacity trailer. A jaw crusher is used to crush the rock to less than 5cm. The crusher product is hammer milled and screened at 2mm. The oversize is recirculated to the mill for regrinding. The milled dolomite is sold as agricultural lime and the milled limestone as stock feed. The production output was 350 tonnes per week in 1999.

The agricultural lime from Lilyvale farm is sold to customers over a large radius from Kabwe, including Lusaka (140km), Mazabuka (200km), Mkushi (165km), Mpongwe (160km) and Mwinilunga (700km). This operation has customers from far and wide because it is the only source of dolomitic agricultural lime on the Great North Road, the main north-south transport route through Zambia. Agricultural lime is available in 100kg and 50kg bags. The former manager of the operation, Mr Ben Fielding, offered his farm workers free agricultural lime to use on their own smallholdings.

Mindeco Small Mines Ltd, Mindeco Small Mines Ltd, Lusaka

Limestone from the greater Lusaka area is processed by Minedeco Small Mines to produce agricultural lime. Mindeco is a former parastatal company that is essentially a custom milling operation that produces mineral fillers for local industry. The limestone is jaw crushed and ball milled to a powder. Mindeco have plans to introduce a vertical impact mill (Hazemag) to improve the quality and production capacity of the existing plant. Current production of agricultural lime is approximately 3000 tonnes per year, which the company hopes to increase to 5000 to 10,000 tonnes per year over the period 2003 to 2005.

The ex-works price of the agricultural lime is US$20 to 30 per tonne (depending upon the quantity bought). Customers either collect from the works or negotiate with a local transporter to deliver the agricultural lime. The main market is within the Lusaka, Kafue, Mazabuka, Monze and Chisamba area (Lusaka and Southern provinces). Agricultural lime is available in 50kg bags for small-scale farmers.

Ndola Lime Ltd, Ndola Lime Ltd, Ndola, Copperbelt Province

Ndola Lime is located to the east of Ndola and 260km north of Lusaka. The calcitic limestone is worked for the production of quick lime and hydrated lime; also the quarry is shared with Chilanga Cement. Agricultural lime is a by-product from the lime production process.

The limestone from Ndola Lime is known as the Kakontwe Limestone (Lower Kundelungu Formation, Kundelungu Group, Katanga). The limestone dips 25 to 35^{o} to the North and extends along the east-west strike for approximately 9km. The workable calcitic limestone is 100m thick and is bounded by dolomitic limestone on both the foot wall and hanging wall. The eastern side of the deposit has poorer quality limestone; it is more friable and results in a higher degree of decrepitation during calcination. The calcitic limestone is divided into ten zones, L_1 to L_{10}, of which mainly L_1 and L_3 are worked (although a small proportion of the other lithologies can be tolerated). L_1 is a hard, massive fine-grained grey limestone (80 to 80% $CaCO_3$) with a consistent quality. L3 is a semi-hard medium-grained, light grey limestone (with greater than 90% $CaCO_3$). The dolomitic limestone that bounds the calcitic limestone is white, thinly bedded and contains less than 3.5% MgO (equivalent to 15% dolomite mineral); currently it is not worked (although the company have considered working this material for production of agricultural lime).

The limestone is extracted by drilling and blasting the quarry benches and then hauled to the primary jaw crusher. The jaw crusher product is screened on 35mm with the coarse material diverted to the vertical shaft kiln and the finer material to the rotary kiln. The limestone for the rotary kiln is screened and crushed to produce feed material in the size range 35 to 10mm. The limestone for the vertical shaft kiln is screened and crushed to produce feed material in the size range 70 to 35mm. The quicklime from both kilns is effectively the same quality. It is mixed and crushed in the quicklime plant to finer than 10mm. Output is approximately 1000 tonnes per day, with the annual plant capacity rated at 300,000 tonnes. A small proportion of the quick lime is hydrated, 75 tonnes per day, mainly for the export market (South Africa, Zimbabwe, Malawi and the DR Congo) and a small amount for the Zambian market (e.g. for sugar refining).

Dust is a problem around the site with inhalation a nuisance (especially in the hydration plant) and a hazard to health. Dust is collected from the crushing and milling plant (prior to calcination) by filters and electrostatic precipitators, with a proportion fed back into the production line and the remainder sold as agricultural lime. The agricultural lime is sold cheaply in attempt to reduce the amount of material the operation was to deal with. However, Ndola lime is calcitic and not ideal for treating farmland that requires additional magnesium as well as calcium. Ndola Lime is the nearest source of agricultural lime for farmers in the Copperbelt and North-West provinces. For this reason it is well known and is often the agricultural lime used by farmers, if not through choice but by economic necessity.

Uniturtle Industries (Z) Ltd, Lusaka

Dolomitic limestone from Lusaka West (10km west of Lusaka) is processed by Uniturtle to produce agricultural lime. Uniturtle is a private company that mainly produces decorative stone (e.g. tiles and grave headstones) and has in the last few years expanded into production of mineral fillers, agricultural lime and stock feed.

