

REVIEW OF THE SULPHUR INDUSTRY IN THE REPUBLIC OF SOUTH AFRICA, 2012

DIRECTORATE: MINERAL ECONOMICS



mineral resources

Department:
Mineral Resources
REPUBLIC OF SOUTH AFRICA

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ABSTRACT

The aim of this report is to review the sulphur industry in the Republic of South Africa, by outlining the structure of the industry on a national and international scale. The report also covers the local and international minerals related economic information regarding the availability, exploitation, marketing and utilisation of sulphur. The trade discussions cover the recent global developments on exports and imports. Market analysis was conducted to establish price trends and demand and supply dynamics. The report also gives an update on recent local and global developments in the South African and gives an outlook of the sulphur industry.

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1. INTRODUCTION

Sulphur is a non-metallic element widely distributed in nature. It is the fourteenth most abundant element in the earth's crust and an important constituent for animal and plant life. Sulphur is characterised by various shades of yellow, albeit it also occurs in greenish and reddish to yellowish-grey. It is soft, odourless, has a relative density of 2.05 to 2.09, is a non-conductor of electricity, fuses, and burns easily.

Sulphur in its elemental form is found in meteorites, near hot springs and volcanic regions. It is most commonly found as a component of sulphide minerals such as: pyrite (iron sulphide), cinnabar (mercury sulphide), galena (lead sulphide), sphalerite (zinc sulphide) and stibnite (antimony sulphide) and sulphates minerals, such as gypsum (calcium sulphate), alunite (potassium aluminium sulphate) and baryte (barium sulphate). In petroleum liquids, sulphur is present in an organic form, but within petroleum gases sulphur may occur as hydrogen sulphide (H_2S), rendering the gas 'sour'. 'Sour' gas generally contains between 1 and 60 percent H_2S .

The sulphur industry can be broadly divided into voluntary and involuntary categories. Voluntary production involves the mining of sulphur or pyrite as its main objective, whilst involuntary production occurs when sulphur and sulphuric acid are produced as by-products.

The main use of sulphur is in the production of sulphuric acid (H_2SO_4), while other applications include, but not limited to manufacturing of fungicides, matches, gunpowder, fireworks and vulcanising of rubber. In the agricultural sector, it is used in the manufacture of phosphatic and nitrogenous fertilisers. It is used in ore leaching (copper, uranium and vanadium), petroleum and coal refining, in the production of inorganic and industrial organic chemicals, explosives, synthetic rubber and plastic materials, and in lead acid batteries.

2. OCCURRENCE OF SULPHUR

Sulphur is invariably present in petroleum deposits (Middle East, Venezuela and Russia), natural gas deposits (Canada, France and Russia), tar sands (Canada) and bituminous or oil shale (the USA) or as organic compounds in coal. Sulphur combined in various metallic sulphides occurs in deposits that are magmatic (pyrrhotite, pentlandite, chalcopyrite), metasomatic (pyrite, pyrrhotite) and hydrothermal (pyrite, galena). Elemental sulphur also occurs in solfataric-type deposits associated with volcanism and recent hydrothermal activity.

Commercial deposits of elemental sulphur are unknown in South Africa. Pyrite is found in numerous deposits in South Africa but most of the known deposits have not been economically exploited for pyrite alone. Typically, many of the deposits also contain other minerals and in some cases pyrite can be recovered as a by-product, for instance, the auriferous conglomerates of the Witwatersrand Supergroup contain pyrite and uranium.

In the Barberton district of Mpumalanga, all the auriferous deposits are pyritic but the presence of arsenic in many of them makes pyrite unsuitable for sulphuric acid production. However, where the host rock is quartzite, pyrite is virtually the only sulphide mineral present. The gold and antimony deposits of the Murchison range in the Limpopo province all contain sulphides.

In some of the deposits, stibnite and arsenopyrite are the dominant sulphides while in others it is pyrite. At Areachap, in the Northern Cape, a series of big lenses of cupriferous pyrite occur along a zone of fissuring in quartz schist of the Kheis Group. Pyrite also occurs in large quantities in the ore of the now defunct Prieska copper mine, in the Northern Cape. Pyrite is a minor but common constituent of all coal deposits, with average content of 1%. The carbonaceous shales of the Pretoria Group contain considerable pyrite mineralisation in places, e.g. at Pretoria.

3. GENERAL MINING AND PROCESSING METHODS

Elemental sulphur is derived mainly from subsurface bedded deposits or salt dome cap rocks, which are mined using the Frasch process. This entails the injection of super-heated water into the sulphur-bearing deposit to melt the sulphur, which is then forced to the surface with compressed air.

