

## **STATUS OF FLUORSPAR INDUSTRY IN THE REPUBLIC OF SOUTH AFRICA, 2009**

DIRECTORATE: MINERAL ECONOMICS



**mineral resources**

Department:  
Mineral Resources  
**REPUBLIC OF SOUTH AFRICA**

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Compilers:

Lerato Ramane - Sharon.Ramane@dme.gov.za

Mphonyana Modiselle - Mphonyana.Modiselle@dme.gov.za

Dinesh Naidoo - Dinesh.Naidoo@dme.gov.za

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The Directorate Mineral Economics, Mineralia Centre,  
234 Visagie Street, Pretoria 0001, Private Bag X59, Pretoria 0001  
Telephone (012) 317- 8538, Telefax (012) 320 4327  
Website: <http://www.dme.gov.za>

## **DEPARTMENT OF MINERAL RESOURCES**

Director-General

Adv S Nogxina

### **MINERAL POLICY AND PROMOTION BRANCH**

Deputy Director General

Mr. M Mabuza

### **MINERAL PROMOTION CHIEF DIRECTORATE**

Chief Director: Mineral Promotion

Dr. S Ndabezitha

### **DIRECTORATE: MINERAL ECONOMICS**

Acting Director

Ms. N Dlambulo

Acting Deputy Director: Industrial Minerals

Mr. D Naidoo

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## **1. INTRODUCTION**

Fluorspar is the commercial name for the mineral fluorite (calcium fluoride,  $\text{CaF}_2$ ), when pure it consists of 51.1 percent calcium and 48.9 percent fluorine. Fluorine is found in small amounts in a wide variety of minerals, such as apatite and phlogopite. Fluorite generally appears in a wide range of colours and usually contains mineral impurities such as calcite, quartz, barites, various sulphides and phosphates. Commercial fluorspar is graded according to quality and specification into metallurgical grade (min. 80 percent  $\text{CaF}_2$ ), ceramic grade (min. 80-96 percent  $\text{CaF}_2$ ) and acid grade (min. 97 percent  $\text{CaF}_2$ ). An estimated 50 percent of total world production is used for the production of hydrofluoric acid (HF), a key intermediate in the production of a wide range of organic and inorganic fluorine based chemicals.

## **2. OCCURRENCES**

Fluorspar is found in a wide range of geological environments across the globe. The primary economic source of fluorspar is in vein deposits, where it occurs as the main mineral or with metallic ores such as lead, zinc, silver and barites in particular. Vein deposits are found around the world and include the El Hemman deposit in Morocco, the Rosiclave deposit in United States, Osor deposit in Spain and recently exploited deposits in China. Replacement deposits are associated with intrusive igneous rocks, such as the Rio Verde deposit, San Luis districts deposit in Mexico and Vergenoeg deposit in South Africa. Stratiform deposits are typified by cave; such as Illinois deposit in the United States.

## **3. EXPLOITATION**

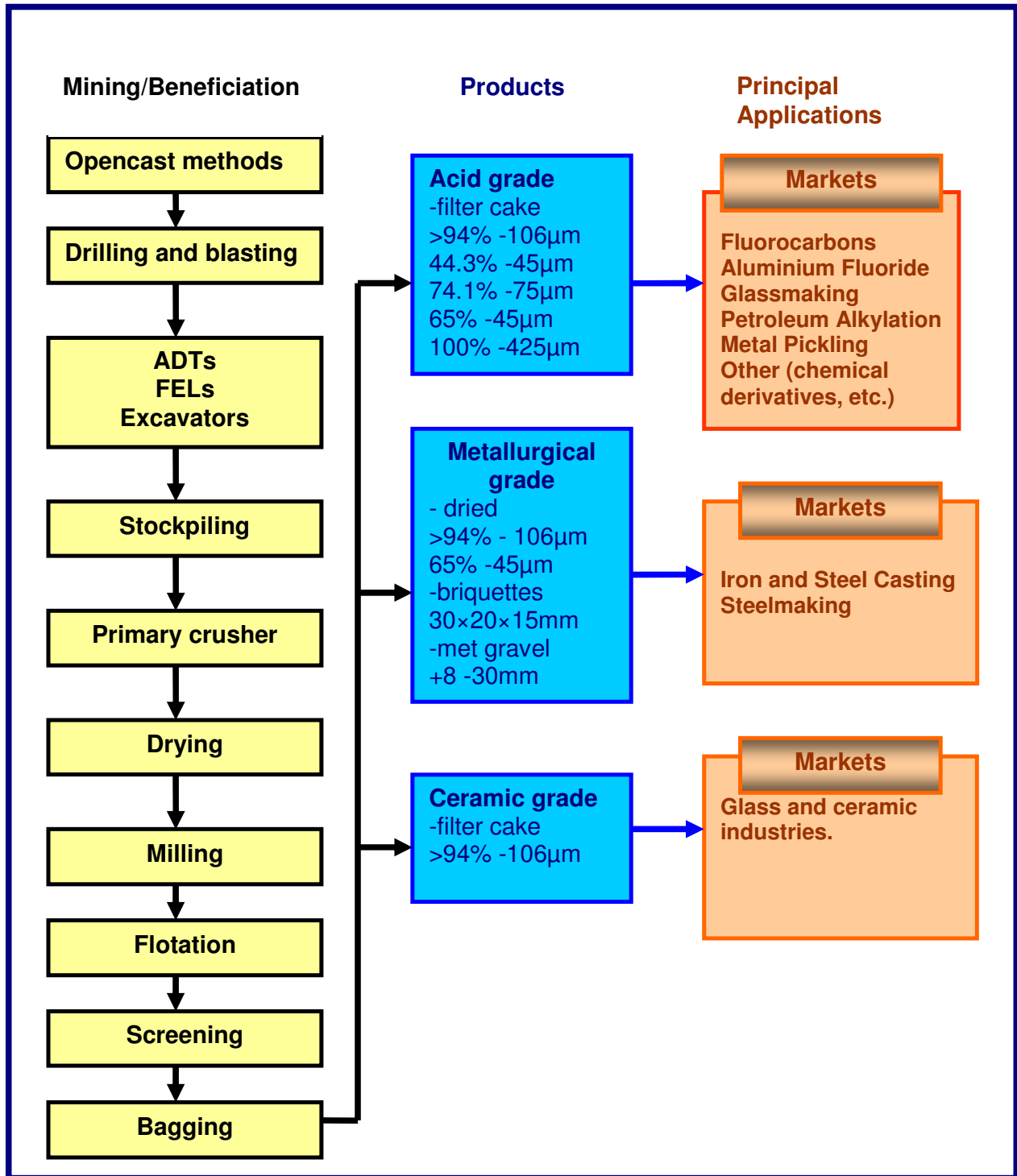
Fluorspar mining methods vary according to geological conditions of individual deposits. Deep deposits usually require underground mining techniques while opencast methods usually involve wide, shallow deposits and deep deposits if the ground is unable to support underground mining, despite a substantial overburden. In mining the vein, shrinkage stopping is commonly used, but open stopping (removal of the ore with minimum waste from the footwall and hanging wall) can also be used, where strong walls occur. Room and pillar method is used in stratiform or bedded deposits. Replacement deposits are mined using the cut and fill method if the deposit is deep and narrow.

