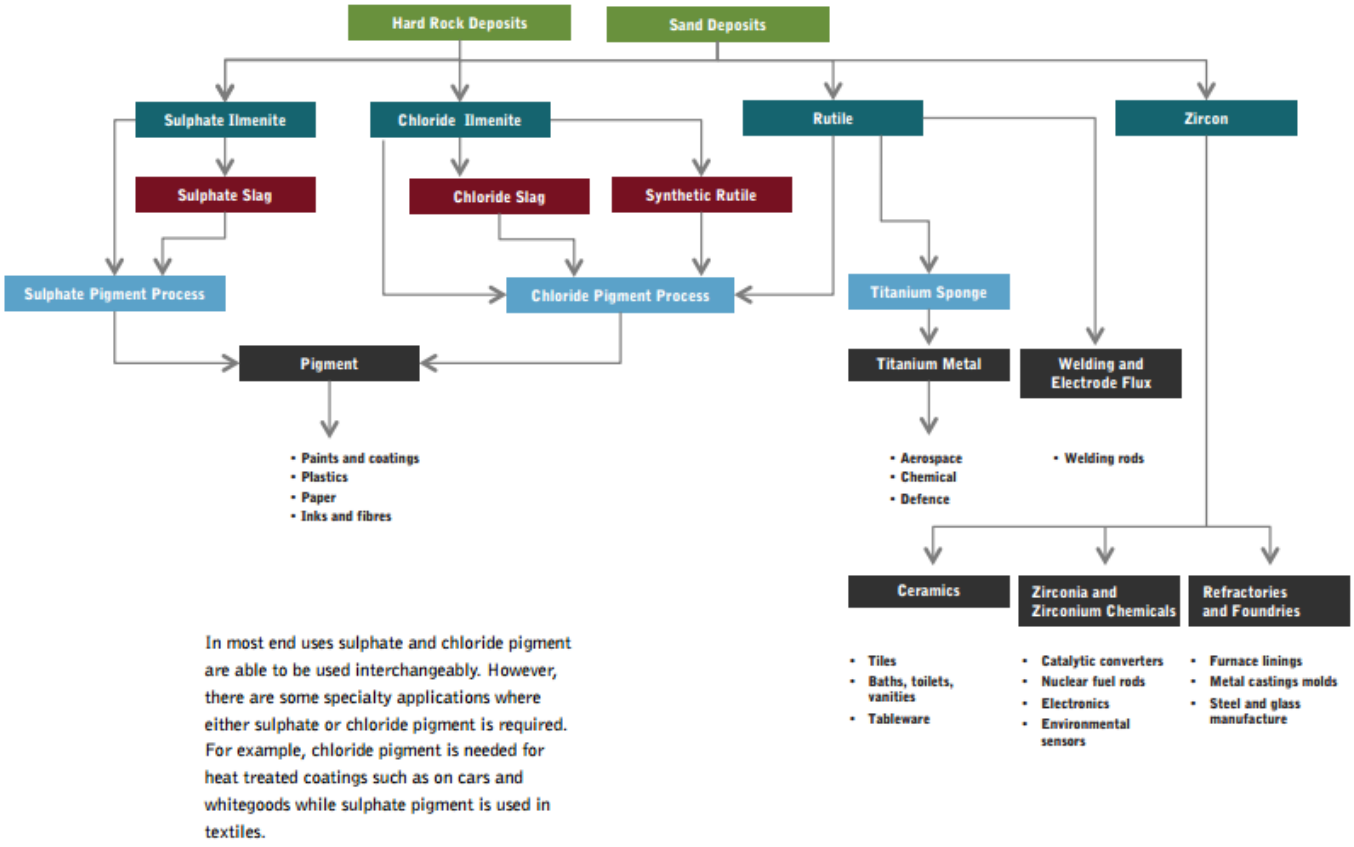
Mineral Sands Industry Information

This document is designed to provide information on the mineral sands sector and aspects of Iluka's operations for those considering an investment in the company. It should be read in combination with information contained within the Iluka Investor Modelling Information document, available on Iluka's website, as well as other information available in the Investors & Media section of the website, which includes company statutory disclosures as well as briefing papers on various aspects of the industry.

Iluka acknowledges the contribution of TZ Minerals International (TZMI) for data to prepare various charts in this publication.

Prepared May 2015, updated November 2019

THE MINERAL SANDS INDUSTRY – OVERVIEW



In most end uses sulphate and chloride pigment are able to be used interchangeably. However, there are some specialty applications where either sulphate or chloride pigment is required. For example, chloride pigment is needed for heat treated coatings such as on cars and whitegoods while sulphate pigment is used in textiles.

The mineral sands industry involves the mining and processing of zircon and titanium dioxide products (ilmenite, rutile and upgraded titanium dioxide products of synthetic rutile, slag and upgraded slag). The two product categories have different properties, prices and distinct end use markets.

Mineral sands deposits typically contain both titanium dioxide mineral and, usually, a minor proportion of zircon. The relative weighting of each mineral (known as assemblage in an ore body) varies by deposit.

Assemblage has a strong influence on the financial viability of a deposit, being primarily influenced not by the cash cost of production (as in many minerals) but by revenue to cash cost (or margin) characteristics. Analysis undertaken by Iluka demonstrates that, when compared to current deposits and operations, the industry is facing declining grades and assemblages for future deposits being developed.

