A review of sub-Saharan heavy mineral sand deposits: implications for new projects in southern Africa

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Synopsis

The importance of the heavy mineral sands to southern African economic well-being cannot be over emphasized. The value of the worldwide titanium dioxide industry is estimated at $7 billion. Six out of eight of the world's proposed new project areas are in southern and eastern Africa, and a seventh at Tamil Nadu in India is partly owned by a South African company, Kumba Resources. The HMS industry can be highly lucrative; its return on capital is the best in the mining industry. There are, however, problems, particularly in the smelting technology. The often considerable affect of mining on environmentally sensitive coastal dunes is also becoming increasingly important. The medium-to long-term demand for Ti-dioxide pigment and ceramic grade zircon appears very healthy. If, as predicted, the costs of producing titanium metal can be reduced, then there is huge potential for the metal. In summary, the HMS industry is an attractive one to be in, with good returns and generally manageable risks. New business opportunities and their economic implications for Africa are discussed.

Introduction

Surficial dune and paleo-dune deposits of chemically inert and physically resistant heavy mineral sands (HMS) occur as economic concentrations along the sub–Saharan coastline. Worldwide these are an important source of titanium, titanium dioxide and zircon. Seventy five per cent of the world's titanium is produced from HMS, the rest being extracted mainly from hard rock sources in Canada and Norway (*TZMI*, 2001). South Africa is the second largest producer of titanium and zircon in the world after Australia. There are now three producing mines in South Africa: Richards Bay Minerals and Ticor, both in KwaZulu-Natal, and Namakwa Sands in the Western Cape. There are also another two well-advanced projects in Mozambique (Moma) and Kenya (Kwale).

Growing interest in heavy mineral sand deposits is reflected in the fact that since 1997 three international conferences on aspects of the heavy minerals industry have been held in South Africa. The geology, mining, environmental management, beneficiation, smelting and pigment manufacturing of heavy minerals and the deposits they occur in are topics of discussion. Detailed understanding of the geomorphology, mineralogy, internal structure and heavy mineral distribution within dune cordons and heavy mineral placers has grown significantly over the past two decades

HMS deposits contain percentages of heavy minerals that vary from 10 wt% to 35 wt% with economies of scale being the main advantage for larger deposits (Rozendaal *et al.*, 1999). Ilmenite ($TiFeO_3$) is the principle product, with zircon ($ZrSiO_4$) and rutile (TiO_2) as co-products and high quality pig iron and monazite as possible by-products. Ilmenite, rutile and 'synthetic rutile' (upgraded ilmenite) are the most important sources for titanium dioxide (Ti-dioxide) and are an indirect source of titanium metal.

Although strength and chemical inertness allow for important uses of titanium in the aerospace and medical industries, over ninety-five per cent of total titanium supply is for pigment production. Zircon is used as foundry sand, in TV screens and as a source of zirconia for the chemical industry, with its most important use being in the ceramics industry. It is estimated that South Africa earns R750 million annually through exports of zircon (www.rbm.co.za).

Six of the world's eight largest new HMS projects are in sub-Saharan Africa with the seventh at Tamil Nadu in India (partially owned by Kumba Resources), and the eighth being the large deposit at Murray Basin in Western Australia. One of the six African new projects, the Corridor Sands at Chibuto in southern Mozambique, promises to be the world's largest source of titanium.

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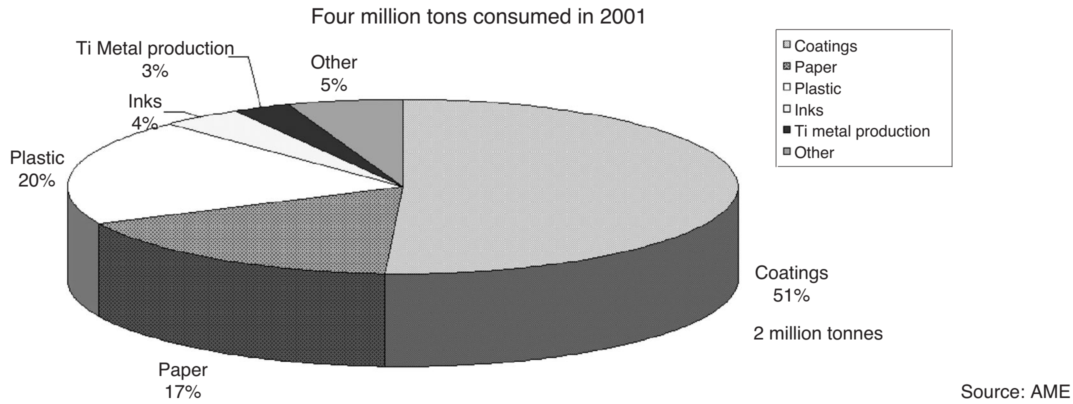

Figure 1—Uses of titanium dioxide

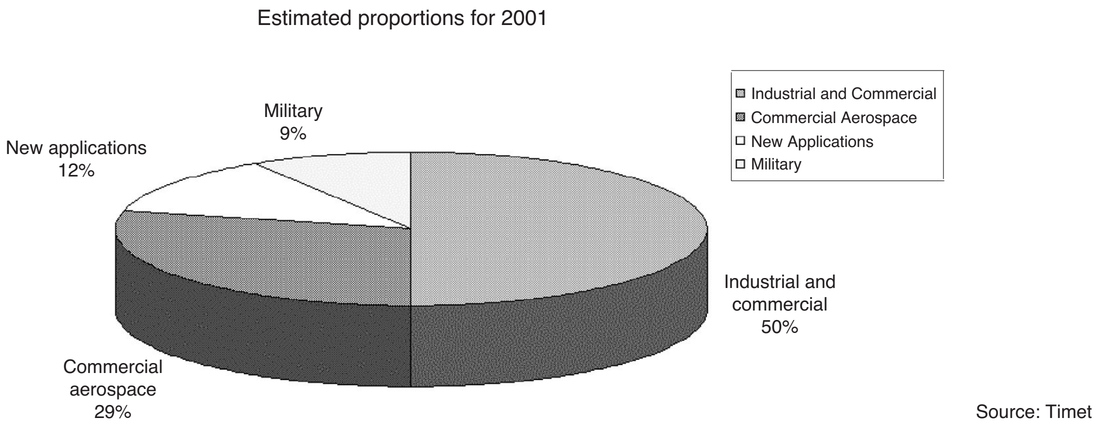

Figure 2—Uses of titanium

The relative ease of mining these loosely consolidated, profitable deposits makes HMS operations attractive. Mining coastal areas of natural beauty and environmental importance is not uncontested, as Richards Bay Minerals (RBM) discovered when they were prevented from expanding their operations into the St Lucia coastal dunes in the 1990s. Waste products of the ilmenite-upgrading technologies along the so-called sulphate route, produces large amounts of iron sulphate, some of which is economically recycled and sold. The chloride route involves calcining ilmenite with coke and chlorine gas to produce Ti-dioxide. Furthermore, the smelting of titanium slag is tricky with even the largest of companies, for example Anglo American at Namakwa Sands struggling to make new technologies work. The development of new technologies, such as electrolytic separation of titanium metal and improvements in electrostatic mineral separation should have a marked effect on the viability of future projects.