In South Africa, sulphur is recovered in the form of elemental sulphur, pyrite, sulphuric acid, ammonium and sodium sulphates, from four sources, namely pyrite, metal sulphide smelter gases, coal and crude oil. However, because sulphuric acid is the form in which more than 85% of sulphur-in-all-forms (SAF) is used, most elemental sulphur and pyrite are converted to sulphuric acid. Most of the acid produced is used in the leaching of uranium ores and fertiliser production.

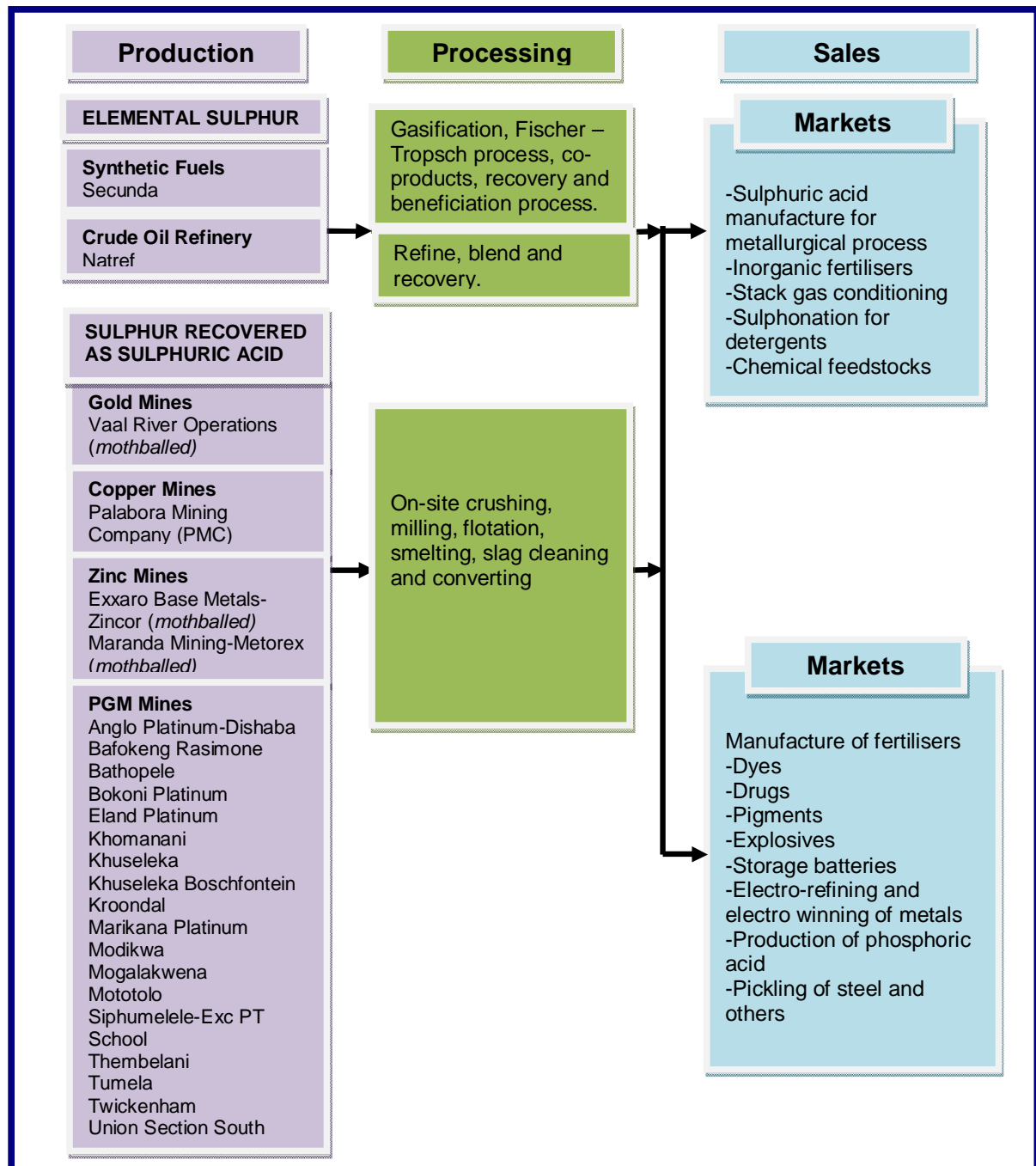
Elemental sulphur in South Africa is recovered from crude oil refining and also produced by Sasol as a co-product of its synthetic fuel production from coal to liquids (CTL) process in Secunda. All crude oil refineries in South Africa produce sulphur via Claus desulphurizing process that converts hydrogen sulphide gas to elemental sulphur. In Sasol Synfuels process coal is gasified using steam and oxygen at high temperatures to produce synthetic gas (syngas is a mixture of carbon monoxide and hydrogen) at Sasol Synfuels. The syngas from Sasol's Advanced Synthol (SAS) reactors which utilises a high temperature Fischer Tropsch (FT) process is used to produce a synthetic form of crude oil and chemical feedstock. After coal gasification the gas is cooled and hydrogen sulphide gas that is formed has to be separated from the syngas before being recovered using the Stretford process. This yields an estimated 140 kt per annum of granular sulphur. Apart from fuel other products that are also co-produced include ammonia, oxygenated hydrocarbons, ethylene, propylene and crude tar acids to name a few. Ammonia is used in the production of fertilisers and explosives (Fig 1 and 2).