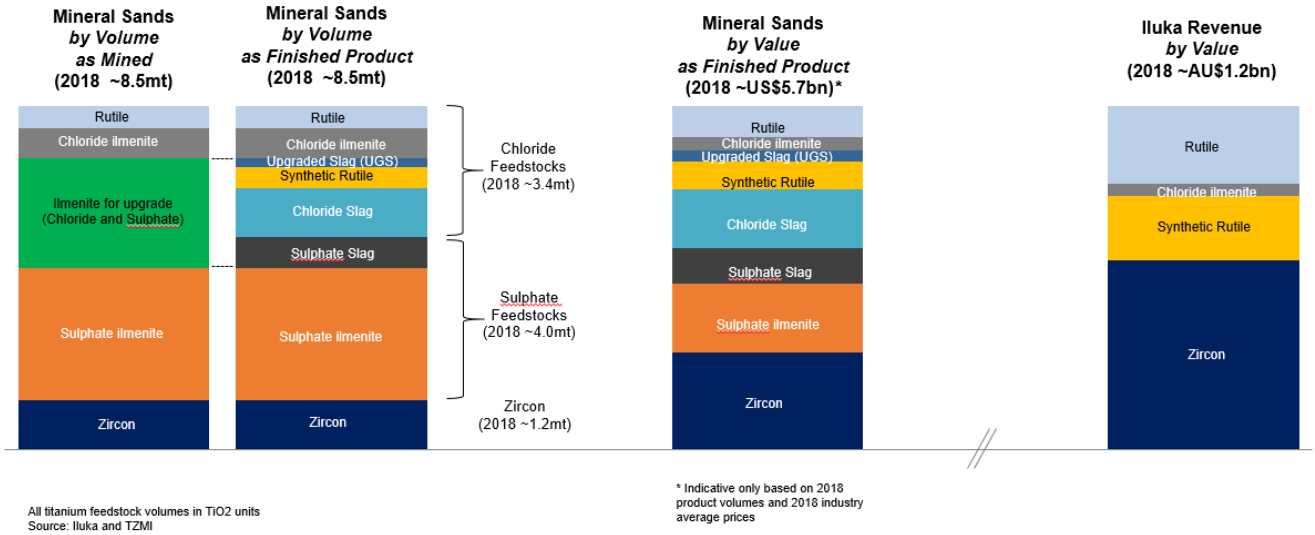
ZIRCON

Zircon is an opaque, hard wearing, inert mineral. It is primarily used in the production of ceramic tiles. Other applications include use in refractories and foundry casting and a growing array of specialty applications as zirconia and zirconium chemicals, including in nuclear fuel rods, catalytic fuel converters and in water and air purification systems.

TITANIUM DIOXIDE

Titanium dioxide is mined as ilmenite or rutile (or other variants of titanium dioxide). Both are dark coloured minerals which, with processing, become white and opaque. It is primarily used as a whitening pigment in paints, plastics and paper. The raw minerals are also used in the manufacture of titanium metal and welding flux wire cord.

MINERAL SANDS MARKET CHARACTERISTICS



Zircon

In 2018 around 1.2 million tonnes of zircon was produced globally.

In the majority of mineral sands deposits, zircon is produced in lower quantities than titanium dioxide. The historical average ratio between the two mined product streams is in the range 1:4 to 1:5.

Titanium Dioxide Feedstocks

In 2018 around 7.4 million tonnes of titanium dioxide (TiO_2) was produced. Titanium feedstocks are either chloride or sulphate, with the split globally around 50:50. Chloride feedstocks are generally used in chloride pigment plants and sulphate feedstocks are generally used in sulphate plants.

Titanium dioxide feedstocks are graded by their titanium dioxide content, which ranges from ~50 per cent for sulphate ilmenite to ~95 per cent for natural rutile.

Feedstocks are either sold as raw minerals (rutile and chloride or sulphate ilmenite) or as upgraded feedstocks. Upgrading involves chloride or sulphate ilmenite being heated in a kiln or furnace to remove impurities (mostly iron) and increase the TiO_2 content. Upgraded feedstocks are synthetic rutile, chloride and sulphate slag and upgraded slag. Iluka produces rutile, chloride ilmenite and synthetic rutile at its operations in Australia and the US.

Titanium Dioxide Content of Feedstocks

Form of titanium dioxide	TiO_2 %
Rutile	95-97
Synthetic rutile	88-95
Ilmenite - sulphate - chloride	 52-54 58-62
Slag - sulphate - chloride - upgraded	 80-85 85-90 95

Revenue to Cash Cost Ratio

For most commodities, unit cash cost is used to benchmark projects' relative economics. In this instance, the grade of valuable mineral, scale and mining method, and associated costs, are key factors influencing unit costs. In mineral sands, heavy mineral (HM) grade provides a good indication of the cost of mining - how much ore needs to be moved to capture heavy mineral.

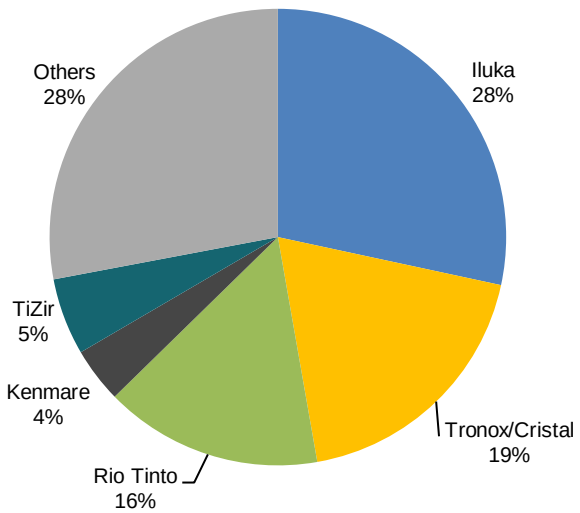
However, most mineral sands mines produce several product streams – predominantly ilmenite, with lesser quantities of the more valuable minerals of rutile and zircon. The weighting of each of these minerals (referred to as the assemblage of the deposit) varies significantly by deposit, but with ilmenite typically dominating the assemblage and zircon the minor constituent.

Consequently, the economics of mineral sands projects is influenced as much by assemblage – which shapes the revenue per tonne characteristics – as the deposit grade or cost of mining.

For this reason, the industry tends to use a margin curve or revenue: cash cost ratio curve to assess the relative attractiveness of mineral sands deposits and operations.

ZIRCON PRODUCTION

Major Zircon Producers (2018 ~ 1.2mt)

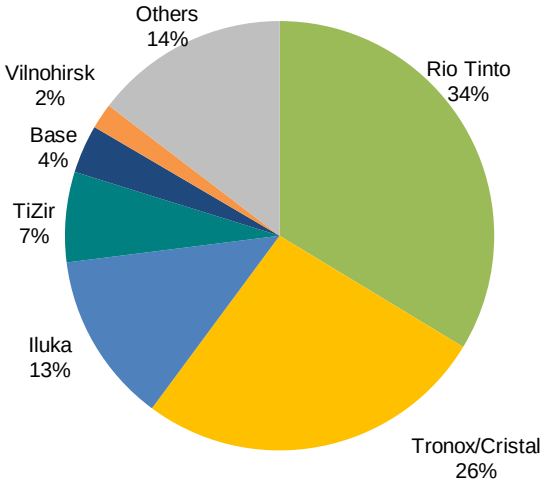


Source: Iluka and TZMI

- Iluka's zircon production is predominantly from the Jacinth-Ambrosia mine in South Australia
- Rio Tinto owns the Richards Bay Minerals mine in South Africa
- Tronox/Cristal owns mines the KZN and Namakwa mines in South Africa and has Australian based operations
- Kenmare operates the Moma mine in Mozambique
- TiZir operations the Grande Cote mine in Senegal