Fluorspar ore is commonly blended before use in order to maintain a constant feed grade to the beneficiation plant. The ore is crushed, washed and screened before processing (Fig. 1).



Most modern plants use a combination of gravity and froth flotation processes. Gravity concentration uses liquids to separate the gangue minerals to produce either a coarse grained metallurgical grade fluorspar or to provide the feed for a flotation plant producing acid and ceramic grade fluorspar. Preceding flotation, the ore is ground very finely to liberate impurities and then fed into tanks containing an agitated chemical solution. The fluorite grains stick to the bubbles rising through the tank and overflows as froth. Lower grades fluorspar is produced in addition to the higher grade fluorspar. Lower grade concentrates can be sold as ceramic grade fluorspar or pelletized and sold as metallurgical grade fluorspar.

FIGURE 1: FLUORSPAR INDUSTRY FLOWCHART



Source: DME, Directorate Mineral Economics

#### 4. WORLD SUPPLY

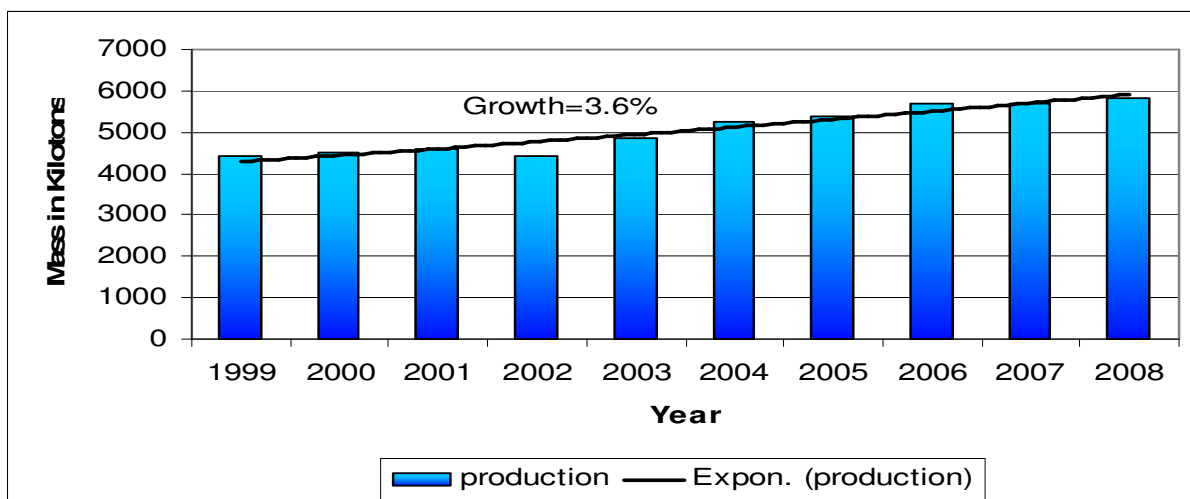
World production of fluorspar has grown at an annualised compound growth rate of 3.6 percent from 1999 to 2008. Growth was driven by demand from the fluorochemical and aluminium industries (Fig. 2). Total world production of fluorspar was estimated to be 5.84Mt in 2008. China was the biggest producer accounting for approximately 55 percent, followed by Mexico (17%), Mongolia (7%) and South Africa (6%) (Fig.3). China continues to reduce its export quotas to support its downstream fluorochemical industry, which have allowed other countries to make up the shortfall on world markets (Table 1). Mexico is a growing, competitive producer and Mongolia is a new producer. However in recent years mines have closed in France and Italy as a result of the depletion of ore bodies.

