



GLOBAL

ZIRCONIUM REVIEW

“A diversified international investment firm with a global perspective for global excellence”

ZIRCONIUM REVIEW

What is zirconium?

For over 2000 years, zircon (Zr) has been used as a gemstone. Today it is used in a wide range of sectors due to its many beneficial qualities such as manufacturing products and industrial processes. Zircon is a zirconium silicate mineral with the chemical formula $ZrSiO_4$. Its physical and chemical characteristics are comparable to those of titanium. Zircon occurs in a wide range of colors such as yellow, brown, red, and colorless. Colorless zircon has a brightness and fire that rivals those of diamond, which can be used as a lower-cost alternative for diamond. It has a hardness of 6-7.5 Mohs, melting point of 1852 °C and a boiling point of 4409 °C, a specific gravity of 4.7, and a tetragonal crystal structure.

Desirable characteristics of zirconium metal

- Malleable
- Ductile
- Easily forms stable compounds (less reactive or unreactive state)
- Highly resistant to corrosion
- Resistant to heat
- Alloy
- Stable at high temperature
- Excellent thermal shock resistance

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Uses/Application

- Nuclear application -used as an alloy to form zircaloy which is used in nuclear reactors since it does not readily absorb neutrons only at a higher rate.
- Gemstone- used in jewelry as a natural gemstone. Occurs in several colors like red, yellow, clear, and brown
- Manufacturing high-temperature resist parts-combustors, blades, and vanes in jet engines
- zirconium is superconductive at low temperatures and is used to make superconducting magnets.
- Mixed with vanadium or praseodymium makes blue and yellow pigments for glazing pottery
- Other uses catalytic converters, furnace bricks, lab crucibles, surgical instruments, to make television glass, remove residual gases from vacuum tubes, and as a hardening agent in alloys such as steel.

Geological occurrence

The crust of the Earth contains a significant amount of zircon. Zirconium ore are placer deposits in nature and may take millions of years to form. Zircon is more resistant to weathering and erosion than most other minerals because of its hardness, chemical inertness, and endurance. because of its high density, zircon tends to spontaneously separate from typical silica sand. Zircon thus concentrates in sedimentary deposits and is found in most sands. It is concentrated economically in heavy mineral sand deposits. These alluvial deposits contain mainly sub-millimeter grains of zircon derived from the weathering of granitic rocks and metamorphic. Zirconium (Zr) is commonly found in felsic rock and igneous rock rich in silica and feldspar, rarely found in mafic rocks, and very rarely in ultramafic igneous rocks. The most common source of zircon is zirconium silicate mineral ($ZrSiO_4$). A mineral baddeleyite is a natural form of zirconium oxide or zirconia (ZrO_2). The zircon deposits are typically found in combination with heavy minerals, such as kyanite, monazite, garnet, staurolite, and the titanium-bearing minerals ilmenite and rutile.

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Reserves/Resources

Zirconium is not a rare earth element it's the most common mineral. Because it is resistant to weathering, it is slightly mobile in the environment but can be transported by wind and water to form alluvial and marine deposits or sand. It is 10x more abundant than lead and more than twice abundant as zinc and copper. Zircon and zirconia sand deposits are abundantly found in Australia, South Africa, India, Sri Lanka, and the USA (Lenntech, 2022). According to the Indian Mineral year book 2017, the estimated total zirconium reserves in the world are 74 million tonnes of ZrO₂. The largest reserves in the world are in Australia (64%), South Africa (19%), and India (5%).

Zirconium Consumption

Around 1,2 Mt of zircon were consumed worldwide in 2006, with ceramics (51%) and foundries (15%), refractory (15%), chemicals (9%), Tv glass (8%) and other (2%). In 2019, the ceramic industry accounted for (52%), refractory and foundry (25%), chemicals and fused (20%), Tv glass and other 3% (Zirconet, 2020).

Combined, China(1.2Mt), Australia (711K tonnes), and the United States (98K tonnes) consume 78% share of the total volume of the world's zirconium ore and concentrate (Index Box, 2022). China commands most of the worldwide market share for zirconium, accounting for about 50% of the total revenue as is the largest consumer and producer of ceramic tiles were more than 1,450 ceramic tile manufacturers in the country. In the current situation, China is gaining recognition as the nuclear energy consumer with the quickest rate of growth. It is anticipated that demand for zirconium would rise as more attention is paid to developing nuclear power resources (Modor intelligence, 2022).