TITANIUM DIOXIDE PRODUCTION

High Grade Chloride Titanium Dioxide Feedstock[1] Production by Major Producer (2018 total ~2.5mt TiO2)

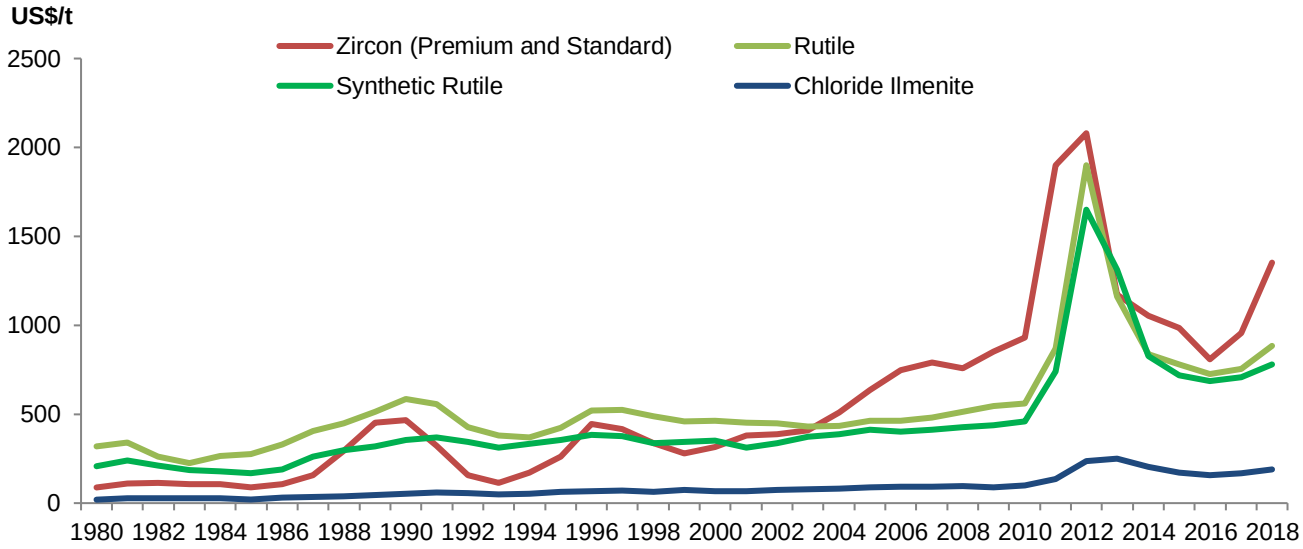


- Iluka produces rutile and synthetic rutile from assets in Australia and Sierra Leone
- Rio Tinto owns the Richards Bay Minerals mine in South Africa, producing chloride slag. Rio also owns the QIT operations in Canada, producing high grade, upgraded slag (UGS).
- Tronox/Cristal's operations in South Africa produce chloride grade slag and smaller amounts of rutile. The company also operates a synthetic rutile kiln in Australia.

Source: Iluka and TZMI

MINERAL SANDS PRICES

Selected Annual Mineral Sands Prices



Source: Iluka and TZMI

Mineral sands products were traditionally sold on the basis of long term contracts, often referred to as legacy contracts This historical contractual setting resulted in an extended period of relative price stability and only modest price growth.

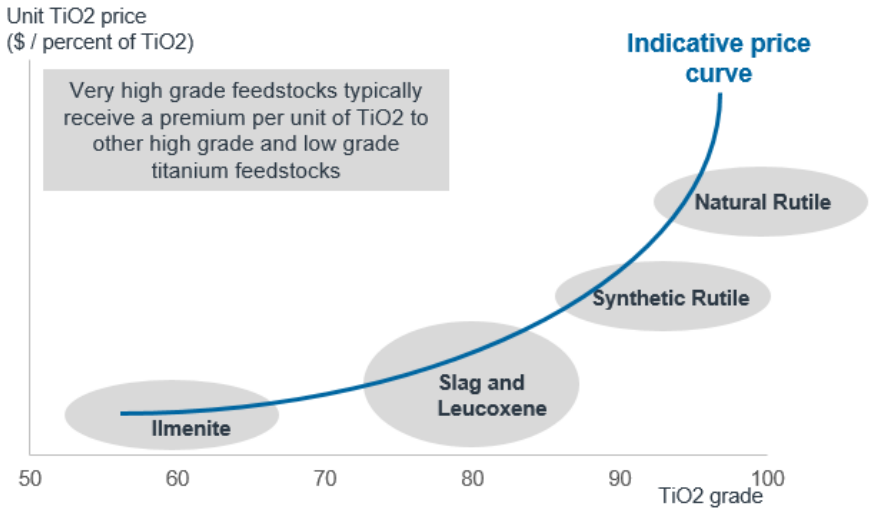
Constrained pricing in the context of declining grade and/or assemblage, increasing costs and adverse currency movements, were major contributors to the historically poor returns in the titanium feedstock industry. Low returns acted as a disincentive for new investment, with the industry still largely reliant on mining provinces which have been in existence for many years. Iluka was the first of the major titanium dioxide producers to come off so-called "legacy contracts" at the end of 2010 and consequently had the opportunity, under the prevailing market conditions,

[1] Defined as >80% TiO2 grade, includes rutile, synthetic rutile, chloride slag and upgraded slag

to increase its rutile and synthetic rutile prices. The remaining use of legacy contracts by other industry participants reportedly ended at the end of 2014.

Most high grade titanium feedstocks are sold to major pigment or titanium metal customers on contractual periods of varying periods, typically less than 12 months. Volumes to the welding and titanium metal sectors are usually sold on a shorter basis, usually monthly to quarterly contracts. Titanium product prices are based on value in use, with price increasing by titanium grade, see chart below.

Titanium Feedstocks Pricing by Titanium Grade



In 2015 Iluka introduced a new zircon pricing and payments framework. The approach entails an Iluka benchmark or contract price and spot pricing arrangements.

Mineral sands products are not exchanged traded. As such, there are no readily sourced representative traded prices for mineral sands products. In Iluka's case the vast majority of its sales are direct; the company does not make use of distributors or agents to any significant extent.

