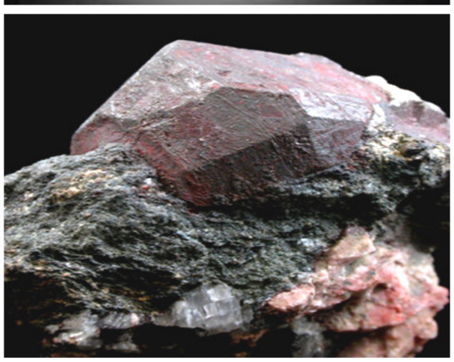
REPORT R71/2008

AN OVERVIEW OF SOUTH AFRICA'S TITANIUM MINERAL CONCENTRATE INDUSTRY

DIRECTORATE: MINERAL ECONOMICS






mineral resources

Department:
Mineral Resources
REPUBLIC OF SOUTH AFRICA

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DIRECTORATE MINERAL ECONOMICS

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1 INTRODUCTION

Titanium was first discovered in 1791 and is the ninth-most abundant element in the Earth's crust and the seventh-most abundant metal. Titanium minerals are present in most igneous rocks and in sediments derived from them. Economic deposits of titanium minerals occur in beach sands in which the highly resistant titanium minerals were concentrated by natural erosion and along ancient and recent shorelines.

Ilmenite ($FeTiO_3$), rutile (TiO_2) and leucoxene ($CaTiSiO_5$), a secondary weathering product of ilmenite are all titanium bearing minerals used primarily to produce white pigment. A very small percentage of these minerals (± 10 %) are used to make titanium metal and chemicals which may be regarded as by-products of the white pigment industry.

The principal white pigment ores are ilmenite and rutile both of which are present to lesser or greater amount in most igneous rocks. All economically exploitable ilmenite and rutile deposits occur as recent beach sand or fossilized dune deposits generally referred to as heavy mineral beach sands, though hard-rock resources are known.

Other ‘heavy’ minerals commonly occurring in association with ilmenite and rutile in heavy mineral beach sands are zircon, monazite and garnet, each of which may have economic value. Pig-iron is a significant by-product recovered during the processing of ilmenite concentrates to titanium slag, itself an intermediary product in the manufacture of titanium pigment.

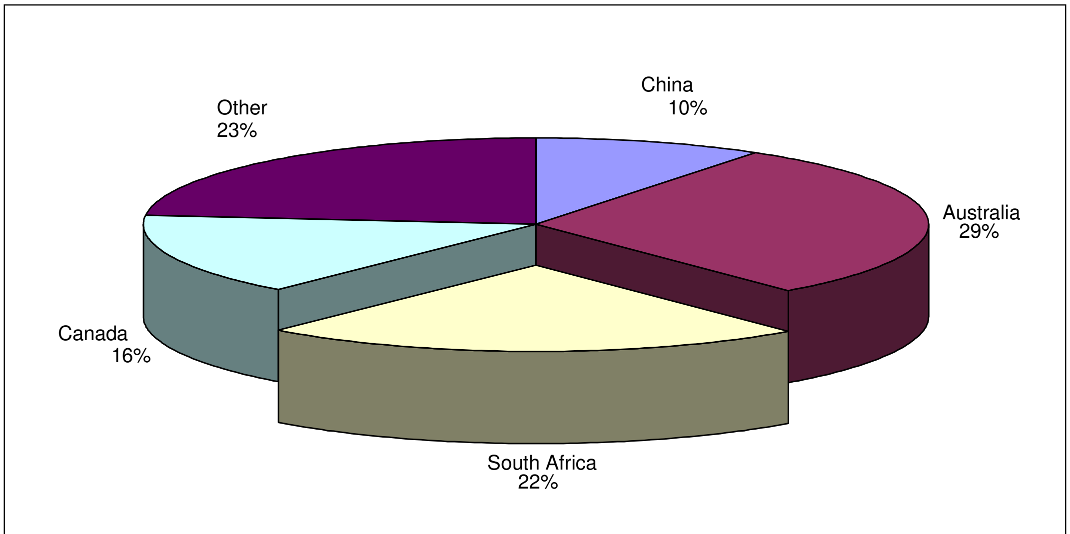
Australia and South Africa collectively account for just over 50 percent of the total supply of titanium mineral concentrates.