Though the type and grade of deposit is important, the ability to market the HMS products provides the competitive leverage and determines the profitability of the operation. In this respect the products are akin to industrial minerals where consumers have very narrow tolerance on the type and levels of impurities in the products.

Demand and uses of heavy mineral sands products

Titanium

Over fifty per cent of titanium dioxide production is used in the manufacture of pigments in lacquers, paints and enamels (www.tzmi.com). Titanium dioxide's ability to absorb ultraviolet light slows the degradation of plastics and paints and makes it useful as an inert barrier in sunscreen lotions. Being non-toxic, biologically inert and non-fibrogenic it can be safely used as a whitener and filler in foodstuffs, pharmaceuticals, and cosmetics. Products from the beneficiation of ilmenite via the chloride route are used at the premium end of the business, in paints, plastics and the chemical industry, whereas those produced via the sulphate route are used mainly in the paper industry. Rutile is used as a high-grade top-up in times of increased plant utilization, and in the production of titanium metal.

Titanium metal is forty-five per cent lighter than steel, twice as strong as aluminium, and can be machined with the same equipment as stainless steel (Saager, 1984). These characteristics, combined with the low thermal expansion coefficient and high melting point (1670°C), have enabled titanium and its alloys find important applications in the aerospace and defence industries. Under atmospheric conditions the metal is resistant to corrosion; it is unaffected by strong alkalis, chlorides sulphides or nitric acid. These properties mean that titanium is now being increasingly used in chemical processing plants, oil refineries, water desalination, and especially heat transfer applications where mildly corrosive seawater is the coolant. Titanium's good cryogenic properties mean that it can be used in tanks for shipping liquid nitrogen, hydrogen or helium (Kuhlman, 1980).

The metal is increasingly used in advanced engineering applications, spectacle frames, jewellery, bicycle frames and sporting goods, the most important of which has (since 1995) been the manufacture of golf club heads. In fact, eighteen per cent or 4750 t of the USA's total demand for titanium metal in 1996 was attributed to its new-found use in golf clubs (*Mining Journal*, June 98). Its general inertness means that it is finding use in prosthetic surgery, such as hip replacements, spinal implants, and dentistry, and in heart pacemakers.

Zirconium

Less than five per cent of recovered zircon is used in the production of metal, whilst over ninety-five per cent is used in various zirconium compounds (www.roskill.com). Its hardness, high melting point and low expansion coefficient when heated means that standard grade zircon is particularly suited as foundry sand and as an abrasive. Almost half of the zircon produced is used in ceramics applications because of its ability to scatter and reflect light. The surface layer of most tiles, bathware and crockery obtain their glazed finish, durability and resistance to discolouration from zircon being melted into their surfaces. The chemical stability and insensitivity of zircon to reducing gases during fluctuating furnace temperatures suggests that development of ceramic engines is probably an expanding market for zircon.

Zirconia finds a variety of applications in the chemical industry including antiperspirants, adhesives, catalysts, aqueous polymers, gelatin hardening and dyes. Zr-oxychloride is used in leather tanning, Zr-carbonate acts as an insolubilizer in the paper coating industry, while potassium hexafluorozirconate acts as a flame retardant for textiles.

Zirconium metal is relatively soft, malleable and easily worked. It has a high density with a high melting point of over 1670°C, and is therefore also used in modern superconductors. Other high technology uses for the oxide are in oxygen sensors, fuel cells and transducers in audio equipment. Due to its low absorption cross-section for thermal neutrons, zirconium is used in control rods for the nuclear industry. Also its ability to absorb X-rays makes it an important component of TV screens.