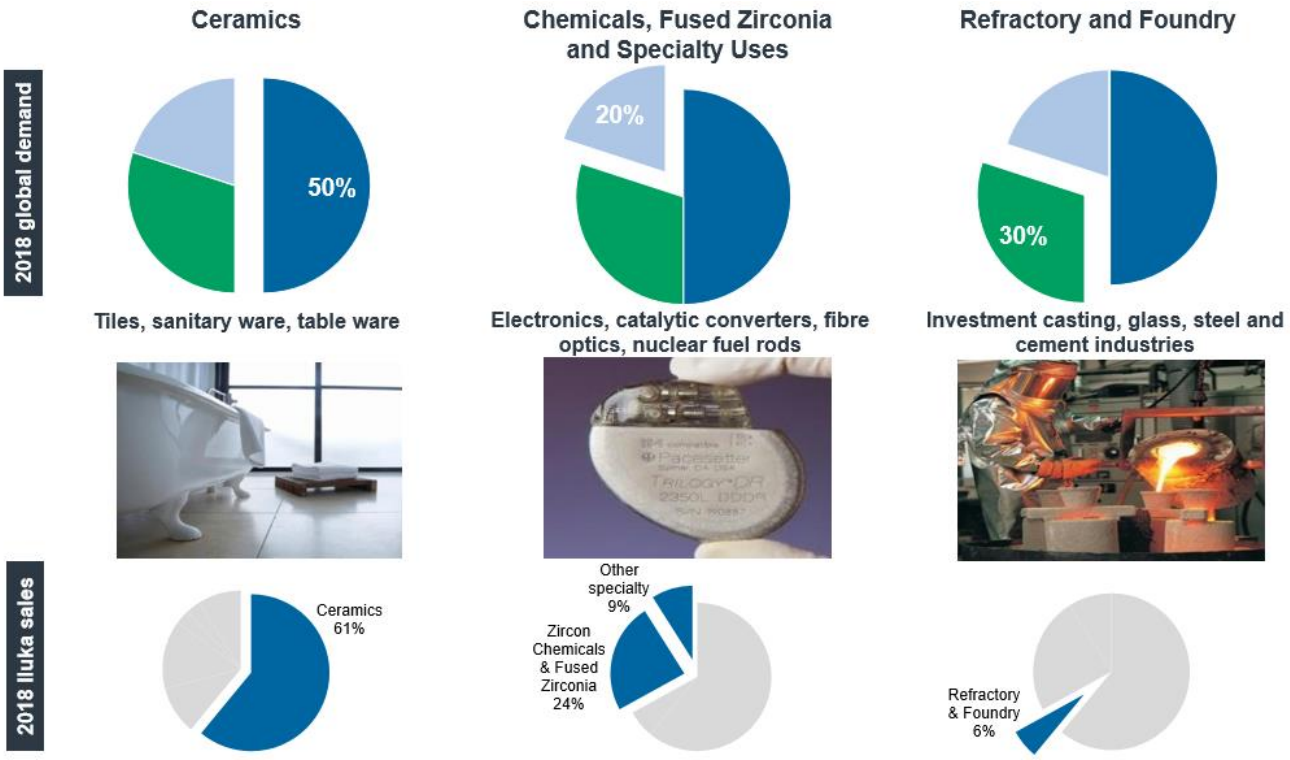
Selected Iluka annual weighted average received prices for the last five years are shown in the table below. For latest pricing commentary, please refer to Iluka's latest quarterly and financial results at www.iluka.com.

Selected Annual Weighted Average Mineral Sands Prices
US$ / tonne

	2014	2015	2016	2017	2018
Zircon (premium and standard)	1,054	986	810	958	1,351
Zircon (all products)	1,033	961	773	940	1,321
Rutile (excluding HYTI)	828	763	731	790	952
Synthetic rutile	750	Not disclosed	Not disclosed	Not disclosed	Not disclosed

Source: Iluka

ZIRCON DEMAND OVERVIEW



Downstream zircon industries are characterised by a large number of small producers.

Growth drivers for zircon demand include urbanisation, construction and industrial production.

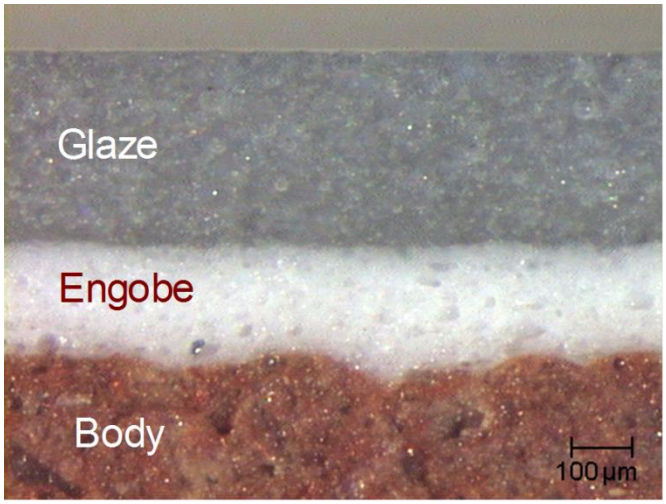
Zircon Applications and Attributes

CERAMICS	
Floor and wall tiles | Sanitary ware | Table ware	**Opacity (whiteness)** – high refractive index **Hard wearing** – water, heat, chemical and wear resistant
REFRACTORY & FOUNDRY	
Steel and glass production | Casting of manufacturing parts, including engines	**Temperature stability** – low thermal expansion, high thermal conductivity, high melting point **Non-wetability** – resistant to molten metals
ZIRCONIUM METAL	
Nuclear reactor cores and rods | Heat exchangers | Superalloys	**Low thermal neutron absorption –** increases nuclear reactor efficiency **Inert -** corrosion resistant
ZIRCONIA AND ZIRCONIUM BASED CHEMICALS	
Refractories | Pigments | Abrasives | Electronics | Catalysts | Fibre optics | Purification systems	**Range of unique properties** – thermal stability, oxygen conductivity and dielectric and piezoelectric properties

Zircon in ceramics

The ceramics market represents the largest proportion of zircon demand, at around 50 per cent of zircon consumption annually.

For its use in ceramics, zircon sand is milled by Iluka customers, to produce zircon flour or frit, which, along with other ingredients, is used as an opacifier in ceramics manufacture. Few tile manufacturers process their own zircon; instead they typically purchase flour and opacifier from millers for use in the bodies, engobes and glazes of tiles.