TABLE 1: CHINA EXPORT QUOTAS, 2001-2008

Year	Mass (kt)
2001	1 150
2002	1 000
2003	850
2004	750
2005	750
2006	710
2007	685
2008	660

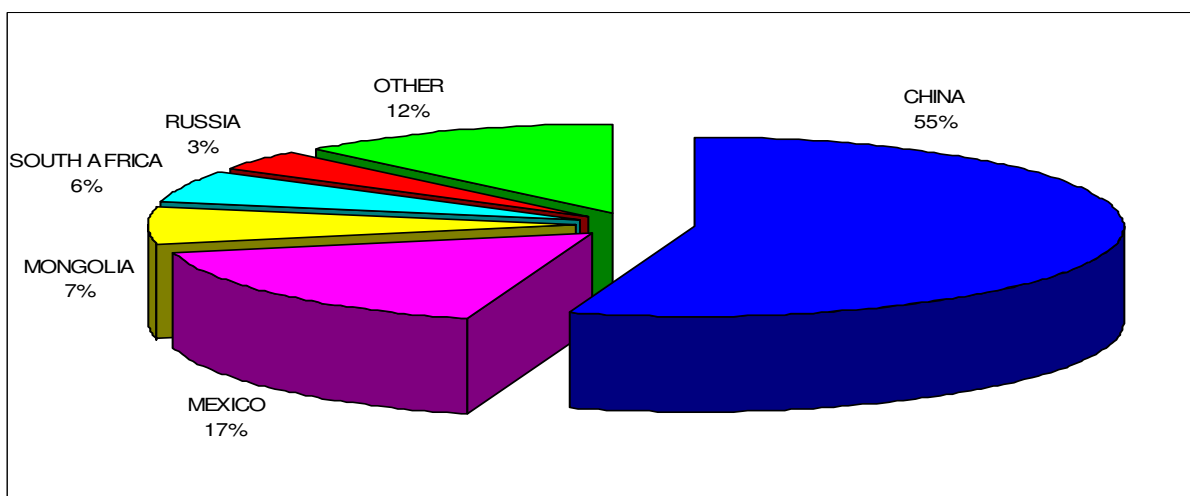
Source: DME, Directorate Mineral Economics

FIGURE 2: WORLD FLUORSPAR PRODUCTION GROWTH RATE, 1999-2008



Source: USGS, 2009

FIGURE 3: WORLD PRODUCTION OF FLUORSPAR, 2008



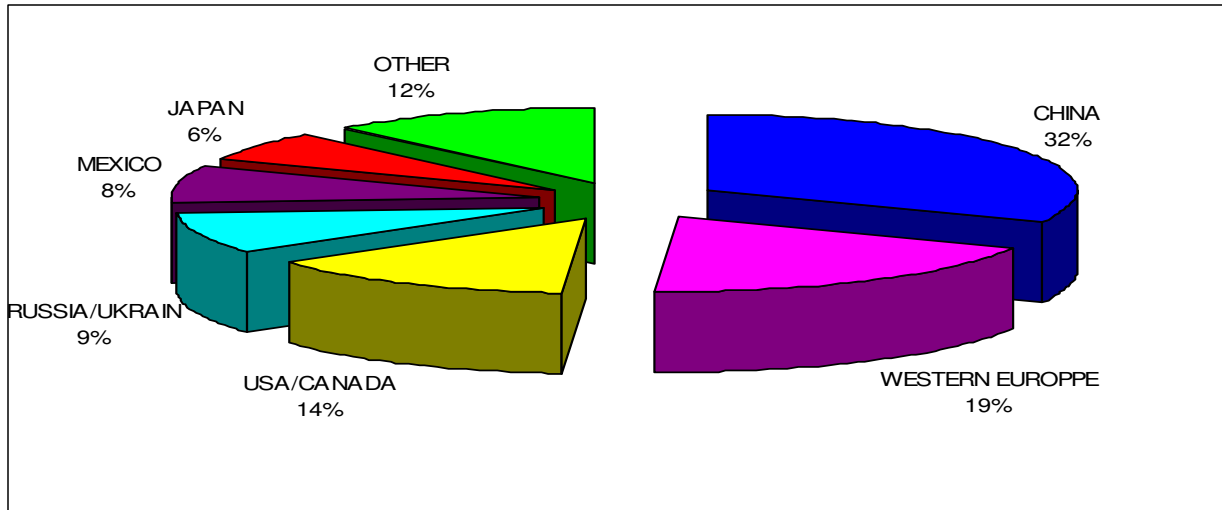
Source: USGS, 2009

## 5. WORLD DEMAND

China accounts for 32 percent of world fluorspar demand, followed by Western Europe at 19 percent (Fig. 4). About 47 percent of fluorspar production is consumed in the production of HF, the starting point for the manufacture of fluorocarbons. Steel production (42%) and aluminium production (7%) are the next significant markets (Fig. 5). The use of metspar as a flux in the steel industry is declining as the use of alternate fluxes is increasing.