The main product from Synfuels and crude oil refining process is fuel but the commercial production of this is not possible without a desulphurization process that recovers sulphur and makes it available in an environmentally friendly elemental form. Hydrogen sulphide gas cannot be released to atmosphere because it is an environmental pollutant. Total sulphur production from the coastal crude oil refineries (Sapref, Engen Caltex) and at Sasolburg's National Petroleum Refiners of South Africa (Natref) amounts to an estimated 120 kt per annum. The refined crude oil is used as a feedstock together with fuel components from synthetic fuels, it is further refined and blended then molten sulphur and other products (i.e. petrol, diesel, liquefied petroleum gas, jet fuel, illuminating paraffin, bitumen and fuel oil) are recovered.

Sulphuric acid is also produced as an involuntary by-product by Palabora Mining Company, Anglo Platinum Group and Zincor (mothballed in 2011), a division of Exxaro Base Metals. The sulphuric acid recovery process entails mining, concentration, smelting and converting. The ore is drilled, blasted and hauled from below the surface and the ore is reduced in size by crushing and milling. Water is added to produce a pumpable slurry. The separation of valuable content from the rock takes place in the flotation cells where reagents are added to the slurry to produce high grade concentrate. The electric furnace is used to smelt the concentrate to produce a sulphur rich matte with gangue

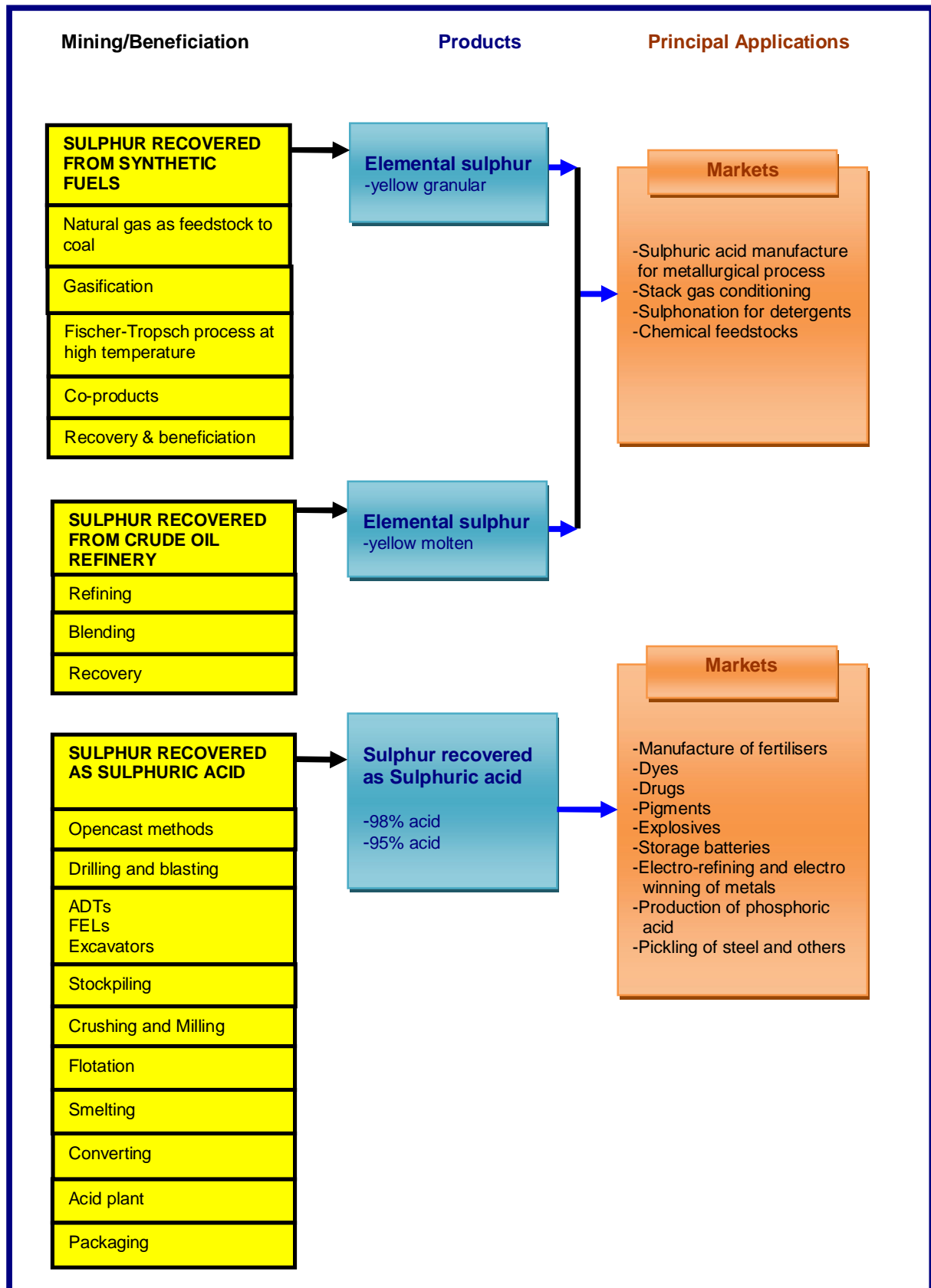
impurities removed as slag and the slag is pumped into the converter. From the converter the slag is reduced in an electric furnace to recover the desired products and recycled back to the converter. Oxygen enriched air is blown through the converter to oxidise sulphur contained in the furnace to sulphur dioxide (SO₂). At the acid plant the SO₂ gas is converted to sulphur trioxide by passing it over catalytic beds and the subsequent addition of water produces 98 percent H₂SO₄ which is sold to fertiliser manufactures etc (Fig 1 and 2).