Source: Iluka

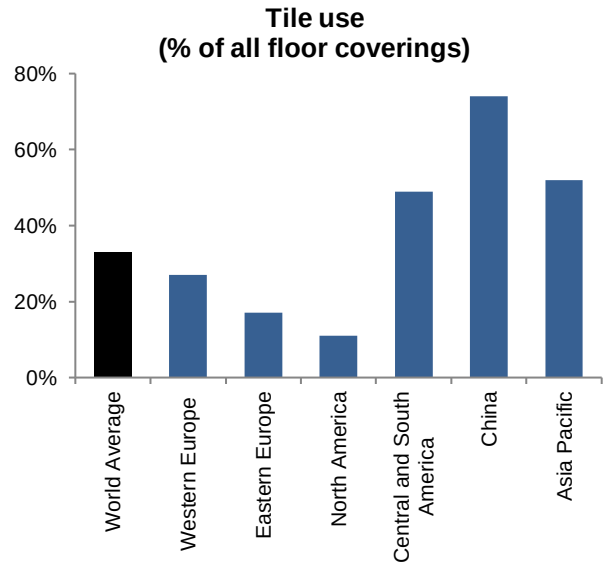
Europe has traditionally been the largest tile producing region with tiles predominantly made in Spain and Italy. However, in recent years China has surpassed Europe, producing over 6 billion square metres of tiles per year.

Tile demand

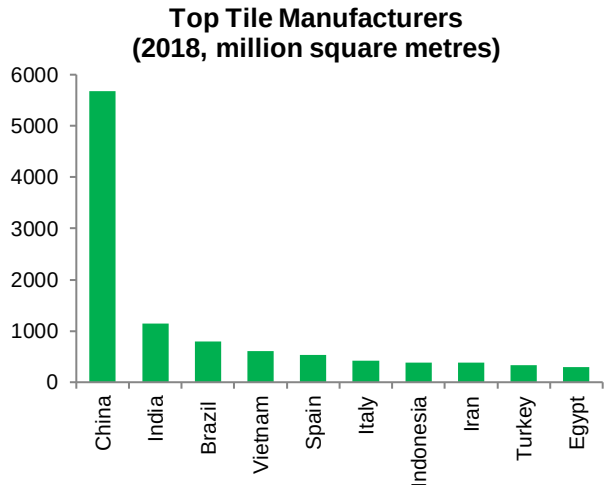
Urbanisation and personal consumption trends have a key influence on tile, and hence, zircon demand. A preference for tiles is influenced by several factors.

- Culture - some regions, particularly the Middle East, have strong historical and cultural preference for tiles.
- Climate – tiles are more prevalent in warmer regions, for sanitary and cleaning purposes.
- Preference - Personal or society-based taste.
- Cost – certain varieties of tiles are less expensive or more readily available relative to other floor coverings (e.g. timber or carpet).

Many developing countries are large tile users. China in particular has shown a strong preference for tiles with an estimated 75 per cent of all floor coverings being tiles. Central and South America and other parts of the Asia Pacific also use a large proportion of tiles.



Source: Ceramic World Review



Source: Ceramic World Review

Tile Properties and Zircon Content

There are two main categories of tiles – porcelain and non-porcelain. Non-porcelain tiles include clay and other stone based ceramic tiles. Globally, it is estimated that 60 per cent of tiles produced are porcelain, similarly in China around 70 per cent of tiles produced are porcelain.

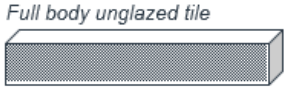
Major Tile Categories

Polished Porcelain (Unglazed) (~20% of tiles)

A high density, wear resistant and water impervious (vitreous) tile body typically polished for aesthetic quality.

Produced with either single composition across the tile depth (full-body) or with two layers of different compositions (either produced with double-charging using a single press or with double-pressing using two subsequent presses).

Full body unglazed tile



Zircon contained in main body ~5% of total weight.

Double charged tile

Double charged tiles generally only have zircon in top layer.

Glazed Porcelain (~40% of tiles)

Glaze to enhances the aesthetic appeal and allow cheaper materials to be used in the body. Glaze also imparts durability and non-porous surface.

Typically, a white engobe layer between body and glaze needed to ensure bonding of the glaze layer, prevent cracking of glazes, to fully mask the colour of the body and serve as a white basis for decoration. Glaze and engobe combined in some compositions.

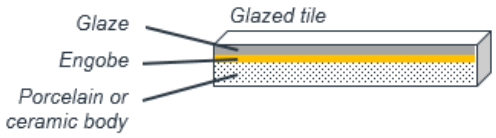
Typically digitally printed and used as flooring.

Glazed Ceramic (~40% of tiles)

Glaze applied to porous ceramic tile for hard wearing, non-porous surface. Have less strength than porcelain. Decorative effects can be applied.

White engobe required to mask tile body colour and provide base for decorative pigments.

Typically applied to walls.



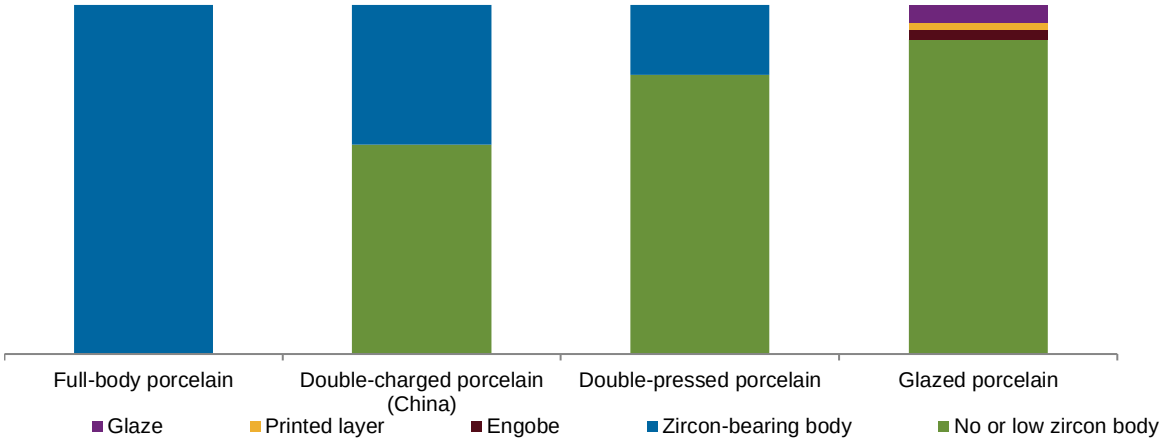
Zircon contained mainly in engobe (~6-12% zircon) and glaze (~8-16% zircon).

These components are ~3-10% of tile body thickness.

Source: Iluka and Ruidow

Porcelain tiles have the highest weighting of zircon. There is however large variation in the amount of zircon used per tile within the suite of porcelain tiles, as shown in the chart below.