Over the past decade, demand for fluorspar has grown by just over 2.2 percent per year, but from 2003 to 2007 growth rates exceeded 4 percent per year as the industry started to recover from effects of restrictions on the use of some fluorocarbons. Demand for acid grade fluorspar, the main source of fluorine for manufacture of HF and derivative fluorine chemicals including refrigerants, slowed by some 15 percent since the start of the year 2009, after experiencing a long run of price increases and strong sales over the past two years.

FIGURE 4: WORLD FLUORSPAR DEMAND, 2007

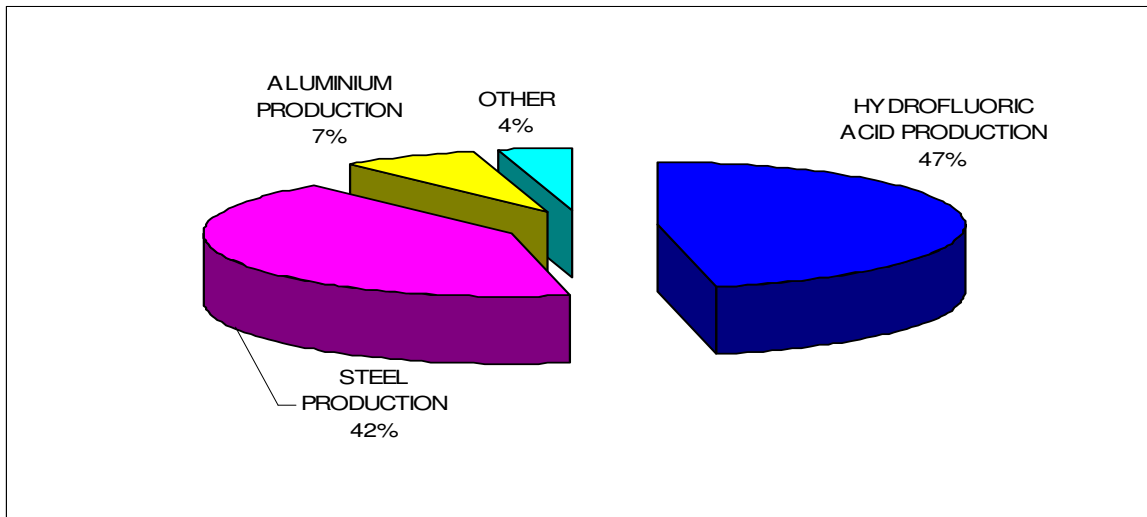


Source: Mineral Price Watch, 2007

## 6. WORLD MARKETS

The grade of fluorspar determines its end use. Approximately 50 percent of world fluorspar production is of acid grade.

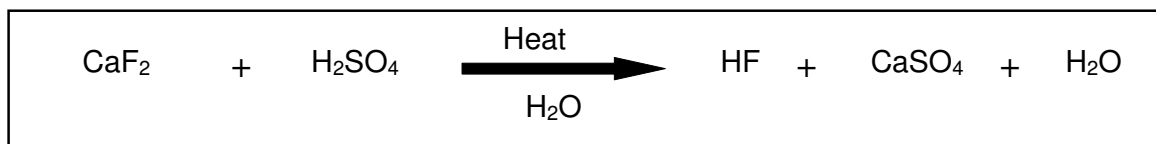
FIGURE 5: WORLD FLUORSPAR MARKETS



Source: SRI Consulting, 2007

### 6.1. Acid Grade Fluorspar

Acid grade fluorspar is used in the production of hydrofluoric acid (HF), mostly in China, USA, and Europe. HF is produced by heating acid-grade fluorspar and sulphuric acid, as per the following chemical reaction:



Approximately 2.2t of fluorspar is required; to produce 1.0t of HF. About 54 percent of HF produced is used in the production of fluorocarbons, which are used as refrigerants, non-stick coatings, medical propellants and anaesthetics. Small amounts of Hf are used as catalysts in petroleum alkylation, for stainless steel pickling, for metal etching in electronics manufacture and in uranium processing. The other main use of fluorochemicals is in the manufacture of fluoropolymers and fluoroelastomers for use in plastics (polytetrafluorethylene) (PTFE) for

example. PTFE, which is used in insulation of electrical wire and cables as well as aerospace, coatings and electronics.

Acid grade fluorspar is also used in the production of aluminium, as aluminium fluoride ( $\text{AlF}_3$ ) is a component of the molten bath in the electrolytic reduction of alumina to aluminium metal.

## **6.2. Metallurgical Grade Fluorspar**

Metallurgical grade fluorspar is used primarily as a flux in steel making to reduce slag viscosity, to lower melting point and remove impurities from steel. Even though refractory and steel technology has advanced, metspar has maintained and strengthened its position in modern steel markets. Metspar also has a desulphurisation effect. It is also used in basic oxygen furnaces of carbon steel plants, though its use has been declining due to competition.