FIGURE 1: SOUTH AFRICA'S SULPHUR, SULPHURIC ACID INDUSTRY AND COMPANY STRUCTURE



Source: DMR, Directorate Mineral Economics

FIGURE 2: SOUTH AFRICA'S SULPHUR, SULPHURIC ACID INDUSTRY FLOWCHART



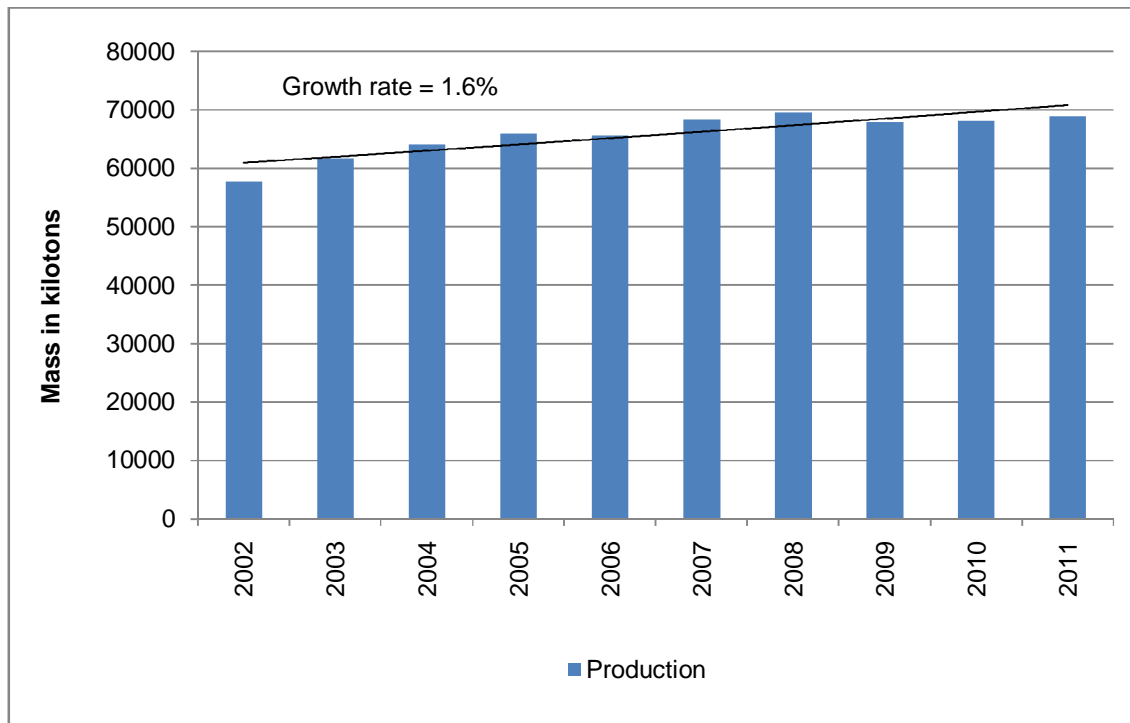
Source: DMR, Directorate Mineral Economics