Zircon Containing Layers of Tiles



Source: Asian Ceramics

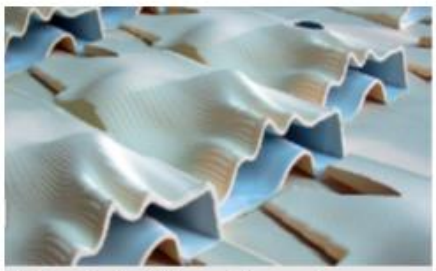
Emerging Tile Trends and Zircon Content Implications

Innovation in ceramics form and design is leading expansion in applications of tiles including large format slab tiles, digital printing and exterior tile cladding. These trends have broadly positive implications for zircon content:

- All tile plants globally transitioned to digital printing and use zircon in engobe and glaze enforcing minimum zircon loadings (ensures white base for printing)
- Cost reduction focus leading to thrifting zircon thereby compromising whiteness ie. less white tiles (technical limits before visible)
- Higher loading in large format and exterior tiles for strength and durability
- Range of other new applications, including 3D printing and exterior applications
- Increasing focus on environmental impacts and standards favour tile use and zircon content

Digitally printed tile effects include wood and marble look, often require white base

Large, thin, slab tiles can be 6mm thick



3D printed tiles offer unique shapes and texture

Design and durability increasing use as building exterior

Zircon in roof tiles increase solar reflection and reduce heat

Digitally Printed Tiles

Designer tile manufacturing, facilitated by new technologies like digital printing, is a growing global trend, and especially marked in China. This technology allows designs printed on tiles to be highly varied, for instance to include stone and marble-like features, wood-like grains, graphic prints and many other features. Increasingly, many ceramic industry participants rely on the aesthetic attractiveness of ceramic tile products as their source of competitive advantage. Tile design, innovation and product appeal are seen as crucial success factors.

Digital printing is superior to conventional printing techniques (rota and screen printing) as it offers greater versatility in designs, allows optimisation of pigment, requires significantly less manpower and factory footprint, allows printing on uneven surfaces and value-adding special effects, enables on-the-run changes to printed tile designs and prevents unnecessary accumulation of slow-moving tile inventory, among other benefits.

Digitally printed tiles, based on Iluka's analysis and supported by industry feedback, have significantly higher zircon content relative to non-printed tiles and tiles printed with conventional techniques. Higher zircon content is recorded regardless of the colour of the tile design with dark and light coloured printed tiles having higher zircon content than similar coloured conventionally decorated tiles.

Zircon Chemicals

The zircon chemicals sector has grown strongly in recent years. This is mainly due to the versatility of zircon in this sector, making it applicable to a large array of end uses. In many cases zircon's function is highly specialised and few materials can provide the properties required.

Zircon in the chemicals sector is used to produce two intermediate products: a fused zirconia and a zirconium chemical, with half of the latter then used to produce chemical zirconia.

Several end uses, including ceramic pigments and steel and glass refractories, are specialty applications of zircon relating to the ceramics and refractories sectors more broadly, with growth expected to match.

Another large end use, and one of the strongest growing, is catalytic converters for automotive and industrial exhaust systems. These reduce the emissions from the engine by catalysed chemical reactions.

Other uses include:

- Pigment and paper coatings
- Zirconium metal (and nuclear fuel tubing)
- Antiperspirants
- Cosmetics
- Paint dryers
- Fire retardants
- Glass and cubic zirconia
- Optical fibre ferrules
- Dielectrics (in motherboards and capacitors)
- Piezoelectric devices (e.g. pressure sensors)
- Oxygen sensors
- Electronics
- Fuel cells

Growth of the sector is linked to increased usage of electronics and communications, energy efficiency and emission controls.

Regionally, zircon chemicals demand is dominated by China. China's large, low cost manufacturing base provides it with a comparative advantage in the production of fused zirconia and zirconium chemicals.

95 per cent of global zirconium oxychloride (ZOC) production is concentrated in China (the main chemical intermediate product) – a market which is becoming more consolidated, with the top three players holding nearly half the market, and small producers facing cost and environmental pressure. This market prefers standard grade zircon.

Fused zirconia production, which lends itself to more of the industrial end uses, detailed above, is more geographically balanced, with major players operating factories in China, the US and Europe, although domestic Chinese production is growing. This market demands premium grade zircon with low impurities.

Refractories and Foundries

Zircon demand to the refractory and foundry markets has been stable in recent years.

Demand for refractory use is mainly for steel and glass manufacture.

In the case of the glass industry, the Chinese glass industry is currently suffering from overcapacity which impacts demand, however, growing markets such as global smart glass applications provide increasing demand for zircon.

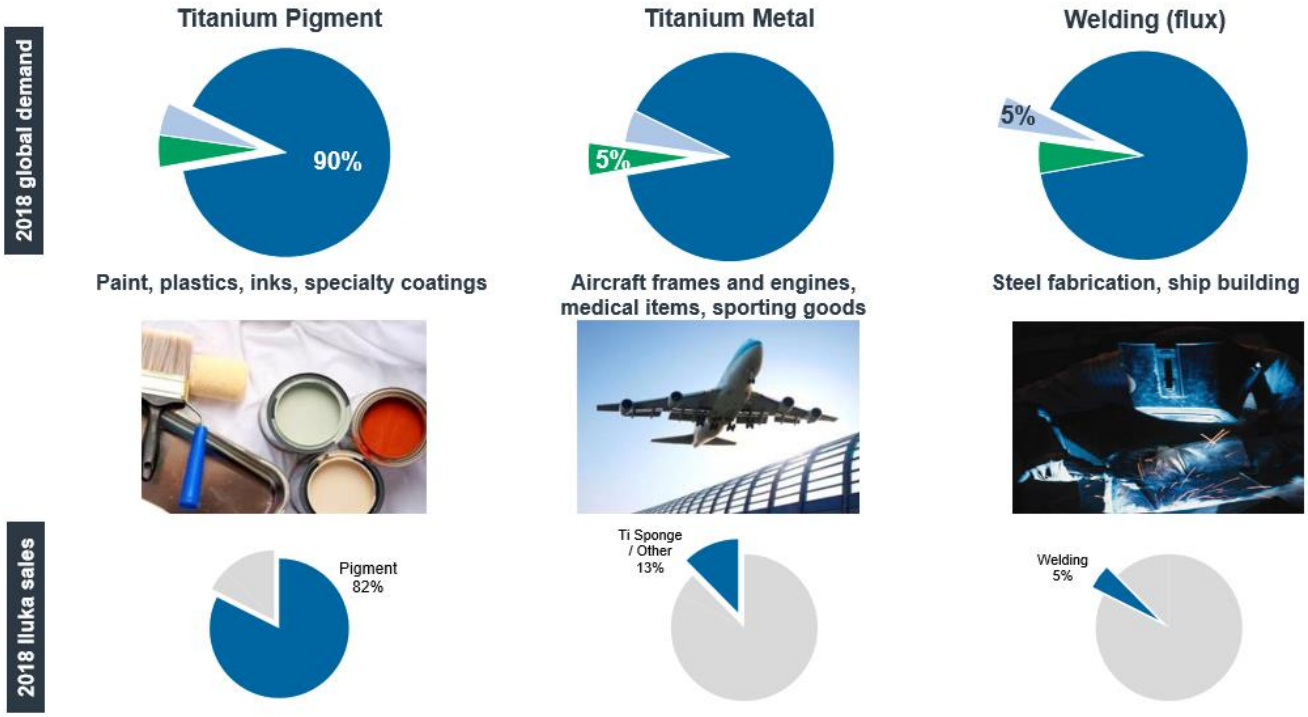
The foundry and investment casting market is highly fragmented, and as such, zircon is sold into these markets via intermediaries. Zircon is used in high-end castings in this market, such as turbine blades, engine components and golf clubs, with consumption being linked to regional industrial activity.