Metspar in the steel industry is added in gravel form, which is usually in the 10 – 75mm range. The size used varies with applications. The absence of chemical processing in metspar production reduces fines accumulated during production and shipping. However metspar is friable, it is susceptible to degradation, which increases the risk of penalties being imposed on metspar content delivers.

## **6.3. Ceramic Grade Fluorspar**

Ceramic grade fluorspar is used in the glass and ceramic industries; smaller quantities are used in the manufacture of magnesium and calcium metals and welding rod coatings.

## **7. WORLD TRADE**

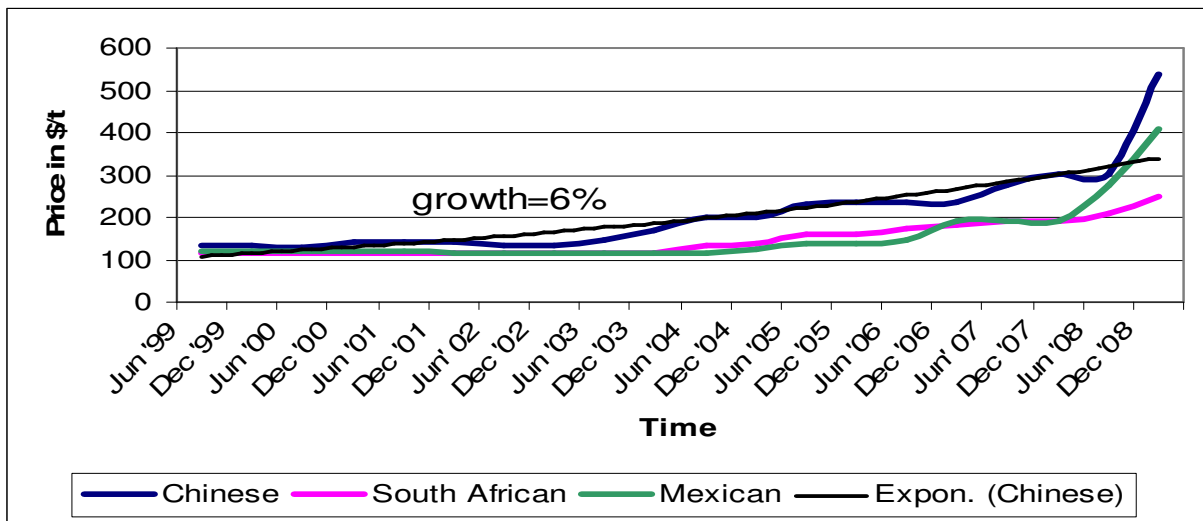
World trade of fluorspar is estimated at 2 Mt. Major exporters are China (35%), Mongolia (25%), Mexico (20%) and South Africa (15%). The major importers are USA (32%), Japan (23%) and Germany (15%).

## 8. WORLD PRICES

As fluorspar is not traded on commodity exchanges, there are no day-to-day price indices as in the case of many metals. Spot prices tend to be much higher than contractual prices. Global growth of fluorspar demand particularly in China has a direct effect on prices. Chinese prices have increased at a rate of 6 percent per annum since 1999. A reduction in Chinese exports of fluorspar was the leading cause, but other factors such as increasing costs in China (production, domestic transport and taxes), high freight rates and inflationary pressures contributed to the rise in prices. The Chinese government announced that it would reduce export taxes to zero in 2009 and give financial support to exporters in an attempt to increase its share of global trade in the current economic downturn.

Mexican and South African prices, both of which move in tandem with Chinese prices, have grown at a rate of 4 and 4.5 percent pa respectively, since 1999 and were estimated at \$360/t and \$250/t respectively in 2008 (Fig. 6). South African producers announced that contract prices for shipments of acid grade fluorspar in 2009 negotiated at the end of 2008 were in the region of \$350/ton, free on board (FOB) Durban, compared to a previously published price of \$250/ton which was negotiated in 2007 for shipments in 2008.