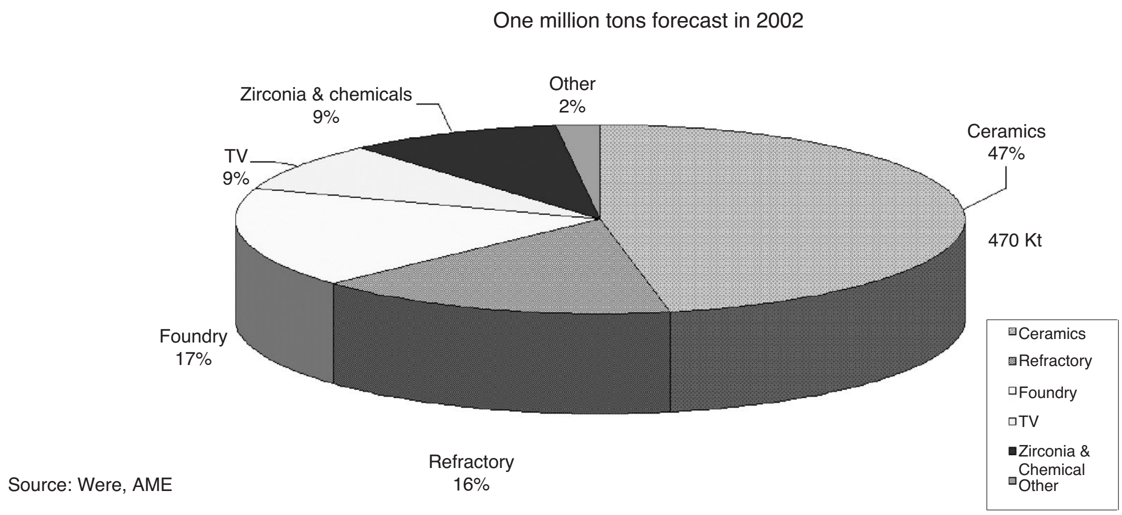

Figure 3—Zircon consumption

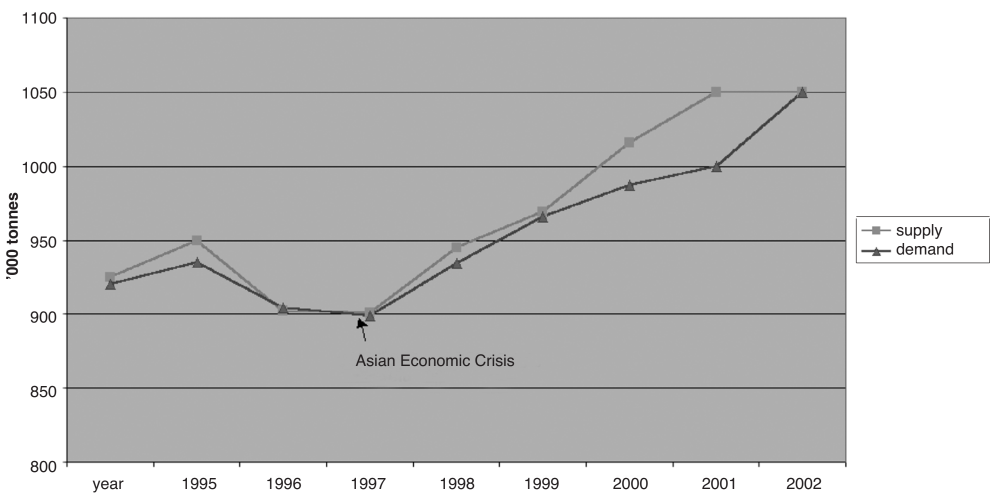

Figure 4—Zircon supply/demand

Supply and heavy minerals sand (HMS) producers

Production from heavy mineral sand deposits takes place mainly in the southern hemisphere, whereas the pigment producing beneficiators of mineral sands reside mainly in the northern hemisphere. Seventy per cent of HMS production is controlled by the top five companies. Dominance of the Indian Ocean region in the supply of zircon and titaniferous feedstock was investigated by Taylor and Moore (1997) who at the time of reporting identified the region as the world's most important producer of chloride grade pigment outside North America.

New non-African projects

A number of new projects worldwide are likely to make an impact on the industry, in the near future. Within the Indian Ocean region Taylor and Moore (1997) list India, Indonesia, Sri Lanka and Western Australia as the countries with the best potential for heavy mineral production. Kumba and Australia's Mineral Deposits Ltd have a strategic alliance to develop two new deposits in Tamil Nadu State, southeast India. Reports about the size of the deposit are not impressive, but the region is supported by good infrastructure including the deep-sea port at Tutuicorin. It also represents the opening of the Indian HMS industry to a genuine free market, to foreign investment, and to a potentially important role in the global industry. It has been suggested that India has total resources of 400 mt of ilmenite, with significant grades of zircon, rutile and rare earth elements (REEs).

The Murray Basin deposits in Western Australia are hosted in 320 000 sq km of fine intertidal-type sand and aeolian silts in a region high in slimes and covered by deep overburden. Rutile and zircon grades are reportedly high, but so are the chromite, magnesium impurities and radio-nuclide levels. Iluka Resources is the dominant company in the area, but other companies, notably Sons of Gwalia, and juniors such as BeMax and Basin Minerals also hold ground (*AME*, 2001). The politics and infrastructure are far superior to the planned new African operations. Assuming the technical difficulties can be overcome, and the Australian government makes good on its promises for infrastructure upgrades, the region should become a major mineral sands province.

Price movements and production forecasting

Prices for sulphate grade titanium dioxide averages $300/t, with the chloride product at around $400/t. There is not likely to be any dramatic reduction in sulphate grade production, as many of the remaining plants remain in the cash-strapped former Eastern Bloc.

Rutile prices have been on a steady decline since the mid-1990s. It should be noted that the current price of around $500/t is five times greater than that for sulphate grade ilmenite. Ironically, the price of natural rutile is capped by a lack of assured supply, exacerbated by the closure of Sierra Rutile in 1996. The product has substitutes in the form of synthetic rutile and QIT's upgraded slag. Trends for synthetic rutile have held within the range $300–$400/t since the early 1990s. The price for QIT's upgraded slag is usually higher at around $500/t. The economics of synthetic rutile production are currently inherently inferior to that of producing titania slag, which also produces pig iron as a co-product (Richard, 1999).

Production of zircon has increased over the last twenty years by about 1.8% p.a. Most of the new African projects are not enriched in zircon so there is no anticipated upsurge in

Table I

Summary of current and future African HMS producers

Operation	Ownership	African operations	Other operations	General
Richards Bay Minerals	RioTinto-BHPBilliton 50%-50%	RBM in Natal. RioTinto has exploration projects in Madagascar & Mozambique	RioTinto has exploration projects in Murray Basin	RBM world's most profitable HMS operation. 25% of global share of rutile, ilmenite and zircon
Tigen	BHPBilliton	Tigen; Zambezi Province, Mozambique		Moderate grade, awaiting final approval
Moma	Kenmare resources	4 deposits in Nampula Province, Mozambique		Moma Project moving ahead. Direct supply contracts signed with pigment producers. No plans to smelt
Namakwa Sands	Anglo American	Namakwa Sands West Coast	Exploration licences dropped in Mozambique	Zircon at Namakwa Sands is very high quality
Ticor	Kumba Resources and Ticor of Australia	Hillendale in production Fairbreeze to open in 2004?	Exploration at Tamil Nadu in India	Kumba is becoming an important player
Corridor Sands	Western Mining Corporation	Chibuto, Gaza Province		Largest titaniferous deposit in the world. Life of mine—100 years
Kwale	Tiomin Resources	South of Mombasa, Kenya	Canadian deposits	Mining Permit issued after long political–legal problems. No plans to use Tiomin's proprietary upgraded slag technology in Africa
Sierra Rutile	Nord Resources have recently sold to a small US co.	100 km SW of Freetown, Sierra Leone	?	World's largest rutile mine. Country very unstable
QMM	RioTinto & Madagascar Govt	Fort Dauphin, Madagascar.	RioTinto has REE rich deposits in Orissa India to develop	Country unstable. Serious environmental problems. Despite feasibility study, project seems stalled.
Xolobeni	Australian Mineral Commodities	Xolobeni is one of a number of deposits along the Transkei coast.	?	Poor infrastructure, environmental concerns. Possible small-scale production for feed to existing smelter?

production from the region. Australia is the world's largest supplier of zircon, accounting for almost 40% of supply. South Africa has a third of the market, but is closing the gap on Australia due to increased production at Namakwa Sands. This trend may reverse though as more Murray Basin deposits are initiated, assuming the fines problems can be overcome. Monthly prices for zircon have been volatile, but generally follow the state of the world economy. For example, in 1999 during the Asian economic crisis, prices dropped to below $300/t (www.roskill.co.uk).