4. PRODUCTION

4.1 World

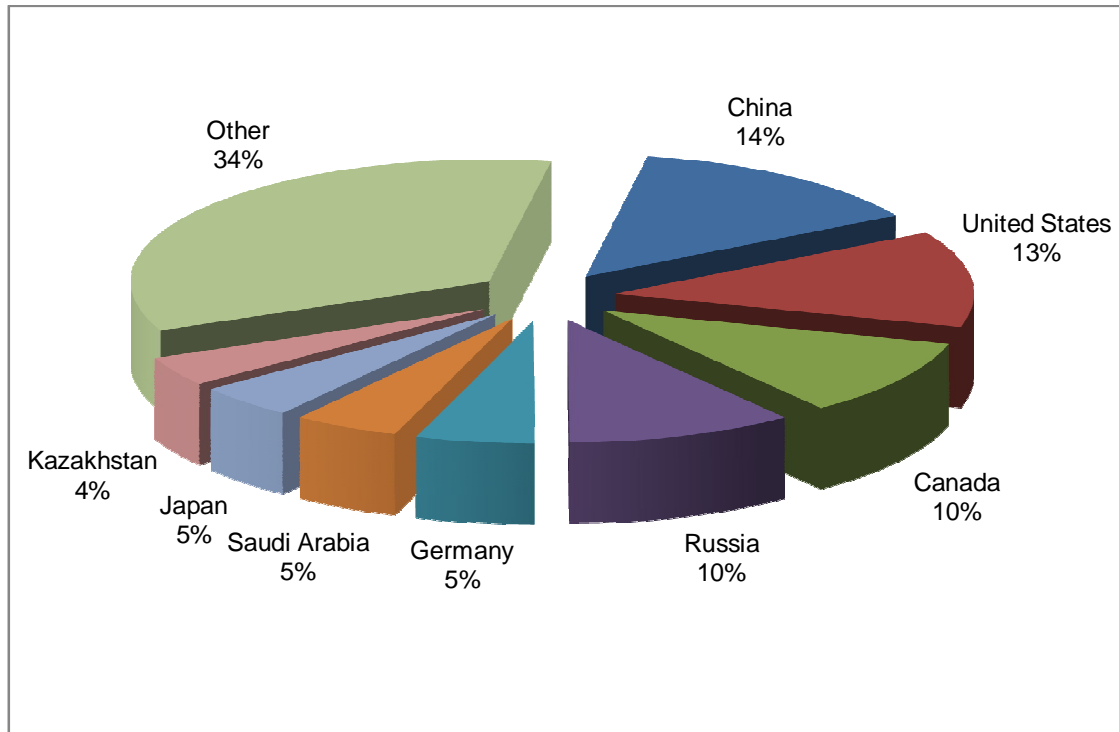
World production of sulphur in all forms (SAF) increased slightly during the last few years at an annual growth rate of 1.6 percent to an estimated 69.1 Mt in 2011 from 57.7 Mt in 2002 (Fig 3). Although the industry has slightly recovered from 2009 to 2011, it has not reached the production levels of 2008, owing to decrease in refinery operating capacity as a result of shutdowns and closures. In 2011, China was the largest producer accounting for 14 percent, followed by the United States (US) at 13 percent, Canada and Russia at 10 percent each (Fig 4). South Africa accounted for 0.7 percent of the world output in 2011. Global output of elemental sulphur increased by 6.1 percent to 53.7 Mt in 2011 from 50.6 Mt in 2010.