FIGURE 6: WORLD ACID GRADE FLUORSPAR PRICES, 1999-2008



Source: Mineral Price Watch, 2009



## 9. SOUTH AFRICA

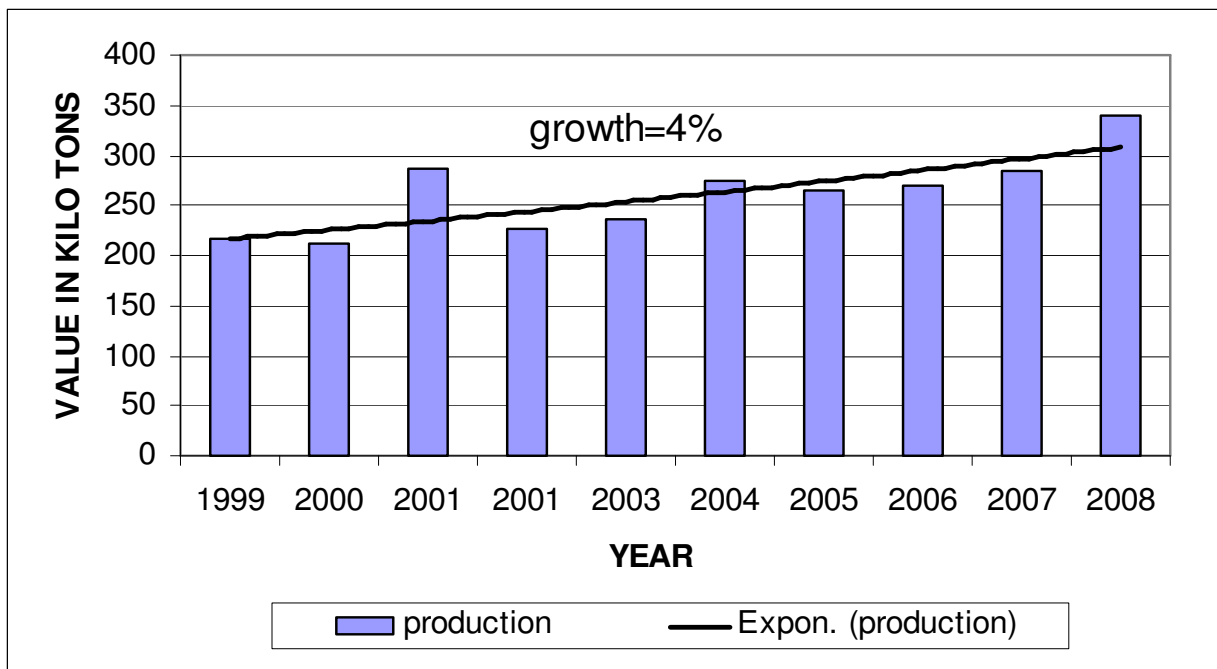
### 9.1. OCCURRENCES

South Africa fluorspar's largest occurrence of fluorspar is located in the Bushveld Complex – currently mined by Vergenoeg. The Vergenoeg fluorspar resource remains one of the biggest in the world and reserves are sufficient to accommodate any changes in the depletion rate without noticeably reducing the mine life from its current 100 year plus. Fluorspar deposits are also found in the Malmani subgroup, of the Transvaal Supergroup, in the south western part of Marico District, south of Zeerust.

### 9.2. SUPPLY AND DEMAND

South Africa's production of fluorspar has grown at a rate of 3 percent pa from 1999 to 2008 and peaked at 340 kt in 2008 (Fig. 7). Growth was driven by attempts by South African producers to make up for shortfalls on world markets as a result of China's reduction in export quotas. South Africa's producers are the Vergenoeg Fluorspar Mine, owned by Metorex and Sallies' Witkop Mine, which is currently mothballed.

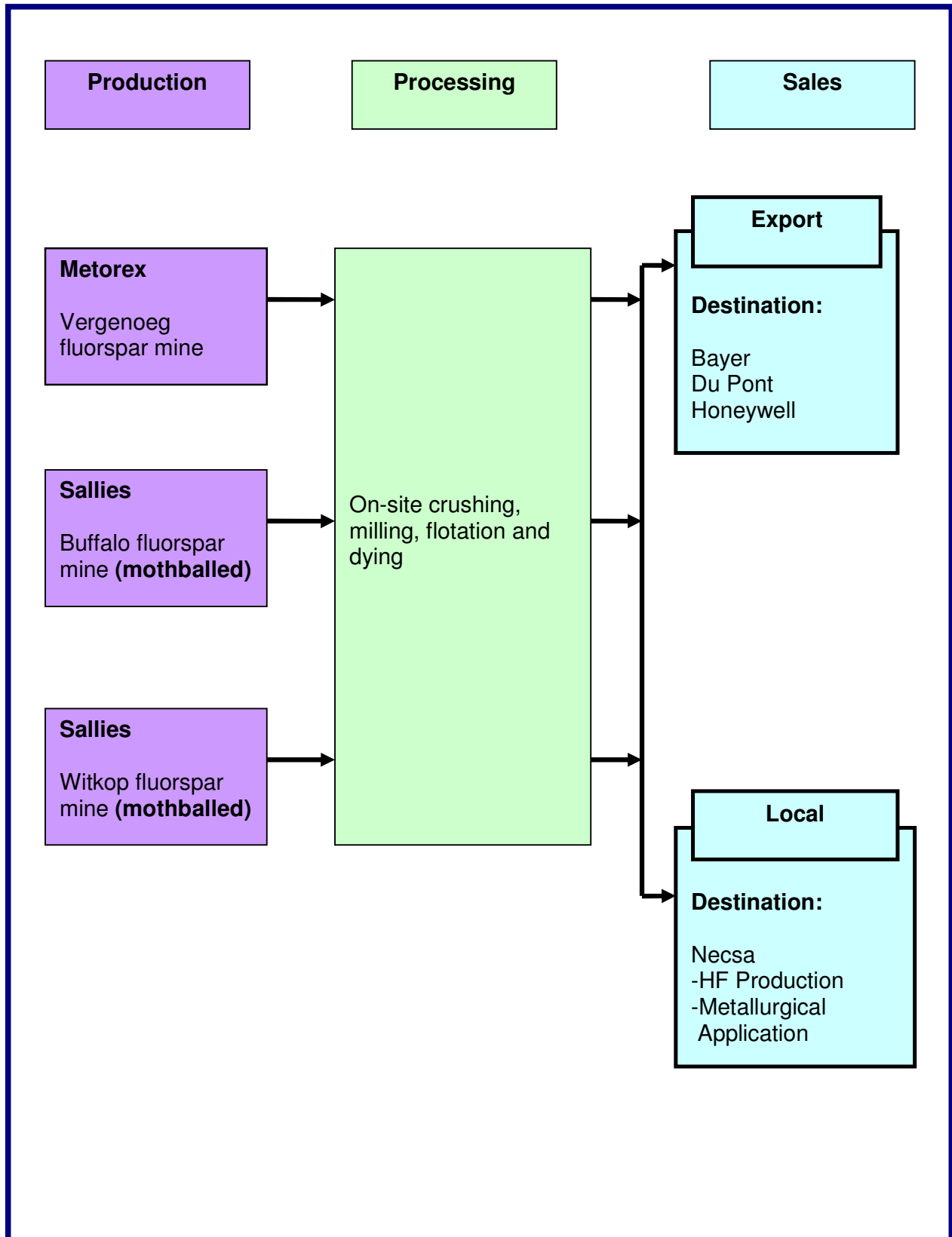
FIGURE 7: SOUTH AFRICAN PRODUCTION OF FLUORSPAR, 1999-2008