Standard grade zircon prices now average $400/t, but the longer-term prognosis is good. The main application for zircon is in the ceramic glaze market, which has grown continuously over the last twenty years. Varying proportions of standard and micronized ceramic grade zircon are used, depending on the quality of the glaze. This has increased steadily with the increased strength of the Chinese economy and of their South East Asian neighbours. In South Africa, approximately four hundred tons per month of zircon are consumed in the manufacture of local tiles, which represents about sixty per cent of the market.

The use of zircon in TV and monitor screens is currently a small part of the market. Given the trend for larger screens, and continuing concern over radiation emissions, however, this market should continue to grow. It is particularly important in Asia, where over seventy per cent of TV sets are now produced. The proximity of this region to India and to a lesser extent Australia, gives them a competitive edge over the southern African deposits. The last twenty years has seen little growth in nuclear generating capacity, so consumption of zirconium metal remains fairly constant at 7 000–8 000 tpa.

Impact of recycling and substitution on the market

Titanium dioxide cannot be economically recycled nor are there any pending new technologies to allow this to happen. Zircon can be effectively replaced by tin oxide as a glaze, but this is unlikely to happen to any great degree as it is four times the price. The use of zircon in its various applications is largely dissipative and therefore recycling is not possible. Recycling of zirconium metal is theoretically possible, but the small amounts used in any one application mean that levels are negligible. Approximately half of total titanium metal is now recycled annually, much is derived from the scrapping of aircraft and tank armour.

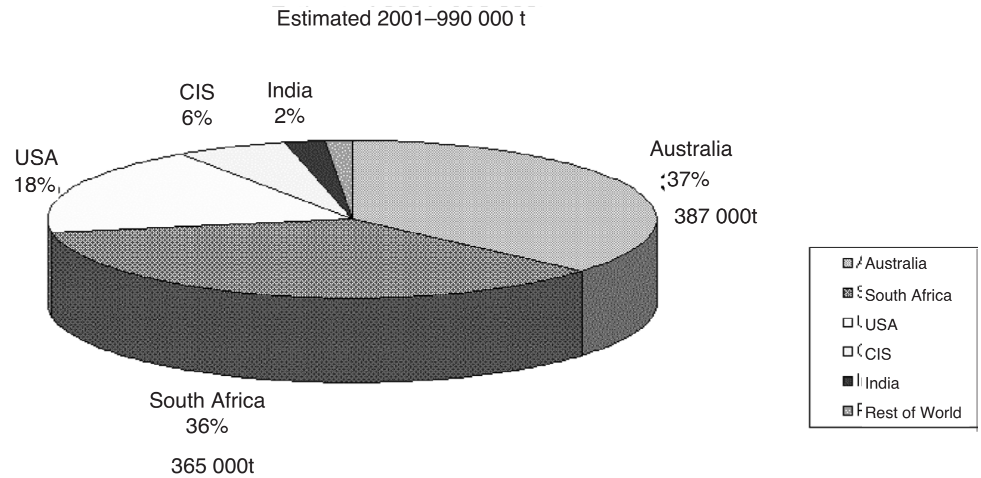

Figure 5—Zircon production by region

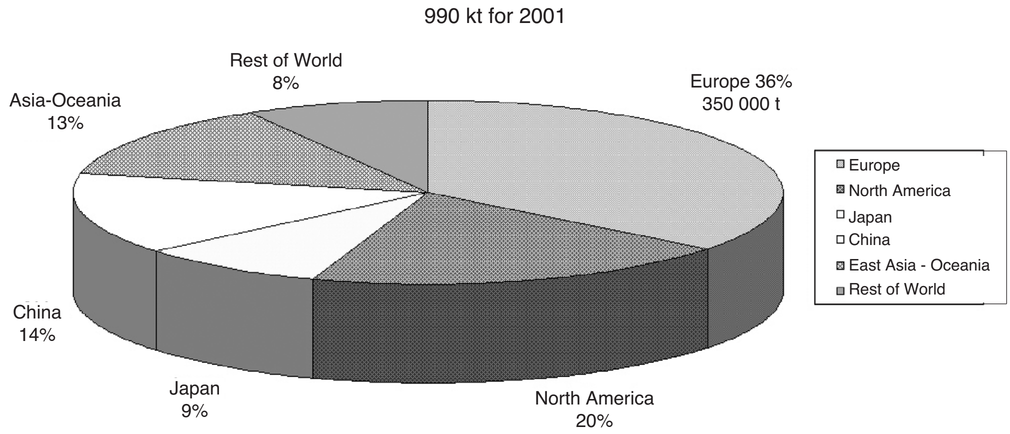

Figure 6—Zircon consumption by region

Supply–demand balance

The supply and demand balance for the various HMS products depends on a number of factors, including productive capacity, technological advances and the state of the world economy. The demand for titanium products appears to be inelastic, there being no real substitutes for titanium dioxide as a pigment. The situation in the titanium-metal industry is more complicated as there is a scrap market, and supply from the HMS-derived rutile operations is hard to determine. Interestingly, from 1980 there has been a price increase in real terms for HMS-derived products of approximately 1.3% p.a., whereas there has been a fall in base metal prices of 2% (www.tzmi.com). This superior price performance is due in part to the tight industry structure that is dominated by a few producers. An analysis of market fundamentals by Murphy and Taylor (1999) indicated that by 2005 the deficit in supply will absorb all the feedstock from new projects that were being developed in Southern Africa. More recently Were (2001) has indicated that demand in the next decade is predicted by most experts to grow between two and three per cent, whereas supply is only expected to rise by 0.5%.