2 STRUCTURE OF SOUTH AFRICA'S TITANIUM MINERALS INDUSTRY

2.1 Main producers

South Africa is the second largest producer of titanium-bearing minerals in the world after Australia, accounting for about 22 percent of 6,1 Mt global production (Fig 1). In South Africa, titanium economic minerals, ilmenite and rutile, are produced from the extensive beach placer deposits located along the eastern, southern and north-eastern coasts with minute deposits along the west coast, north of Cape Town. Titanium minerals are recovered at three major mines namely, Richard's Bay Minerals' Tisand (Pty) Ltd and Exxaro's Hillendale and Namakwa Sands mines.

Figure 1: Percentage regional distribution of 6,1 Mt world titanium minerals production, 2007



Source: USGS statistics

Richards Bay Minerals (RBM), situated along the Indian Ocean coastline in northern KwaZulu-Natal at Richards Bay, is a leading producer of titania slag, high purity pig iron and rutile in South Africa. Richards Bay Minerals is the trading name for two registered companies, Tisand (Pty) Ltd and Richards Bay Iron and Titanium (Pty) Ltd (RBIT). Tisand is responsible for the dune mining and mineral separation operations, and RBIT the smelting and beneficiation process. The company is jointly owned by Rio Tinto plc and BHP Billiton, and is one of the largest single mining operations in South Africa.

Richards Bay Minerals (RBM) is the largest titanium slag producer in the world with annual productions of about 1 Mt, and mining reserves estimated to last around 20 years at current production rates.

Namakwa Sands, formerly owned by Anglo American Operations but acquired by Exxaro in 2007, is another major player in the production of titanium slag. The Brand se Baai mine and Saldanha Bay smelter facility produces about 250 kt of titanium slag per annum as well as pig iron and rutile from reserves of about 500 Mt. Another Exxaro subsidiary, KZN Minerals, operates the Hillendale mine and smelter near the town of Empangeni in Kwazulu-Natal.

2.2 Mining and processing

Dredging and dry mining techniques are used for the recovery of heavy-mineral sand deposits. Gravity spirals are used to separate the heavy minerals suite, while magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is beneficiated to synthetic rutile or titaniferous slag. Although numerous technologies are used to produce synthetic rutile, nearly all are based on either selective leaching or thermal reduction of iron and other impurities in ilmenite. Titaniferous slag with a TiO_2 content of 75 percent to 95 percent is produced commercially using pyrometallurgical processes.

- Richards Bay Minerals

Richards Bay Minerals (Tisand) mines heavy mineral sands by means of dredging sand from a man-made freshwater pond and separating the heavy mineral fraction in a floating separator. The heavy mineral concentrate is then road-hauled to a plant (RBIT), some 7 km inland, for separation of the heavy minerals into ilmenite, rutile and zircon fractions. The ilmenite is smelted and transformed to titanium slag, with pig-iron recovered as an important by-product. The slag is then milled and then classified into two product sizes suitable as a raw material for both the sulphate and chloride pigment processes (see section 4).