Source: USGS, 2009

More than 90 percent of South Africa's production is exported to the leading fluorochemical producers viz. Honeywell / du Pont (USA) and Bayer (Germany). Local sales are mainly to NECSA which produces HF and other downstream fluorochemicals, with smaller amounts used in metallurgical applications (Fig. 8). Local sales volumes have been declining since 2002, attributed to the improved modern smelting technologies using less fluorspar flux compared to the previous years.

FIGURE 8: FLUORSPAR INDUSTRY AND COMPANY STRUCTURE



Source: DME, Directorate Mineral Economics

## 10. DEVELOPMENTS IN 2008/09

Sephaku Holdings announced that it will start exploration work on two fluorspar projects in South Africa. The Naauwpoort/Kromdraai project is adjacent to the Vergenoeg Mine. Resources are estimated at more than 8 Mt of ore grading 24.6% calcium fluoride ( $\text{CaF}_2$ ). Sephaku's Plattkop project, contains an additional resource of 4 Mt. Sephaku plans to build a 130 kt per year flotation plant that would be fed by a blend of ore from both deposits at 32%  $\text{CaF}_2$  average feed grade.

Metorex sold a 15 percent stake in the Vergenoeg Mine to a BEE consortium, Medu Capital for R105.7 million in 2009. Metorex introduced BEE into Vergenoeg to meet the ownership requirements of the Mineral Petroleum Development Resources Act (MPDRA), which state that companies operating in South Africa have to have 15 percent BEE ownership of their assets by 2009 and 26 percent by 2014.

The International Chamber of Commerce Arbitration Court in Switzerland ruled in favour of Honeywell International in a supply contract dispute with fluorspar producer Sallies. Sallies will have to pay Honeywell R11.5 million plus interest. The amount awarded was significantly lower than the R65 million that was originally claimed or the R42 million claimed by Sallies in its countersuit. Following the Court's decision, Sallies requested that the Federal Supreme Court of Switzerland review the decision. As part of Sallies' request, it asked the Swiss Supreme court to instruct the Arbitration Court to reject Honeywell's request and approve their counterclaim.

Sallies announced temporary closure of the Witkop Mine in 2009. The mine stopped production due to the deteriorating demand of acid grade fluorspar as a result of the global economic crisis. There has been significant destocking by consumers resulting in Witkop's inability to secure future orders. Sallies mothballed its Buffalo Fluorspar mine in October 2008, which was treating tailings from previous fluorspar mining activities. Fluorspar produced from the tailings was high in phosphorus – 1200 parts per million (ppm) compared with 400 ppm from the company's Witkop mine. Sallies found it difficult to market the high-phosphorus product at a reasonable price and the operation lacked mining infrastructure.

Camec continued work to identify the size of the Doorhoek fluorspar deposit. It is envisaged that 1.5 Mt of ore will be milled to produce 350 kt of acid grade fluorspar.

## 11. VALUE ADDITION

Pelchem, a chemical subsidiary of the Nuclear Energy Corporation of South Africa launched the Fluorochemical Expansion Initiative (FEI) in 2009, aimed at enhancing value addition in the fluorochemicals industry in the country. This initiative would increase the consumption of fluorspar on a local scale. South Africa's competitive advantage is that it has an estimated 18 percent of world fluorspar reserves, following China's estimated 51 percent. Moreover, Pelchem has leading fluorochemical technology, skills and R&D. The FEI could be used to alleviate the power supply challenges through the production of lithium batteries, solar panels, hydrogen fuel cells and an array of other energy sources from fluorspar derived products. It could also assist in support of the nuclear fuel programme, as fluorspar is used in the processing of uranium.