Although titanium metal accounts for less than five per cent of the total TiO_2 feedstock consumption, it is a high value sector of the market (Were, 2001). As demand is closely linked to the aerospace sector, economic recessions, such as 1981/82 result in a significant drop in civil aircraft orders and a subsequent oversupply in sponge (Saager, 1984). Following a surge in orders from the aviation industry, the prices of titanium tripled in the period 1994–1999. An increase in civil aviation orders was widely anticipated during 2002; unfortunately the attack on the World Trade Centre has badly affected the airline industry, slashing orders of new civilian aircraft.

Production of titanium sponge from hard rock sources Russia, Kazakhstan and China is an important factor. In the mid-1990s increased demand for titanium sponge was met by a surge of exports from the CIS, partly due to the scrapping of large numbers of surplus warplanes.

The intensely competitive market has necessitated the consolidation of pigment production over the last ten years. There are now five main pigment producers: Dupont, Huntsman Tioxide, Millennium, Kronos, and Beyer. There is a strong correlation between pigment price and economic performance of the major powers (see Figure 7), though the average during the 1990s was $2 000/t.

Over sixty per cent of TiO_2 feedstock requirements are now processed by the chloride route, which is cheaper and more environmentally friendly than the older sulphate route technology. Since 1998 there has been a slight oversupply in chloride grade feedstock, caused in part by BHP's decision to revert its Norwegian Tinfoss operation to chloride grade due to the closure of its Beenup Mine. Partly due to this closure, there has been a steady undersupply of sulphate feed for a number of years (Were 2001).

The effects of new technology on the industry

So much of the profitability of HMS operations depends on the processing and marketing of the product that companies guard information on their proprietary technologies jealously (Were, 2001). New technologies for mineral separation include developments in spiral circuits, applications of power ultrasound for cleaning mineral sands, electrostatic and high-tension electrostatic separation, as well as improved gravity separation techniques (Abela, 2003; Collings and Farmer, 2003; Elder and Yan, 2003; Germa *et al.*, 2003). Technological advances in a number of fields should increase the profitability of HMS operations in the near future.

Despite its incredible usefulness, titanium metals major drawback is its cost, currently six times that of stainless steel. The production of Ti metal requires more energy than any other primary metal (see Table II). The process is tricky as molten titanium readily combines with oxygen, nitrogen, carbon, water and most refractories! The two commercial processes (Kroll and Hunter) are similar and involve the chlorination of rutile or synthetic rutile to titanium tetrachloride.

An important area of research is that of using electrolysis to purify titanium dioxide. The work is being undertaken by British Titanium PLC, using the so-called FFC Cambridge

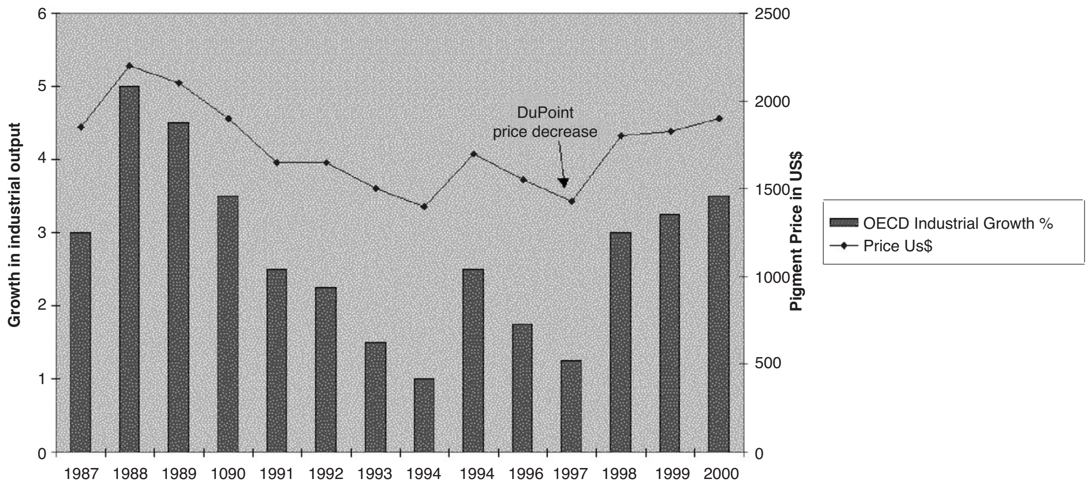

Figure 7—Relationship between industrial growth and titanium dioxide pigment price

Table II

Energy consumption for major metal production

Primary metal/alloy	Energy requirement (kWh/kg)
Titanium sponge	30–40
Magnesium ingot	13–19
Aluminium ingot	13–15
Ferrochrome	3–5
Copper	0.5–1
Steel ingot	~ 1

Modified from Coetzee (1976), by data from Roskill, AME and Brooke Hunt

process, now being tested in a pilot plant (*New Scientist*, June 2001). The process utilizes a cell filled with molten calcium chloride, which acts as the electrolyte. Titanium dioxide powder itself forms the cathode, while the anode is made of inert carbon. The titanium dioxide is reduced to titanium metal, and oxygen is released. The O ions flow to the anode, where they are released as a gas.

It is impossible to quantify the effects that this technology will have on the industry. If the FFC pilot plant is successful then whole new areas of applications could be opened up to the now cheaper titanium metal. This could include increased use of alloys in skyscraper, ship and even vehicle construction. Titanium hulled yachts have already been produced in Japan (Saager, 1984).

Removal of radio-nuclides

Both the real and perceived danger of radioactive impurities that often occur within ilmenite and zircon is an area that is receiving attention. Early research by Aral *et al.* (1997) indicated that although thorium and uranium were uniformly distributed in the zircon lattice, leaching with hot sulphuric acid removed 24% and 13% of these minerals respectively. More recently Aral *et al.* (1997) found that fluxing finely ground zircon with sodium and calcium borates and carbonates almost totally removed the nuclides. The ability to efficiently remove these impurities will definitely improve the marketability of the products from the coastal deposits in Mozambique and Kenya.

U and Th often occur in trace amounts in the zircon crystal lattice. The decay of these radioactive elements leads to a gradual breakdown in the crystal structure to a metamict form, and discolours the mineral. Work at Mintek and CSIRO Minerals has resulted in a potential solution to this problem (Aral, 1999). A heat leach process has been developed which reduces the U and Th content fivefold. It involves heating the zircon to above 1100°C, and leaching with acetic acid whilst using calcium borate as a flux. It is unclear whether BHP imported this knowledge to their JV at Moma in Mozambique.