- Exxaro

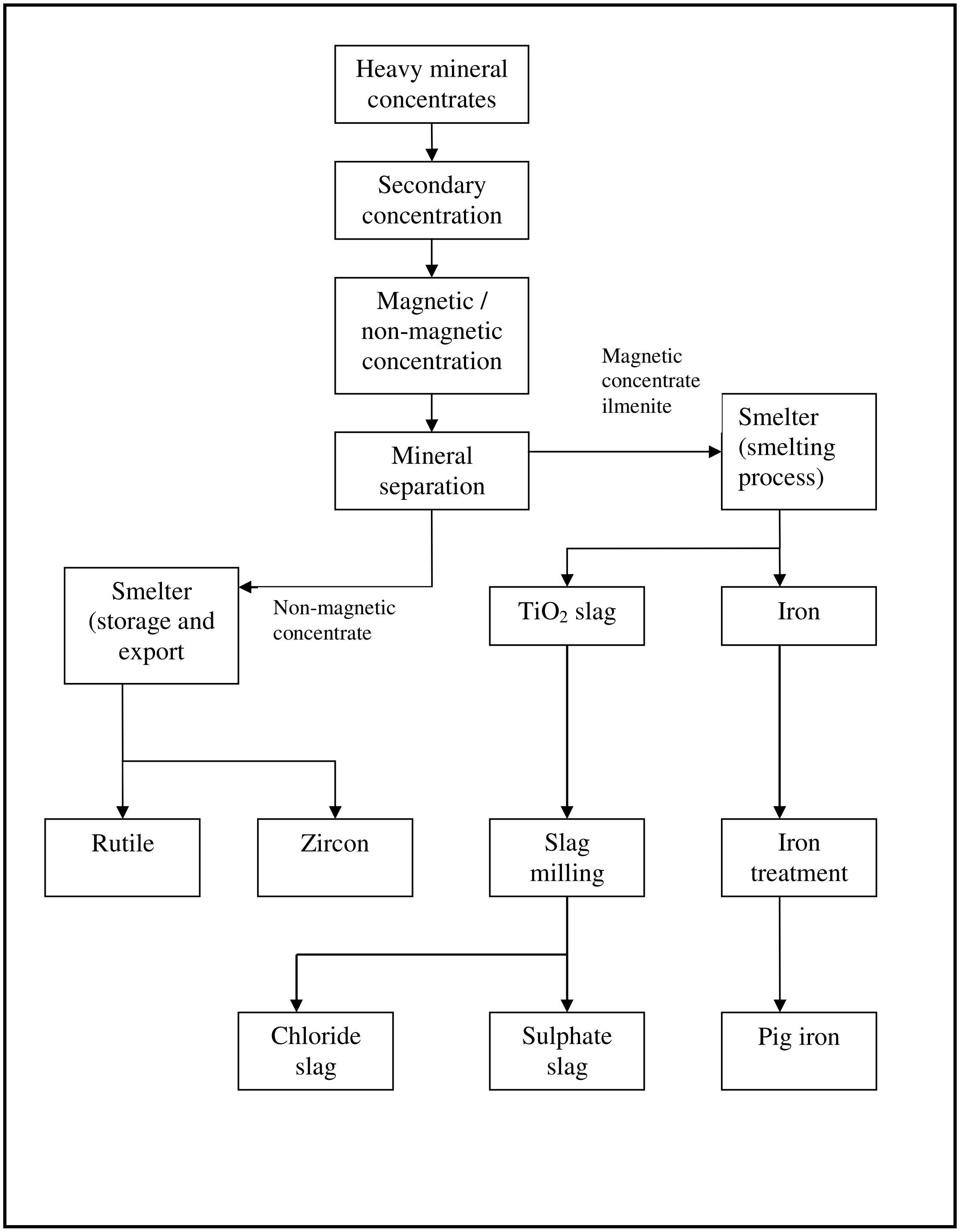
On the west coast, where an upper portion of the Namakwa Sands ore is embedded in a hard silcrete layer, mining operations are carried out by stripping the hard layer with front-end loaders. The mine is divided into three production stages, viz. mining and preliminary concentration of heavy minerals on the mine site at Brand-se-Baai. Processing and separation of heavy mineral fractions are carried out at a mineral separation plant, north of Koekenaap. The ilmenite concentrates are then taken to a smelting operation, situated 7 km from the Saldanha Bay export terminal (Fig 2). The slag milling, viz. chloride slag and sulphate slag are further used downstream in the processing of TiO_2 via the chloride route or sulphate route (see section 4).

KZN Sands, another Exxaro subsidiary, uses hydraulic mining at the Hillendale mine, 20 km south-west of Richards Bay, to produce slurry for the mine's primary wet plant. Further processing, including smelting of ilmenite to produce titanium dioxide slag then takes place at the central processing complex in Empangeni, 20 km west of Richards Bay. KZN Sands produces ilmenite, slag fines, zircon, rutile, leucoxene, low manganese pig iron and chlorinatable titanium dioxide slag (see section 4).

- Huntsman Tioxide Southern Africa

A minor portion of the slag produced in South Africa is consumed by Huntsman Tioxide Southern Africa with a 25 kt per annum capacity titanium pigment plant at Umbogintwini, in Kwazulu-Natal. Huntsman Tioxide is the only company producing titanium dioxide (TiO_2) pigment in the country. In addition to the manufacture of titanium dioxide pigments, the factory is also involved in the manufacture and sale of co-products arising from the pigment plant operation, viz. tionite and gypsum. Beneficiated products are then sold further downstream to local and international consumers. The company uses the sulphate route to produce titanium dioxide (see section 4).