FIGURE 3: WORLD SULPHUR PRODUCTION GROWTH RATE, 2002-2011



Source: USGS, 2012

FIGURE 4: WORLD PRODUCTION OF SULPHUR BY COUNTRY, 2011



Source: *Industrial Minerals*, 2012

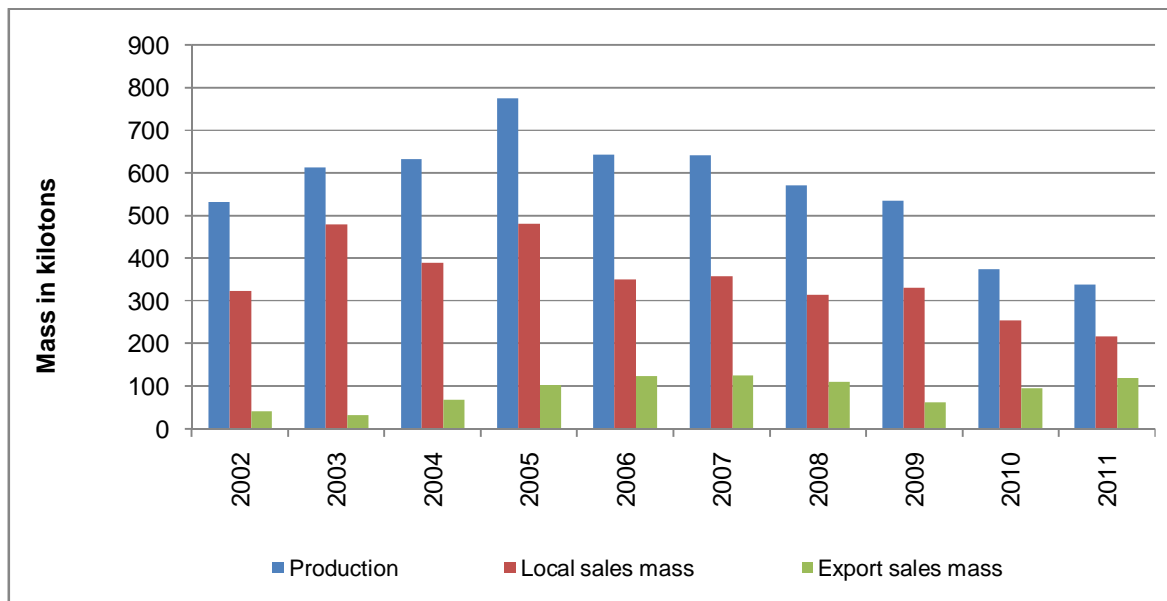
4.2 South Africa

In South Africa, elemental sulphur is recovered from pyrite, sulphide smelter gasses, coal and crude oil. Most elemental sulphur is converted to sulphuric acid. Sulphur was recovered as a by-product from one oil refinery, one synthetic fuels producer, one gold mine, eighteen platinum mines, two zinc mines and one copper mine in 2011.

South Africa's production of SAF declined at an annual rate of 5 percent from 2002 to 2011, attributed to refinery operating capacity decrease as a result of refinery shutdowns and closures (Fig 5). Sulphur recovery from synthetic fuels main consumer is metallurgical operations and they were static due to decrease in gas loads and sulphur feeds. Conditions remained difficult in oil refining industry with a number of unplanned shutdowns compounding the challenges faced and mining activities were suspended or reduced.

Sulphuric acid production from gold mine ceased in 2011, owing to the closure of Vaal River operations. Sulphuric acid production from the copper mine, Parabola Mining Company (PMC) decreased as a result of lower production. Sulphuric acid production from zinc mine stopped in the latter part of 2011 owing to the closure of Zincor operations, as a result of the difficult conditions in the zinc market, including its cyclical nature, low margins as well as significant impact of higher electricity prices and the exchange rate. Sulphuric acid production from PGM mines increased owing to added extra facilities by Anglo Platinum.