Mineral separation processes

Despite recent advances in froth flotation techniques, the only commercial way to separate the THM content from the gangue is by wet gravity techniques, utilizing cones, spirals, Reichart cones and sluices. Dry magnetic and electrostatic beneficiation of the ilmenite-rich deposits near Gravelotte (Northern Province) is unique in that the orebody is amenable to dry milling and generally has coarser size distribution than beach sands The heavy mineral concentrate (HMC) produced from the wet separation process typically contains 90–98% HM. After drying, a combination of magnetic, electrostatic and gravity separators are used to subdivide the HMC. The magnetic minerals, ilmenite, leucoxene and monazite, can normally be separated relatively easily from the non-magnetic zircon and rutile.

There has been a steady development in heavy mineral separation technology in the last twenty years (www.tzmi.com). In the early, 90s for example, permanent REE magnets began to replace the energy consuming electro-magnets. In the newly developed enhanced field separators (EFS), multiple electrodes are positioned so as to increase the sensitivity of the electrostatic field at various points along the sand feed. Electrostatic plate separators (EPS) use the principle of conductive induction. The sand particles themselves acquire a charge from the earthed plate over which they are sliding under the influence of gravity. They are then attracted to the field electrode, away from the non-conductive particles. Both EFS and EPS systems should have the effect of increasing the purity and thus value of the final product.

Froth flotation

Froth flotation has been used for the recovery of zircon and monazite in pilot plants in the Murray Basin (Freeman, Aral, and Smith, 2003). The company CSIRO has used a sodium silica fluoride reagent to successfully separate out a whole suite of HM (Bruckard *et al.*, 2000). This technology seems to be most appropriate in inland deposits where there are a lot of fines (< 70 microns), such as the Murray Basin and possibly Corridor Sands.

Evaluation of HMS deposits

Economic benchmarking of heavy mineral sand deposits was attempted by Graham and Malan (1997) who examined the relationship between annual production capacity and capital expenditure. They identified Namakwa sands, RBM and Sierra Rutile as exceptional deposits, while Hillendale (Ticor), Fairbreeze and Kwale were not considered good investment opportunities. They also identified a value of US$ 6.00/t in the ground and 100 Mt as the lower limits for investment in future HMS opportunities. Values less than US$5.00 are feasible if economies of scale can be employed.

When evaluating a HMS deposit, the exact economic cut-off grades vary depending on the location of the deposit, infrastructure, metallurgy and other economic factors. A good grade deposit would, however, generally have in excess of 5% valuable heavy metals. The ilmenite should be of high enough grade to be used by the chloride or sulphate slag route. The general break-even grade for ilmenite is considered to be 47 to 48% TiO_2; a rise in grade from 51% to 54% TiO_2 will, however, double profits (Canaccord, 2000). The unit costs of slag production fall as TiO_2 levels increase, and there is a large increase in the productivity of the furnace. Currently the co-products zircon and rutile are at least three times as valuable as unbeneficated ilmenite. Rutile is, however, being increasingly replaced by cheaper synthetic rutile that is upgraded from good quality ilmenite. The fewer impurities there are, the better and this is particularly true of

Cr, V, Mn, alkalis and sulphur. The existence of any radioactive minerals, even potentially valuable ones like monazite, is becoming an increasing problem.

If the new mine is simply going to extract and separate out ilmenite, rutile and zircon for direct sale, then capital costs are minimal and a short life of mine can be envisaged. If a synthetic rutile or slagging plant is being developed (as in the case for most of the new African deposits) then much greater investment will be required. The deposit must be large enough to support a life of mine probably approaching thirty years.

The titanium dioxide slag producers are the most profitable—the low cost miner RBM for example operates with profit margins of up to $350/t. Rutile, synthetic rutile and ilmenite feedstock producers commonly operate on margins of as little as $50/t. Chloride grade feed material must be coarser than the sulphate grade, so that it is not blown out in the fluidized bed. The alkali levels, particularly Ca and Mg, and alumino silicate levels must be low to prevent gel formation in the fluidized bed.

The chloride process produces a higher quality product and is more environmentally friendly than the sulphate route, but has the disadvantage of being unable to use feedstock that contains less than 85% TiO_2. The chloride process is also currently more complicated, with higher capital costs. The operating costs are cheaper, though at a worldwide average of $1165/t as compared to $1429/t for sulphate grade (www.ame.com). The sulphate process produces about 4 kg of waste per 1 kg of pigment produced (www.iluka.com).

Dry mining methods with excavator and truck are more flexible and must be used if harder rock interlayers such as calcrete are to be removed. Dry mining is often the only economic alternative in arid areas.

Wet mining using dredger or wheel mounted water monitors is cheaper, mainly due to lower fuel costs, though capital expenditure is greater. Where a dredger is used, a large artificial pond must be created within the dunes. The dredger and towed concentrator plant float on this. This method is used for large tonnage, loosely consolidated, continuous orebodies, as the latest operations have capacities up to 3 000 t per hour (www.nordresources.com).

Ideally the whole projected mining area should lie below the water table, but it may, however, be economically viable to raise the pond level artificially to give sufficient depth for the dredge. A suitable fresh, or at least non-marine, water supply is required for inland operations. The existing water table must not become contaminated.

Due to the dynamic nature of their formation, most recent HMS deposits contain only a low level of fine clay minerals. In older, inland deposits, however, slimes can be a serious problem; a notable example is the now defunct BHP Beenup operation. In situations with more than 10–15% fines, specific slimes handling circuits are required, and crucially more space for the tailings dam.

Serious environmental legislation is at most twenty years old worldwide. In some African countries there is still no modern environmental legislation for mining. There are some major concerns over the impact of HMS mining in Africa. The disruption or saline contamination of coastal aquifers, particularly in Kenya, is potentially serious. However, much effort is put into environmental impact assessments, the fact is that mining is a ‘messy business’. The coastal zone is a complex dynamic system, with usually a rich biodiversity and a sensitive environment that requires careful management to minimize the long-term effects. The temptation for some mining companies to reduce costs by disposing of tailings in areas away from the immediate coastline should be balanced by the fact that 84% of Africa’s population lives along the coast (Wright, 1999).