Figure 2: Basic flow diagram of titanium-bearing minerals processing

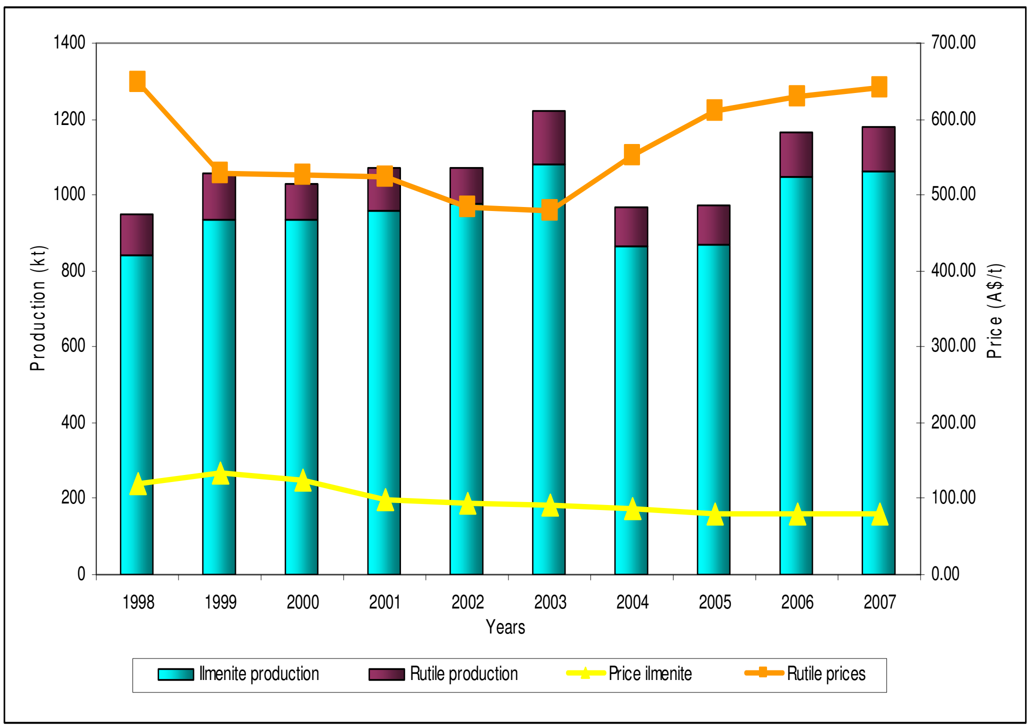


Source: Southern African Pyrometallurgy, 2006

2.3 Production, Consumption and Markets

Over the past decade (1998 – 2007), the country has produced a cumulative total of 10,7 Mt of titanium mineral concentrates. During this period, annual production fluctuated between 950 kt and 1223 kt, generally increasing at a rate of 1,34 percent per annum (fig 3). A notable rise of 12,4 percent was experienced in 2003 relative to 2002. The increase might be attributed to the commissioning of Ticor South Africa (acquired by Exxaro) first furnace in 2003. The increased capacity soon dwindled in the following years, consequent to the supply build up that was experienced in 2003, which helped to sustain exports in subsequent years, 2004 and 2005. Soon after the depletion of the excess stockpile in 2006, production started to normalise again.

Figure 3: South Africa's titanium mineral concentrates production and prices (1998 – 2007)



Source: USGS data, 2007
Note: Titanium slag included in ilmenite production[1]

In 2007 South Africa's production rose slightly by 1,2 percent to 1181 kt compared to 2006. The country contributed 22 percent towards world titanium concentrates production of 6 091 kt in 2007, ranked second after Australia (25 percent), (Table 1).