FIGURE 5: SOUTH AFRICA'S PRODUCTION, LOCAL AND EXPORT SALES MASS OF SULPHUR-IN-ALL-FORMS, 2002 -2011

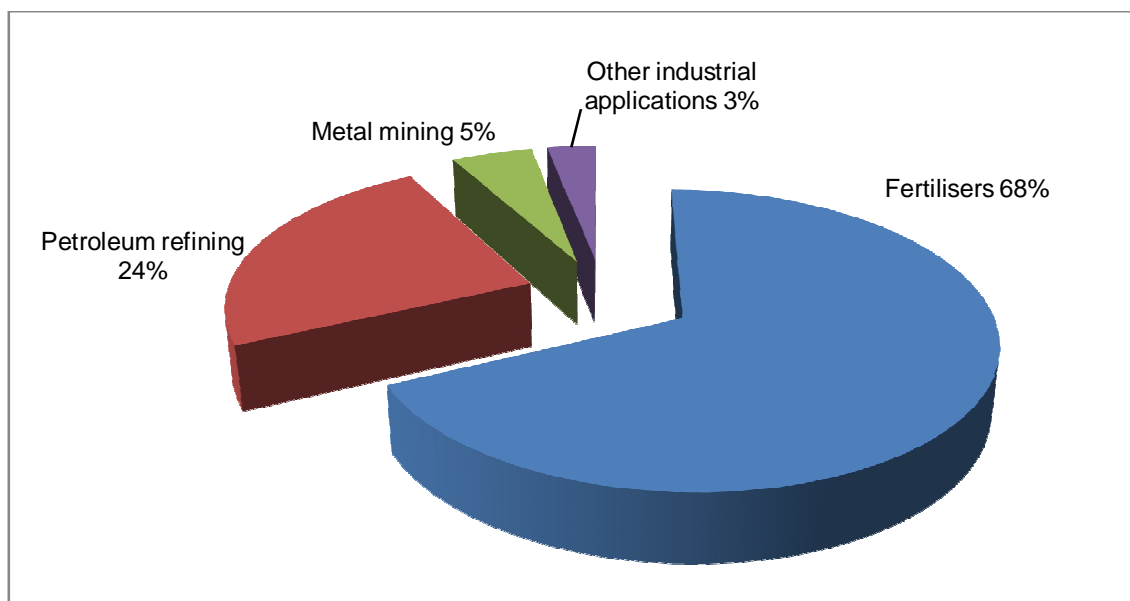


Source: Directorate Mineral Economics

5. DEMAND

About 90 percent of sulphur was consumed in the form of sulphuric acid and the balance in chemical and manufacturing industries. Agricultural chemicals, primarily fertilisers account for 68 percent of sulphuric acid consumption followed by petroleum refining with 24 percent and metal mining's 5 percent. The remaining 3 percent is used in a range of other industrial applications (Fig 6).

FIGURE 6: SULPHURIC ACID CONSUMPTION BY INDUSTRY, 2011



Source: USGS, 2012

6. TRADE

6.1 World

Major exporters of sulphur include Canada, Russia, Germany, Saudi Arabia, United Arab Emirates, Kazakhstan, Iran, USA and Japan. Major importers of sulphur are China, Morocco, USA, Brazil, India, and Tunisia, which are also the main fertiliser producers.

6.2 South Africa

Local sales mass of SAF, which includes elemental sulphur and sulphuric acid, declined at an annual rate of 6 percent from 2002 to 2011. A reduction in the sulphuric acid sales can be attributed in part to closure of Sasol's phosphoric acid plant and the Zincor plant. Other factors include interruption in supplies, high numbers of safety stoppages and industrial actions experienced in the mining sector. Local demand for sulphur is dominated by imports for phosphoric acid production at Richards bay. Export sales of sulphur increased by an annual growth rate of 10 percent to 120 kt and export sales value increased by 16.6 percent to R199.4 million in 2011. Sales to export markets increased to supplement import volumes required for metallurgical operations in the Central African region. In 2011, South Africa exported sulphur to Zambia and Mozambique.

South Africa's imports of crude sulphur increased by 1.9 percent from 677 kt in 2007 to 906 kt in 2011 as the imports continued to outstrip local production. Foskor ramped up production of phosphoric acid which required increased amounts of sulphuric acid, which in turn increased sulphur demand. South Africa imported most of its crude sulphur from Canada, Saudi Arabia, China, USA and India.