The dolomitic limestone is a white medium-grained marble with a uniform appearance and no obvious lamination. It is compact and hard. The limestone is quarried and transported to a stockpile at Uniturtle processing works (Mumbwa road, west of Lusaka city centre). The use of a stockpile enables production to continue throughout the rainy season. The limestone is crushed using a primary jaw crusher to approximately fist-sized lumps. The secondary jaw crusher reduces the limestone to minus 20mm. The limestone is then ground to a powder (agricultural lime) using a vertical impact mill. The mill is also capable of producing powder to minus 50 microns; which is sold as mineral filler. The company has its own engineering workshops and

installed its own process plant infrastructure; the only process equipment bought in were the crushers and mill (from South Africa).

The agricultural lime is sold in 50kg bags (10,000 Kwacha/ US$2.27 each); this price reduces with bulk purchase (4400 Kwacha/ US$1 per bag). Current production is 8,000 tonnes per year with the ultimate aim of increasing production to 15,000 to 20,000 tonnes per year. Their main market is in the Lusaka area and also in Mazabuka and Chisamba (Southern Province). Uniturtle have recently opened a sales outlet in Mazabuka (June 2002). Also they have supplied TAZ (Tobacco Association of Zambia) who have in turn passed the agricultural lime onto the small-scale tobacco outgrowers. Uniturtle also supplied agricultural lime for the food security packs distributed to small-scale farmers by the food security NGO Programme Against Malnutrition (PAM).

Hi-Qwalime Mining Ltd, Munsakamba dolomite quarry, Mkushi, Central Province

The Munsakamba dolomite quarry is located 18km north of Mkushi Boma, a few kilometres south of the border with the DRC (Democratic Republic of the Congo) pedicle and 300km to the north-east of the Zambian capital, Lusaka.

The dolomite occurs as beds, of the Kundelungu Series Group (Katanga System), that dip at approximately 20^{o} toward the centre of the Lusale basin. They lie unconformably over the quartzite and conglomerate of the older Mine Series formation. Outcrops of the dolomite are found along the Munsakamba river and its tributaries. It is a light grey to grey laminated dolomitic marble that consists of a very fine-grained mosaic of dolomite crystals and coarser dolomite in irregular patches and small veins. It also contains a small amount of finely disseminated quartz and mica.

The agricultural lime operation in Mkushi is relatively recent, it only started production in 2000. Mostly the operating plant equipment was purchased second-hand in South Africa by the main shareholders. The dolomite is extracted from an open cast quarry by drilling and blasting; which produces approximately 500 tonnes per blast. It is transported by front-end loader to a hopper with a 50cm screen (to remove oversize material). The dolomite is crushed to –20mm using a hammer mill and then milled to a powder using a ball mill (operated dry). The ball mill product is size classified using two cyclones in series, which produces agricultural lime at the required grading. The plant is capable of producing 200 tonnes per day of agricultural lime over the dry season (April to November); this puts production capacity at 35,000 tonnes per year (although actual production is probably closer to 10 to 15,000 tonnes pa) The operation is estimated to have a life span of at least ten years.

The commercial farmers within the Mkushi farming district provide the market for agricultural lime. The SA investors also own a local farm supplies company and sales outlet, whose existing customer base provided the incentive to start up the agricultural lime operation. Ultimately, the aim is to provide agricultural lime to farmers within a 75km radius of the site. This is realistic as the other production sites are at least double this distance from Mkushi; Ndola is 150km from Mkushi, Kabwe 165km and Lusaka 300km. The current ex-works cost per tonne is US$17.50. Hi-Qwalime have also started to sell 50kg bags at 4000 Kwacha (US$1, 2002) through outlets such as Mkushi Agricultural Company (MAC); this is aimed at the small-scale farmers.

FRECA Mining & Manufacturing Ltd. Solwezi, North-Western Province

FRECA are working the dolomite deposits that occur immediately to the south of Solwezi town, North-Western Province. The dolomites belong to the Chafugoma Marble Formation. They vary in colour from yellowish white, white, pinkish white to grey and dark grey. They may be either massive or finely laminated and quite friable.

FRECA employ small-scale miners to extract and process the dolomite. The overlying soil is removed from the prominent boulder-like outcrops. Fires are set on the dolomite which when hot are doused with water to promote cracking. The dolomite is then removed using picks and crowbars. The rock is crushed by hand using hammers and sieved to remove the dust, which is sold as aglime. During peak production periods, the company employs about 50 workers to do the quarrying and crushing of the dolomite. FRECA have fabricated a hammer mill which will be used in the future to produce aglime from the crushed dolomite.

FRECA have to date produced approximately 10 tonnes of aglime for local small-scale farmers and farm groups. The aglime is sold for 6000 Zambian Kwacha (US$1.3) per 50 kg bag of lime. Aglime was also being sold in smaller packages of 3 to 10 kg of lime per bag. FRECA have been approached by Zambian NGOs, such as Program against Malnutrition (PAM), to explore the possibility of producing aglime for the North-western Province as a whole.

Conclusions

Aglime is a commodity that is taken for granted in the developed world. However, in less developed countries such as many in southern Africa this is not the case. In Zambia there are very few aglime production operations, which range from the old, inefficiently run to those that are more modern and efficiently run. These are geared primarily to supplying the large-scale commercial farmers and largely ignore the small-scale farmer. The FarmLime project visited aglime operations in South Africa and Zambia as part of the research aimed at making low-cost aglime available to small-scale farmers. The knowledge gained from this exercise was used to inform the research carried out into appropriate methods of small-scale aglime production.

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