[1] *To prevent double accounting, the ilmenite and slag productions are reflected as ilmenite production*

Table 1: Production of ilmenite and rutile by country, 2007

COUNTRY	PRODUCTION		SHARE		RANK	
	Ilmenite (kt)	Rutile (kt)	Ilmenite	Rutile	Ilmenite	Rutile
United States[2]	300	W	5.4	-	7	W
Australia	1340	209	24.1	42.6	1	1
Brazil	130	3	2.3	0.6	10	6
Canada[3]	816	-	14.7	-	3	-
China	500	-	9.0	-	4	-
India	340	18	6.1	3.7	6	5
Mozambique	100	3	1.8	0.6	12	7
Norway[3]	380	0	6.8	0.0	5	-
South Africa[3]	1060	121	19.0	24.6	2	2
Ukraine	280	57	5.0	11.6	8	4
Vietnam	200	-	3.6	-	9	-
Sierra Leone	10	80	0.2	16.3	13	3
Other countries	109	-	2.0	-	11	-
TOTAL	5565	491	100	100	-	-

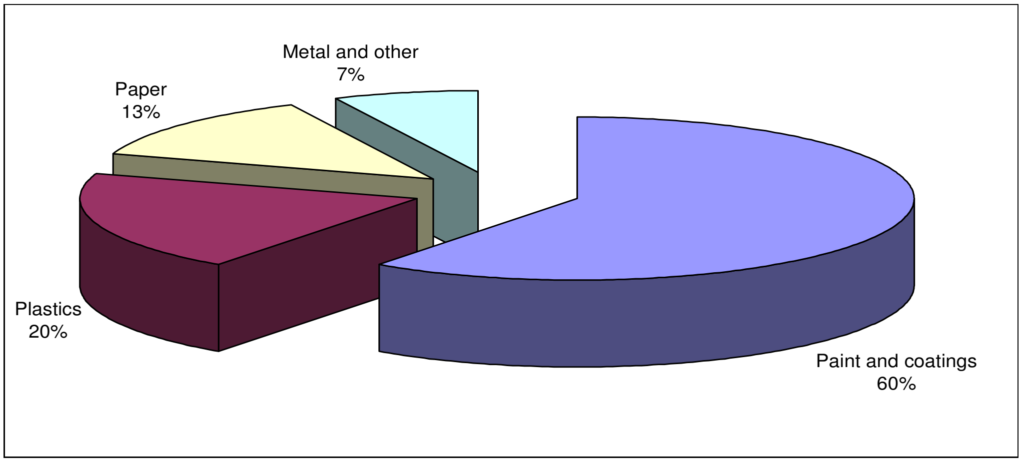
Source: Data based on USGS statistics

Demand for titanium mineral concentrates is driven by the pigment industry, which accounts for more than 90 percent of consumption of all titanium feedstock. The bulk of titanium mineral concentrates are used as feedstock in the production of titanium dioxide pigment. The main applications are in the manufacturing of paints (60 percent), paper (13 percent) and plastics (20 percent), (Fig 4).

The pigment industry uses titanium dioxide (TiO_2) because of its high refractive index and reflectivity, chemical stability, colour retention and thermal stability. This makes titanium dioxide a fundamental ingredient in a wide range of industrial and consumer products including paints, plastics, cosmetics, paper, rubber, ceramics and textiles.

[2] *Both ilmenite and rutile data are accounted as ilmenite production to avoid disclosing company information.*
[3] *Mine production primarily used to produce titaniferous slag.*
W – data withheld