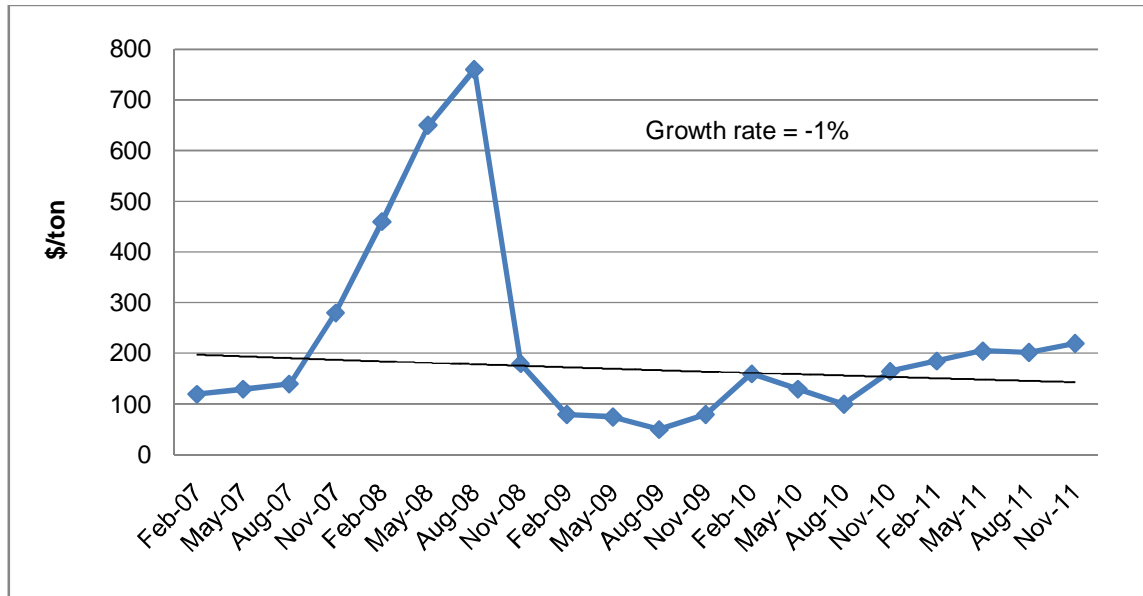
7. PRICES

The sulphur market is very dependent upon the cyclical world phosphate fertiliser market. The South African fertiliser industry pricing of raw materials and final products is linked to international prices, both through international procurement and pricing mechanism. In addition to being dependent on phosphate-based fertiliser prices, sulphur prices depend largely on swings of sulphur production. Price transmission showed that local prices of fertilisers respond more quickly to rises in the international prices than it responds to drops, which means fertiliser producers responds more quickly to chances that threaten their profitability. However, much of price differences were also caused by factors such as exchange rate. The industry has therefore been alternating between periods of shortage and excess of sulphur during the past five years with a dramatic impact on prices.

The international price trend of sulphur, \$/ton spot, fob Vancouver decreased by an annual growth rate of 1 percent between 2007 and 2011 (Fig 7). In 2007 sulphur was in excess whereby it was barely an interesting market. However, 2008 saw the dwindling of sulphur stock as the world faced shortage of sulphur and prices rocketed to almost \$800/t for spot price. In 2009 and 2010, sulphur was again in excess leading to a drop in prices and resulting in refiners having to pay for the removal of excess sulphur from their plants. Fertiliser prices resumed their climb in 2011 amid thin trading, as China continued to lower the export taxes for phosphate fertilisers and also in response to high

energy prices and strong worldwide fertiliser demand driven by rising crop prices. Rising food prices helped to drive increased demand for phosphate based fertilisers, resulting in a surge for input materials like sulphur.

FIGURE 7: INTERNATIONAL PRICE TREND OF SULPHUR, US\$/TON SPOT, FOB VANCOUVER



Source: Various sources, 2007-2011

8. OUTLOOK

World sulphur production is forecast to increase at an average annual rate of 6.7 percent to 95.4 Mt by 2016. A significant increase in production is expected from sulphur recovery at liquefied natural gas operations in the Middle East and expanded oil sands operations in Canada. Approximately 60 percent of this growth is expected to come from the global natural gas processing sector. Global consumption is expected to grow at 4 percent per annum to reach 96.8 Mt by 2016, as a result of sustained growth in the use of sulphuric acid in the manufacture of fertilizers and firm industrial demand, particularly for ore leaching.

The sulphur market remains one of the most difficult to forecast as sulphur regularly alternates between periods of surplus and deficit. Global economic uncertainty is also expected to delay new projects coming on stream, thus affecting some of sulphur markets particularly fertiliser manufacturing and metal ore leaching.

International sulphur volumes will increase as heavier crudes are exploited and this together with more stringent legislation governing the sulphur content of fuels will see a rise on the supply side. On the demand side, the growth of the phosphate based fertilizers will be the main driving force. China will be the main player in this field but increased base metal exploitation will also increase demand for sulphur for sulphuric acid. The growth in mining activity in the central African region will see a greater demand for sulphur in that region, resulting in greater volumes of product passing through South

Africa's harbours and possible expansion of other import routes, such as Beira, Dar es Salaam and Maputo.

The phosphate fertiliser industry is the main consumer for sulphur and sulphuric acid. South Africa's local fertiliser industry is exposed to international markets and the uncertainty of the exchange rate. The agricultural value chain contributes between 17 to 24 percent to Gross Domestic Product (GDP). In 2011, the country became the net importer of over 60 percent of fertiliser products in a bid to satisfy its local demand. In order to reduce the reliance on imports many smaller blending plants and companies are being set up to change the complexion of the local fertiliser industry the concentration within the local fertiliser industry, which will ensure a long term sustainable conducive business environment and long-term investments into the South African fertiliser industry. With the pressure to stop importing Iranian crudes it is possible that sulphur production may increase in the coming years.

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