In 2008, Spanish fluorspar producer Minerales Y Productos Derivados S.A (Minersa) announced that it would replace Tunisian aluminium fluoride maker, namely Industries Chimiques du Fluor (ICF) as the major shareholder and technology partner of Alfluorco, a South African hydrofluoric acid and aluminium fluoride joint venture. Alfluorco situated in Richards Bay, is owned by the Industrial Development Corporation (IDC) (25percent), Metorex (35 percent) and Minersa (40 percent). An environmental impact assessment is being conducted for the proposed R500 million hydrofluoric acid (HF) plant. The project would require 70kt of fluorspar a year which would be converted into 32kt of HF and then into aluminium fluoride. About 8kt of HF will be supplied to Pelchem. Currently South Africa is exporting fluorspar which is converted into aluminium fluoride in other countries and resold in South Africa. As South Africa proceeds with the expansion on the nuclear programme, it will need more HF for use in uranium enrichment process.

The FEI and Alfluorco project is supported by the DMR's beneficiation drive that seeks to promote downstream value addition of minerals in South Africa. The use of offsets in BEE requirements in line with the DMR's beneficiation strategy was a critical enabler of the Alfluorco project which demonstrates Governments intent to create a conducive environment for value addition in South Africa.

## 12. ENVIRONMENTAL IMPACTS

The Montréal Protocol is an international treaty that eliminates the production and consumption of ozone depleting chemicals such as chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform. In the early 1990's, these substances were replaced with fluorinated greenhouse gases (F-gases) which consist of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>). F-gases and certain HFCs, however, have an extremely high global warming potential and are being emitted at an increasing rate. For example, the refrigerant R134a (tetrafluoroethane) is a single HFC compound used in motor vehicle air-conditioners, has no effect on the ozone layer but has a global warming potential (GWP) of 1300. GWP is a measurement of how much effect the given refrigerant will have on global warming in relation to CO<sub>2</sub>, where CO<sub>2</sub> has a GWP of 1.

The Kyoto Protocol, on the other hand, is an international treaty of the United Nations Framework Convention on Climate Change (UNFCCC). This treaty aims to stabilize the concentrations of 4 greenhouse gases (carbon dioxide, methane, nitrous oxide and sulphur hexafluoride) and 2 groups of gases (hydrofluorocarbons and perfluorocarbons) that are produced by industrialised countries.

The EU has since 2003 made efforts to phase out HFC's because of their global warming potential. This coupled with climate change legislation being debated in the US may herald a possible shift away from fluorine based refrigerants. Alternate refrigerants such as ammonia, carbon dioxide and hydrocarbons are being considered. However, the international fluorochemical industry is backing hydrofluoroolefins (HFO's) as HFC replacements, which are likely to consume similar amounts of fluorspar as the compounds that they would replace.

As much as Europe and the USA are moving ahead with legislation to phase out HFC's, China is building a massive fluorochemical market for domestic and export purposes. China was given added time and incentives to implement the Montreal Protocol to phase out CFC's and switch over to the non ozone depleting HFC's. China can produce and export HFCs and earn emission credits for every ton of HFC produced instead of CFC's. It would seem that in this case, the Montreal Protocol is working against the Kyoto Protocol to limit or halt the production of HFC's with high global warming potential.

### **13. IMPACT OF THE RECESSION ON THE FLUORSPAR MARKETS**

The global financial meltdown affected new/renewed supply contracts mining companies in 2008. The effect on demand and prices became more protracted in the 2<sup>nd</sup> quarter of 2009. Aluminium and steel markets were affected first, with the effect on the downstream fluorochemical market becoming progressively worse in 2009. Demand for HF and fluorspar reduced dramatically in 2009 resulting in the temporary shutdown of Witkop and Kenya Fluorspar. Moreover, dampened demand put new mine projects on hold and financing of new projects has become difficult in current economic times. China's continued reduction of export quotas has led to a number of proposed new mining operations such as the Nui Phao Mining Company in Vietnam, Tertiary Minerals in Sweden and Mongolia Minerals. A number of companies have begun investigating reopening old mines or exploiting deposits adjacent to old workings, including Burin Fluorspar in Canada and Hastie Mining in the USA. In China, companies that have previously exploited deposits in Zhejiang have begun developing new deposits in Inner Mongolia, Fujian and Jiangxi. The current financial crisis will delay implementation of most of these projects.

## 14. OUTLOOK

Since over 80 percent of world fluorspar production goes into hydrofluorocarbons (HFCs) and aluminium trifluoride manufacture, future demand for fluorspar will be dependent on end use markets such as refrigerants and iron and steel production. The performance of these sectors is generally linked to global Gross Domestic Product. Demand of fluorspar in the manufacture of aluminium fluoride and synthetic cryolite has grown over the past decade but, growth will be tempered as smelting technology improves.

In the post recession short term, demand for fluorspar is expected to be strong as China continues with its reduction of fluorspar exports. The long-term outlook for fluorspar is uncertain. Efforts by the European Union to phase out HFCs because of their global warming potential together with climate change legislation being debated in the United States may herald a possible shift away from fluorine-based refrigerants to non-fluorine based refrigerants. However, China's move to build a fluorocarbon industry for domestic and export purposes may delay successful implementation of newer environmental legislation. As China obtains emission credits in terms of the Montreal Protocol for moving away from CFCs to HFCs and have invested heavily in its fluorochemical sector, any further moves to switch to HFC alternates would naturally be delayed.



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