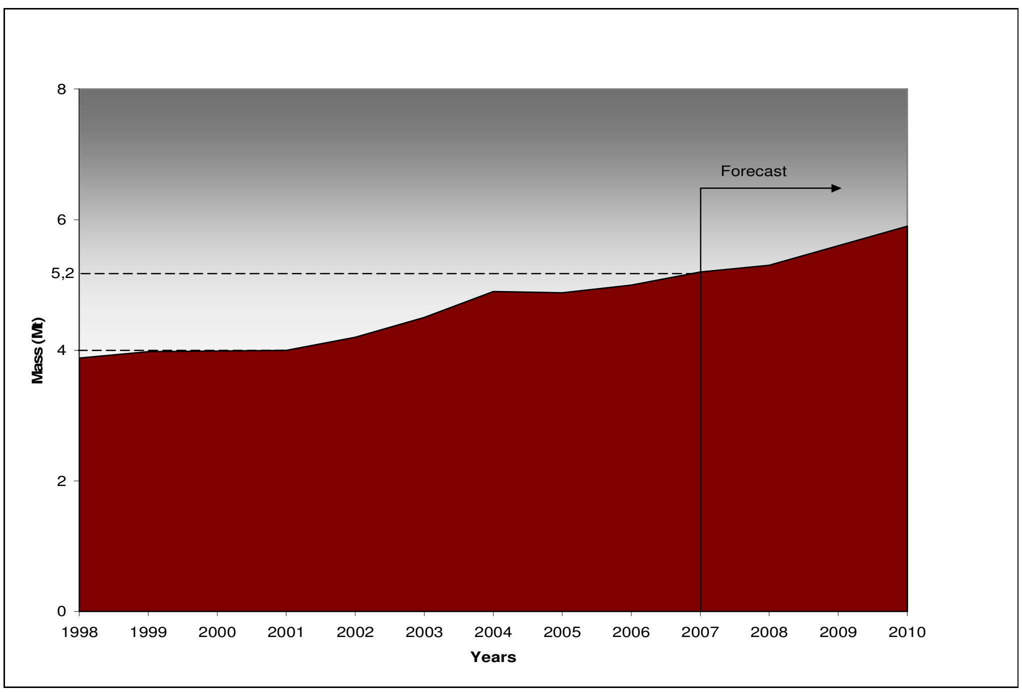
Figure 4: Global consumption of titanium dioxide



Source: GoldInsider 2006

Global demand for feedstock amounts to over 5,8 Mt annually with titanium dioxide pigment production currently at over 5,2 Mt annually (Fig 5). Titanium feedstock consumption is concentrated in North America and Europe, which account for more than half of the world's demand. China has however, in recent years become a major player in the global titanium dioxide industry with consumption growing at approximately 16,5 percent per annum.

Figure 5: Titanium Pigment Demand



Source: Artikol, TZMI, BHP Billiton

During 2007, the titanium market was fairly balanced, with demand estimated at about 5,8 Mt and supply at 6,1 Mt. Prices for ilmenite and rutile were A$ 80,00/t and A$ 647,31/t respectively. Slag prices in 2007 increased by 2 percent compared to 2006, reflecting the preference for high TiO_2 content chloride feedstock. Prices for feedstock generally stabilised in 2007 subsequent to price hikes experienced in 2004 and the first half of 2005. This suggests that existing supply capacity in the titanium feedstock industry is sufficient to satisfy the current needs of the market.

With the existing supply and exploration projects that are underway in Africa and elsewhere in the world, there is minimal risk of shortages of titanium mineral concentrates in the future as new mines are under development (see section 2.5). The possible development of new projects may result in an over supply of titanium mineral concentrates in the market, which may have a negative effect on prices in the future.

2.4 Adding Value to Titanium

Naturally occurring titanium minerals with high titanium dioxide content are scarce in supply. As a result the heavy mineral sands industry has developed several beneficiated products that can be used as substitutes or in conjunction with natural rutile. The main two beneficiated products are titanium slag and synthetic rutile, both produced from ilmenite. As a group, the naturally occurring titanium minerals and beneficiated products are referred to as titanium feedstocks, with ilmenite attributing about 90 percent of the titanium minerals production.

In South Africa ilmenite is upgraded into titanium slag, the bulk portion of which is exported with other titanium bearing minerals. These titanium mineral concentrates are used in several value added sectors, including pigment industry, plastics, superalloys, sporting equipments and medical applications. Other uses are found in batteries, functional fillers and chemical feedstock.

2.5 Recent and future Developments

2.5.1 Mineral Resource Commodities Projects

a) Mineral Resource Commodities (MRC), which is an Australian listed company, is still awaiting the approval from government for the mining rights of the R11 billion titanium deposits of Xolobeni Mineral Sands Project on the Pondoland coast in the Eastern Cape. MRC entered into a BEE agreement with the community-based Xolobeni Empowerment Company (Xolco), which will pay approximately R126 million for a 26 percent ownership. The area to be mined is the tenth largest heavy minerals deposit in the world and is believed to contain more than 9 Mt of ilmenite. The project is expected to have a mine life of 22 years and to produce 250 kt of ilmenite and 19 kt of rutile per annum from its reserves.