New business opportunities

There are significant barriers to any new producer of HMS. A few suppliers, selling to a relatively small number of pigment producers, dominate the industry. A new player might want to form a JV with an established company, as Kumba have done with Ticor, or to produce a higher-grade niche product, as is the case with Namakwa and its zircon. It is the nature of the business that economies of scale play a particularly important role in this industry. The possession of the appropriate technology to upgrade ilmenite to marketable slag is crucial.

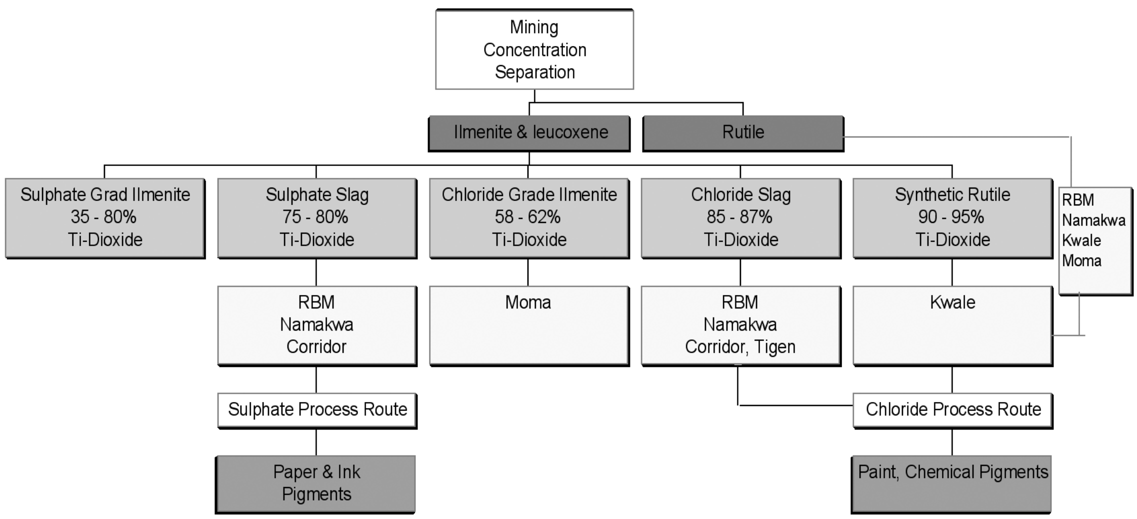

Figure 8—Heavy mineral sands—mining to products’ African operations

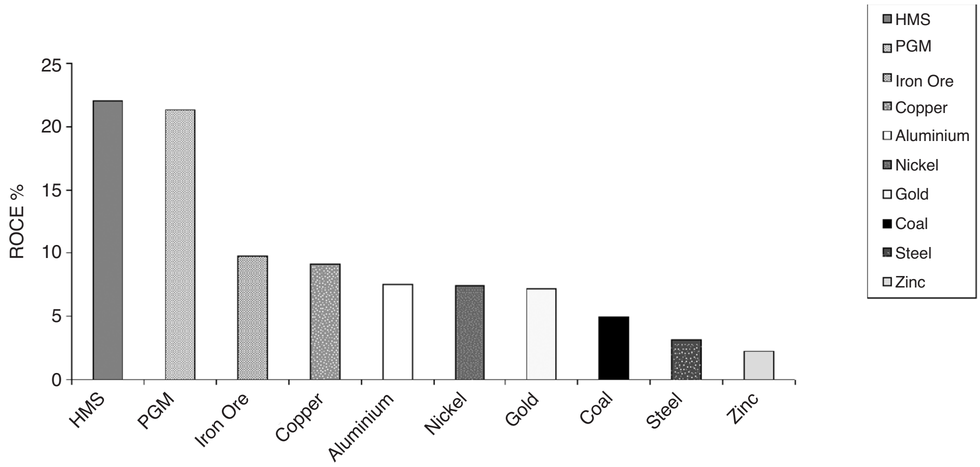

Figure 9—Return on capital employed (ROCE—percentages)

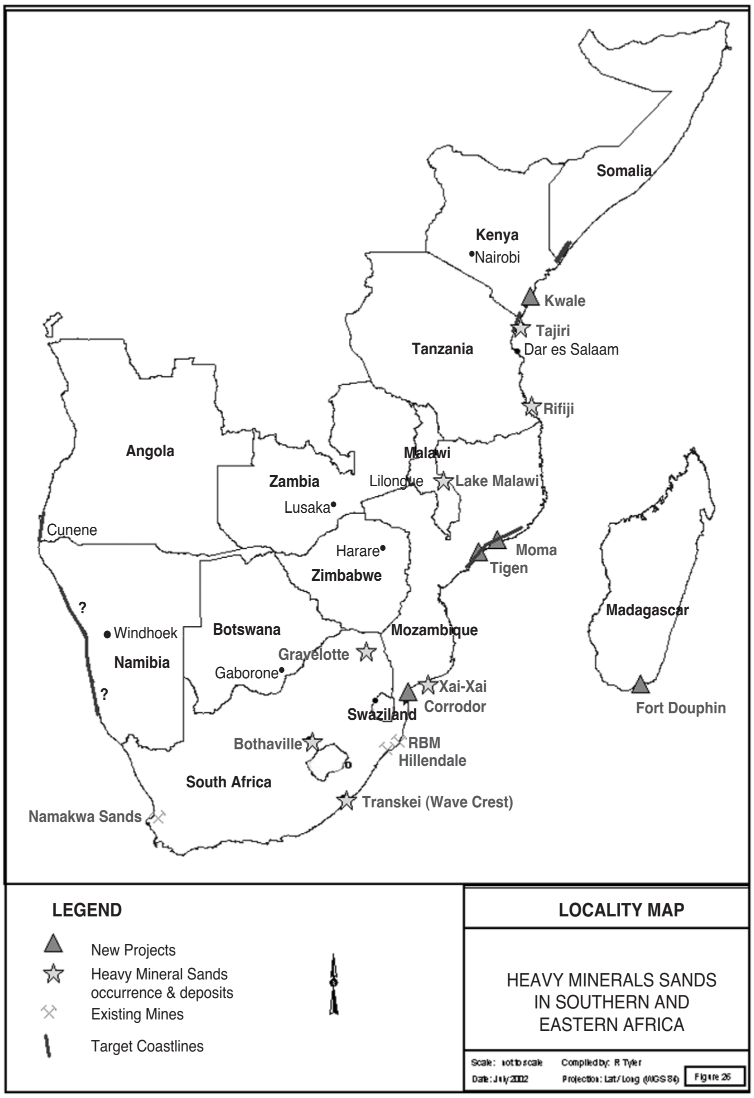

Figure 10—Heavy minerals sand in southern and eastern Africa

The Ti-dioxide market is currently saturated, but the medium- to long-term demand for all the titanium feedstocks, and for ceramic grade zircon is encouraging. There are still no readily available substitutes for them. Their demand is basically driven by the performance of the world economy, if this keeps growing, particularly in the Far East,

then the outlook is positive for the HMS industry. If the science of refining titanium can be made cheaper by electrolysis, then there is huge potential for the use of this metal in the construction and vehicle industries.