TITANIUM DIOXIDE FEEDSTOCK DEMAND OVERVIEW

Titanium pigment is by far the largest end use of titanium feedstocks, accounting for around 90 per cent of demand. Average annual growth of this segment is broadly in line with global GDP growth.

Titanium metal has experienced stronger growth with increasing use in aeronautics (body and engine parts), defence applications, biomedical and sporting goods.

Welding flux cord wire is used in ship building and steel construction applications.



Source: TZMI, Iluka

Titanium Dioxide Applications and Attributes

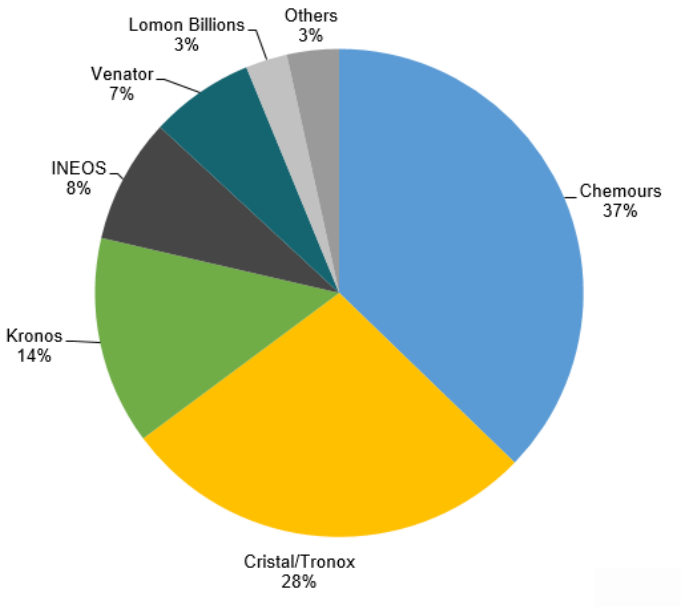
PIGMENT	
Paints & coatings | Plastics | Paper | Inks	**Opacity (whiteness)** – high refractive index **UV protection** – prevents fading, peeling and cracking **Non-toxic –** safe for use in cosmetics and pharmaceuticals
TITANIUM METAL	
Aircraft engines and frames | Military applications | Chemical & desalination plant components | Medical & sporting equipment	**High strength to weight ratio –** fuel efficiency benefits in aviation **Corrosion resistant** – resistant to chemicals, sea water and other elements
WELDING FLUX CORD WIRE	
Ship building | Fabrication | Steel construction	**Slag formation –** shapes, holds and protects weld from atmospheric conditions

Titanium Pigment Industry

Global pigment capacity (chloride and sulphate) was estimated at 6.3 million tonnes in 2018. Around 40% of this capacity was in China and North America and Western Europe accounting for a third.

Titanium pigment, like titanium feedstocks, is classified as sulphate or chloride, with the split being approximately 50:50. Generally, chloride plants are fed with chloride feedstocks and sulphate plants with sulphate feedstocks.

Major Chloride Pigment Producers
(2018 total = 3.0mt)



Source: TZMI and Iluka

Pigment Plant Capacity Utilisation

Pigment plant capacity utilisation (or yield), as with pigment demand broadly, is typically linked to industrial production and GDP trends. Pigment plants typically vary their capacity utilisation to meet market demand. As well as plant running time, this can be achieved through varying the feedstock grade fed into the plant. Subject to individual plant constraints, the feedstock grade can be increased or decreased (higher or lower average titanium dioxide content) to vary the amount of pigment produced.

In periods of stable demand, high grade feedstocks, rutile and synthetic rutile, are typically an important component of feedstock blends to optimise plant efficiencies and output.

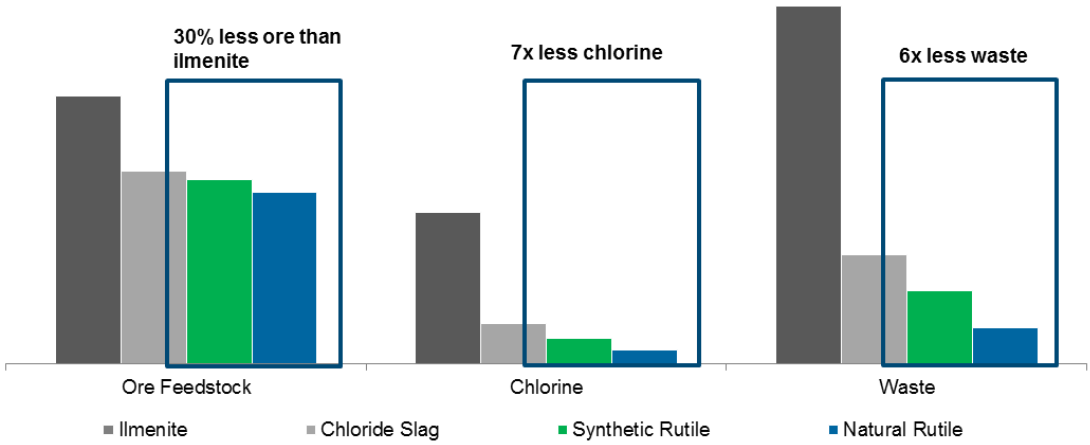
Pigment production and feedstock grade

Titanium feedstock grades are important for pigment producers (which account for around 90 per cent of titanium demand) as they affect the amount of pigment produced. The higher the grade of titanium feedstock going into the plant, the more pigment produced (and less waste).