   The decision towards the awarding of the mining rights by the Department of Minerals and Energy was anticipated to be made available earlier in the first quarter of 2008. However, this was moved to a later date due to the need to thoroughly process the information of the application and balance it with the community's interest and strong opposition against the project by environmentalists.

b) The Tormin project by MRC, which is about 400-km from Cape Town, is expected to produce 49 kt per annum of high quality enriched non-magnetic concentrate containing predominantly zircon and rutile. Production is expected to take place in the first quarter of 2009.

2.5.2 Southern Mining Corporation Projects

a) Southern Mining Corporation has the rights to the Bothaville heavy mineral occurrence, which has estimated reserves of up to 90 Mt. The total inferred resource is estimated in excess of 185 Mt, with possible in situ heavy mineral reserves in excess of 50 Mt, based on an estimated heavy mineral grade of 30 percent. Of this, an estimated 40 Mt comprises the in situ valuable heavy minerals which, at a 75 percent recovery, should yield 30 Mt of valuable heavy minerals. The composition of these heavy minerals is estimated to constitute ilmenite (68 percent), zircon (9 percent), other titaniferous minerals (23 percent), Monazite (<1 percent).

2.5.3 Exxaro Heavy Minerals Projects

a) A proposed hydraulic Fairbreeze mining operation by Exxaro located 45 km south-west of Richards Bay. The mine is aimed at supplementing Hillandale's output to enable KZN Sands mineral separation plant to operate at design capacity of 105 tonnes per hour.

   Commissioning of the mine is planned for the second half of 2008.

b) Exxaro exercised its option of acquiring Namakwa Sands in 2007 with the sale expected to be completed in 2008, on condition that the old order prospecting and mining rights relating to Namakwa Sands are converted and registered into new order prospecting and mining rights.

2.5.4 Richards Bay Minerals Projects

a) Richards Bay Minerals to continue with a R1,2-billion tailings treatment plant project that would self generate its own power with a possible 35 MW of electricity by 2011. The project is going to employ the latest technology to retreat Richards Bay Minerals' waste that had been stockpiled for the past years, with commissioning occurring in July 2010.

   Furthermore this project is expected to extend the life of the mine by five years.

3 RESEARCH AND DEVELOPMENT

There have been numerous research and development projects undertaken by various tertiary institutions like the Central University of Technology, University of Pretoria and University of Cape Town towards finding cost effective methods of producing the titanium metal. Other organisations which have been conducting researches in this line are the Council for Scientific and Industrial Research (CSIR), Department of Trade and Industry, Department of Minerals and Energy and Mintek under the auspices of the Department of Science and Technology. The projects are mainly focused on beneficiation of the metal by different intermediate manufacturing processes like liquid titanium and titanium powder to produce the metal.

Research and Development programmes undertaken in South Africa are complementing similar R&D endeavours in the USA, Australia, Britain and Japan, with about 20 projects currently underway around the world (Table 2).

Table 2: Current R&D projects on titanium production processes

PROCESS NAME / ORGANISATION	COUNTRY	PROCESS	OUTPUT
TIRO/CSIRO	Australia	Chemical	Powder
Armstrong/Interantional Titanium Powder (TIP)	United States	Chemical	Powder
EMR/MSE (University of Tokyo)	Japan	Electrolysis	Powder
FFC Cambidge	UK and United States	Electrolysis	Powder
Idaho Titanium technologies	USA	Chemical	Powder
Idaho Research Foundation	USA	Chemical	Powder
MER CORP	USA	Electrolysis	Powder
OS (Kyoto University	Japan	Other	Powder
Peruke (Pty)Ltd	South Afrrica	Chemical	Powder
Preform Reduction (University of Tokyo)	Japan	Chemical	Powder
SRI International	USA	Other	Powder
VARTECH	USA	Chemical	Powder
BHP Billiton Polar Titanium	Australia	Electrolysis	Liquid titanium
CSIR	South Afrrica	Other	Liquid titanium
QIT (Rio Tinto)	Country	Electrolysis	Liquid titanium
GTT S.R.I	Italy	Electrolysis	Liquid titanium
Tresis International	USA	Chemical	Liquid titanium
MIR-CHEM	Germany	Chemical	Other
MIT two-year titanium initiative	USA	Electrolysis	Other
South African titanium (Peruke)	South Africa	Other	Other

Source Roskill (2007), Abare

4 ENVIRONMENTAL IMPACTS

The titanium dioxide industry is currently more environmentally friendly than it was in the past. Titanium dioxide pigments are stable under normal conditions and inert to most chemical reagents and therefore are not classified as harzardous to human health of the environment. The production of TiO_2 from ilmenite, rutile or upgraded ilmenite, such as synthetic rutile and titaniferous slag, is essentially a purification process in which the iron oxide and other impurities are removed. There are two processes: the older sulphate method (based on sulphuric acid), which uses lower-grade ilmenite than the newer chloride method (based on chlorine), which consumes high TiO_2 content feedstock.