The immediate future for the zircon market looks much more appealing than Ti-dioxide. Much of this zircon will, however, come from various projects in the Murray Basin and India. These areas are in a much better location to supply the expanding Far Eastern tile market than the new African projects.

Despite the technological problems and barriers to entry, the HMS industry is an attractive one. Geological ore definition and mining are considerably easier than an average gold or polymetallic deposit (see Figure 9). As technologies improve, particularly in the field of froth flotation, the returns should improve.

The likelihood for success in Africa

Corridor Sands seems the most likely new project to succeed. It is a very large, reasonable grade deposit whose owners seem committed to seeing the project through. Good infrastructure is being put in place, and the new jetty and private road will give WMC independence from the State Railways. Power should be plentiful because of the proximity of the South African grid and the underutilized (but currently expensive) supply from Cahorra Basa. Slimes handling is a potential problem but new froth flotation technology is becoming available to counter this. There is also no lack of space to store the tailings. The position of this inland site means that WMC are unlikely to attract the attention of environmentalists in the same way that Kwale and Moma at the coast will.

Although the Kwale deposit is small, if mined successfully it should give Tiomin a real advantage in mining elsewhere along the Kenyan and possibly Tanzanian coasts. If they can retain political support and obtain commercial backup, the relatively good grades, particularly zircon and the upgraded synthetic rutile, should keep the operation profitable. Kenmare's operations at Moma are an attempt by a junior company to penetrate the industry. It will be interesting to see if they will attract a major partner to replace BHP. The exploration work at Moma seems to be of a high standard and the operation now has ownership of BHP mineral separation technology. There must be concerns over the remoteness of this operation and the low zircon grade. It is unclear at this stage what beneficiation Kenmare will actually make on site.

Success by Kenmare will definitely encourage companies holding adjacent land in Mozambique, such as BHP at Moebase. Failure by Tiomin will probably set back even further the development of a mining industry in Kenya. A profitable operation should encourage further exploration along the long prospective East African coast. Any serious mining investment seems unlikely in Madagascar until the country demonstrates political stability.

Finally, considering the cheap price of electricity in RSA, the concentration of smelting expertise, and the increased demand for the metal, it would seem an opportune time to investigate anew the economics of establishing a titanium metal smelter in the country. It should be noted that one of the existing major smelters of titanium metal is in Japan, whose electricity costs are greater than South Africa's and who possesses no natural deposits of titanium.

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Table III

Summary of planned new HMS operations

2002/2003 Deposit	TiO_2 ('000t)	Prod	Zircon ('000t)	2004/2005 Deposit	TiO_2 ('000t)	Prod	Zircon ('000t)
Gingko (MB): BeMax	200	Ilm, rutile	60	Douglas (MB): Basin Minerals	300	Ilm	60
Mindarie: MB Minerals	50	Ilm.	35	Tamil Nadu: Kumba	135	SR	13
Old Hickory,US. Iluka	95	Ilm.	45	Jangdarup S.: Cable Sands	130	Ilm	17
Hillendale: Ticor-SA	300	Ilm, slag	75	Kerala: KML	90	SR	
Kwale	200	Ilm, SR	37	Corridor	300	Slag	40
Moma	300	Ilm	0				
Approx Total	1100		250		900		130

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Exposure draft on valuation in the extractive industries*

The International Valuations Standards Committee (IVSC) is an NGO (Non-Government-Organization) member of the United Nations and works cooperatively with member States, organizations such as the World Bank, OECD, International Federation of Accountants, International Accounting Standards Board, and others including valuation societies throughout the world to harmonize and promote agreement and understanding of valuation standards.

It publishes the widely accepted International Valuations Standards book, the latest, sixth edition of which was published in May 2003.

These standards cover the valuation of all assets, whether real property, personal property, businesses or financial interests for any valuation purpose, and provide guidance against internationally accepted principles for the valuer.

In the minerals industry, in recognition of the need for better governance and transparency in the area of valuation, and after several noteworthy scandals, some countries, such as Canada and Australia developed their own Codes for valuation of mineral properties and/or assets, since the IVS applied mainly to real estate valuation, with an emphasis on market value as opposed to historic or fundamental value.

In the last year, IVS has developed a Guidance Note which is specific to the Extractive Industries, and which has now been released for public comment.

The importance of this development is emphasized by the adoption of market value in financial reporting as being 'in the best interests of the public, investors, government and business decision makers', according to the Toronto Accord.

This accord, held in October 2003, supported by the International Accounting Standards Board, the US Financial Accounting Standards Board and the American Society of Appraisers, amongst others, determined that the IVS was the appropriate set of international standards to be supported for these valuations.

It is still unclear as to precisely when, or if, this will apply to the Extractive Industries for financial reporting, but the IVSC Standards are applicable in South Africa, since South Africa is a member State of IVSC, and the Guidance Note now forms a good basis for comparison and/or incorporation into a South African Valuation Code.

The Task Group that formulated the Exposure Draft consisted of representatives from the USA, Australia, United Kingdom, Canada and South Africa, the latter representative being Alastair Macfarlane, who was nominated to attend the Group by the Council of the SAIMM.

The Exposure Draft and its associated Press Release can be read on the IVSC website, www.ivsc.org.

Comments are required via the internet by the end of March 2004, and then it is anticipated that Edition 7 of the IVS will be published in mid 2004, inclusive of the Extractive Industries Guidance Note.

Meanwhile work on developing a South African Code which deals with local and national variations is continuing under the auspices of the Council. ◆