Chloride pigment plants predominantly use a blend of different feedstocks with different titanium dioxide grades. Most chloride pigment plants are orientated to higher grade feedstocks - rutile, synthetic rutile and chloride slag. Chloride ilmenite is typically a minor part of the feedstock blend. The plants are large and sophisticated, where operational efficiency is highly dependent on specifications of feedstock blends.

Rutile and synthetic rutile, having the highest titanium grade, form an important part of the feed component as they increase the average grade going into the plant, thus increasing output and decreasing waste.

High Grade Feedstock Advantage



Source: Iluka

Titanium Pigment Applications

Titanium pigment is used in a large array of end uses, including paints, plastics and paper.

Approximately 80 per cent of end applications can use either chloride or sulphate pigment.

Some of the applications that need chloride pigment specifically are specialty heat treated coatings, including automotive paint and some industrial coatings, while fibres and cosmetic applications need sulphate pigment.

Specific growth drivers for each end market segment are listed below. Broadly, pigment demand is linked to GDP per capita.

Pigment Applications and Growth Drivers

Pigment segment	Application	Growth drivers
Architectural coatings	Residential and commercial paint	New home starts Construction activity DIY spending
Other coatings	Marine Aeronautical Appliances Automotive	International trade Air traffic and travel Industrial production Discretionary spending Car sales
Plastics	Packaging Piping Window frames Appliances Automotive	Discretionary spending Construction Car sales
Paper	Stationery Packaging Laminates	Advertising Construction
Inks	Printing Packaging	Consumption spending
Fibres	Carpets Synthetic fibres	Construction Durable goods spending
Other	Cosmetics Food Pharmaceuticals	Disposable income Consumption

Pigment per Capita and GDP per Capita

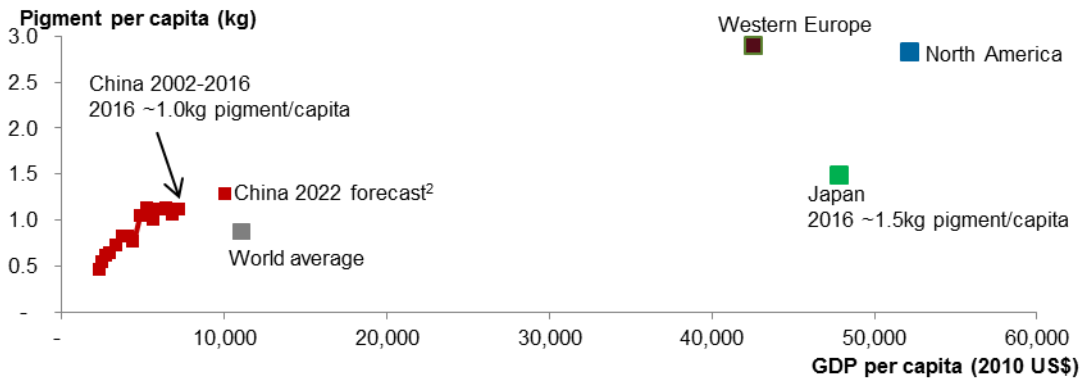
Due to the "quality of life" nature of many end use applications, pigment demand is linked to living standards, or GDP per capita. Pigment per capita, or pigment intensity of use, as with many commodities and consumer based goods, increases with GDP per capita, following an S-curve pattern. That is, intensity of use increases gradually until a certain income level is reached (take-off point), followed by a period of accelerated growth before a saturation point is reached.

The saturation point for pigment per capita varies by region (depending on house size, manufacturing sector size and other factors) but is typically between 2 to 3 kg of pigment per capita.

Following several years of accelerated growth, China is now the largest consumer of pigment globally. Its requirements are met with approximately 80 per cent domestic pigment production, (almost entirely sulphate pigment) and around 20 per cent imports (predominantly chloride pigment).

While China's pigment consumption per capita has grown markedly in recent years, it remains below developed economy levels, at around 1kg per person.

Long Term Pigment Demand Linked to GDP per capita



Note: China 2002-2016, other regions 2016. Source: Iluka, TZMI and Global Insight

Titanium Metal

Titanium metal has a high strength to weight ratio making it ideal for aerospace (engines and frames) and defence armaments applications. It also has high corrosion resistance, leading to use in industrial chemicals and desalination plants, heat exchanges, industrial and power plant cooling systems and offshore oil and gas drilling components. The metal is also non-reactive, leading to applications in medical implants

Welding Flux

Rutile is used in high-quality welds and in growing (but lower rutile consuming) fluxed core wire applications. Demand is typically linked to infrastructure, construction activities and ship building.

China accounts for around two thirds of the global stick electrode market, and one third of the flux cord wire market, with India and Korea other key markets.

MINERAL SANDS LEAD INDICATORS

Medium to long term industry demand is correlated to GDP (per capita), urbanisation, construction (mainly completion, sales and fit outs/maintenance activities) and industrial activity.

A range of leading indicators relevant to zircon and titanium end use markets can be considered as guides to potential shorter term demand trends.

Construction is a key end use sector for both zircon (tiling) and titanium dioxide (paint and pvc pipes and fittings), although unlike other mineral commodities utilised in the infrastructure and construction phase, mineral sands product demand tends to more “latter cycle” and in the case of construction, possibly more closely related to housing or commercial completions and fit outs, rather than the initial construction phase. Lead indicators for demand in the construction sector can include: housing and building approvals; housing starts; floor space under construction; floor space completions; house sales; and house prices.

Many of the end uses of zircon and titanium dioxide also directly or indirectly relate to manufactured industrial and consumer goods. For these sectors, lead indicators include: industrial production; new orders and inventory indices; consumer confidence or sentiment; purchasing managers indices (PMI); retail sales; and electricity generation/capacity.

Specific industry sales or output indicators are also relevant where zircon or titanium dioxide products are key inputs, such as: automotive new orders and sales; ship building; aeroplane orders; defence spending; and nuclear plant construction.

Broad economic lead indicators, such as the OECD lead indicator, which takes into account a range of individual indicators, are used for macro and country specific growth trends.

Changes to government policies aimed at stimulating or otherwise key markets for mineral sands products can also provide an indication of short term demand changes. For example, Chinese government spending on social housing and incentives to invest in private property, is a case in point.

Import and export data on zircon sand, opacifier and flour (intermediate products used in tile manufacture) and pigment, while not necessarily lead indicators, can provide useful information into current industry dynamics, potential inventory positions and downstream market activity.

Iluka also monitors company financial results and commentary from downstream sectors, such as pigment, paint, tiles and retail hardware. These, as well as Iluka’s extensive market knowledge, via its global presence and customer relationships, provide an insight into end consumer demand, capacity utilisation, inventory levels and product price trends.