4.1 The Sulphate Process

The process accounts for approximately 46 per cent of world capacity of about 5 Mt . The process uses sulphuric acid to dissolve the titanium dioxide, which is then precipitated, washed and calcined, and is followed by a final stage which involves chemical surface treatment of calcined product and sizing to produce various grades of TiO_2 pigments. This method produces both crystalline of TiO_2, anatase (used in high quality paper) and rutile (used in paints coatings and plastics).

A typical ilmenite feedstock would produce one ton of TiO_2 and waste material, including two to three tons of iron sulphate, 0,7 t to 1 t of other solids and several tons of sulphuric acid. Due to environmental lobbying, many TiO_2 processes have switched from an ilmenite (45 -55 percent TiO_2) to a slag feedstock (75 – 82 percent TiO_2), thereby reducing the sulphuric acid needed and waste material produced, or have switched to the chloride process. The sulphate method is, however, more labour, energy and capital intensive than the chloride method.

4.2 The Chloride Process

This is the chosen technology for new TiO_2 plants, and currently accounts for just over 54 percent of world capacity. The chloride process produces pigments with superior colour, more effective particle size distribution, consisting of 100 percent rutile content and a high gloss.

The process is considered to be the more environmentally friendly, mainly because it produces less waste. It is a two-step process in which the titanium-bearing ore is reacted with chlorine and coke to produce intermediate titanium tetrachloride ($TiCl_4$). The second step involves purification by distillation, thereafter the $TiCl_4$ is reacted with oxygen to produce pigmentary TiO_2. The chlorine is then recycled. The TiO_2 is chemically surface treated and sized to produce various grades of rutile pigment in a finishing stage. Anatase TiO_2 is not produced by the chloride process.

For each ton of TiO_2 produced, the amount of iron chloride generated ranges from approximately 1,2 t with an ilmenite feedstock to as little as 30 kg with a high grade natural rutile feed. Due to strict environmental regulations, the chlorinating of ilmenite only occurs where legislation allows the deep welling of hazardous iron dichloride at low cost. The chloride method represents a favourable environmental move, as it produces higher TiO_2 containing feedstocks that produce less waste.

5 OPPORTUNITIES AND BARRIERS TO DEVELOPMENTS

The heavy minerals industry is a technologically oriented field and lack of skills throughout the whole value chain is slowing down the necessary future developments in South Africa. There is an absence of world class downstream processing in the country and the infrastructure is limited to initially beneficiated slag.

There is a rising demand for titanium metal applications and new products in the world, but the economies of scale and the high level of technology required to process the metal make it difficult to exploit these markets.

The area of metal production presents favourable prospects contributory to economic growth and employment opportunities. Research and Development facilities at universities and in the industry require investment to establish and promote the material knowledge of titanium.

6 OUTLOOK

The market expected to face a deficit in feedstock as a result of continued increase in industrial applications across the board, but with the current new mine and exploration projects that are underway, there is minimal risk of shortages of titanium mineral concentrates in the future. The industry anticipates a period of slight oversupply in the future, which may also result in the softening of prices if demand growth remains steady.

With new innovative methods currently being investigated to make titanium metal cost competitive, the titanium industry is forecast to grow in all sectors in the medium to long term, thus presenting an opportunity for entry, particularly into the high titanium component of the industry. Consumption of titanium feedstock is also expected to grow as a result of increase in demand in its major driver, the pigment industry.

The expected metal demand growth of 4,2 percent per annum by 2015 presents an opportunity for new entrants such as South Africa to break into the titanium metal market. Penetration into the metal market would present favourable prospects in terms of employment creation and contribution to economic growth, considering that raw materials are extensively mined locally.

South Africa will continue to remain one of the major role players in the titanium feedstock industry in view of several new projects in the development pipeline.

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