2022



ZIRCONIUM REVIEW

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According to the Mordor intelligence report of 2022, following countries below are the biggest consumer of zirconium.

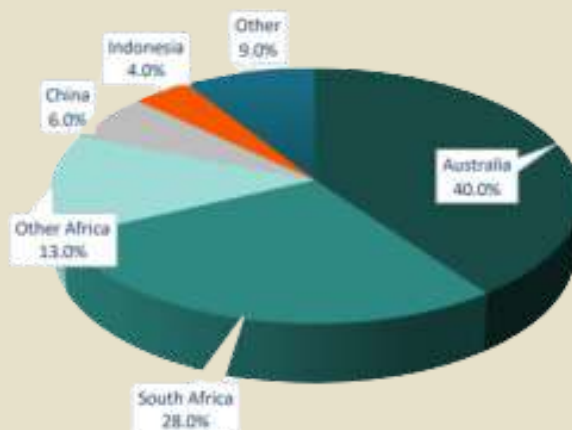
1. China
2. US
3. Japan
4. European Union
5. India
6. Russia
7. Spain
8. Rest of the World

Production

In various regions of the world, alluvial deposits on land and in the ocean are mined for industrial-grade zircon. Zircon can be a byproduct of tin mining as well as the extraction and processing of the titanium minerals ilmenite and rutile. Significant zircon producers are Australia, South Africa, China, Indonesia, Mozambique, India, Ukraine, Sri Lanka, Madagascar, Brazil, Kenya, and several other nations. Each year, more than 1.5 million tonnes of zircon are mined, primarily in South Africa and Australia. Australia, accounts for 35% of the world's output and South Africa comes in second with a 28% share output (Tim, 2018).

2020

The total production in 2020 was 1.2Mt, Australia (40%), South Africa (28%), China (6%), Indonesia (4%), other Africa (13%), and other (9%).



2022



ZIRCONIUM REVIEW

2019

Australia (33%) and South Africa (27%) are the two countries that produce the most zircons globally in 2019, with China (11%) and Indonesia (8%) also making important contributions (Ryan, 2019).

2015

In 2015, it was estimated that 1.34 million tonnes of zirconium minerals were produced worldwide (Indian Minerals Yearbook 2017, 2018). In 2015 with 598 kt, Australia had the biggest production of zirconium minerals, followed by South Africa and the USA.

2014

Australia was a leading producer with a share of 43% of world's production of zircon, followed by South Africa (28%), China (9%), Indonesia (4%), USA (5%), Mozambique (5%), India (2%), and other (4%), According to Statista Zircon produce report. About 1.45 million metric tons (mt) of zirconium mineral concentrates were produced worldwide in 2014, excluding U.S. output (George, 2014).

2013

Despite a declining demand, particularly in China, the global production of zirconium concentrates in 2013 remained roughly at the same level as that in 2012. The total amount of zirconium produced worldwide in 2013 was 1.44 million tonnes, a 1.4% decrease from the previous year. Australia produced 42% of the world's zirconium, with South Africa producing 25% of it and China producing 10%.

2022



ZIRCONIUM REVIEW

Demand and supply

The supply of zirconium increased from 673,000 t to 1,680,000 t between 1999 and 2014 at a compound annual growth rate of 6.75%. Supply fell from 1,680,000 to 1,330,000 t between 2014 and 2016 by 21%. High pricing caused a substantial fall in zircon demand, which resulted in demand destruction in the ceramics industry, from 1.4 metric tons (Mt) in 2011 to 1.1 Mt in 2014. But since 2011, demand has stayed constant at 1.1Mt, and by 2025, it's projected to rise to 1.6Mt. In 2019, there was a 1.2Mtpa demand for zircon sand worldwide. For the past five years, the demand has grown at an average yearly pace of about 1.5%. From 2020 to 2023, this demand is anticipated to rise by 2.7% (Zirconment,2020).

Substitute of Zircon

- Chromite
- Zircon
- Dolomite
- Spinel
- Tantalum
- Hafnium
- Niobium

Price

From 2010 to 2012 the price was a rapid growth up to \$2650/Mt. From late 2012 to 2013 the price fell sharply to \$1300. From 2016 to 2019, prices increased once more, reaching the present range of USD 1500–1600/mt. Zircon prices have risen significantly in 2021 because of the rising demand, low availability, and lack of supply growth in the near future.

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Value

In 2017, the global zirconium market was valued at 1820 million USD and in 2020 market soared to \$2.4B in 2020.

Zircon Global Producers

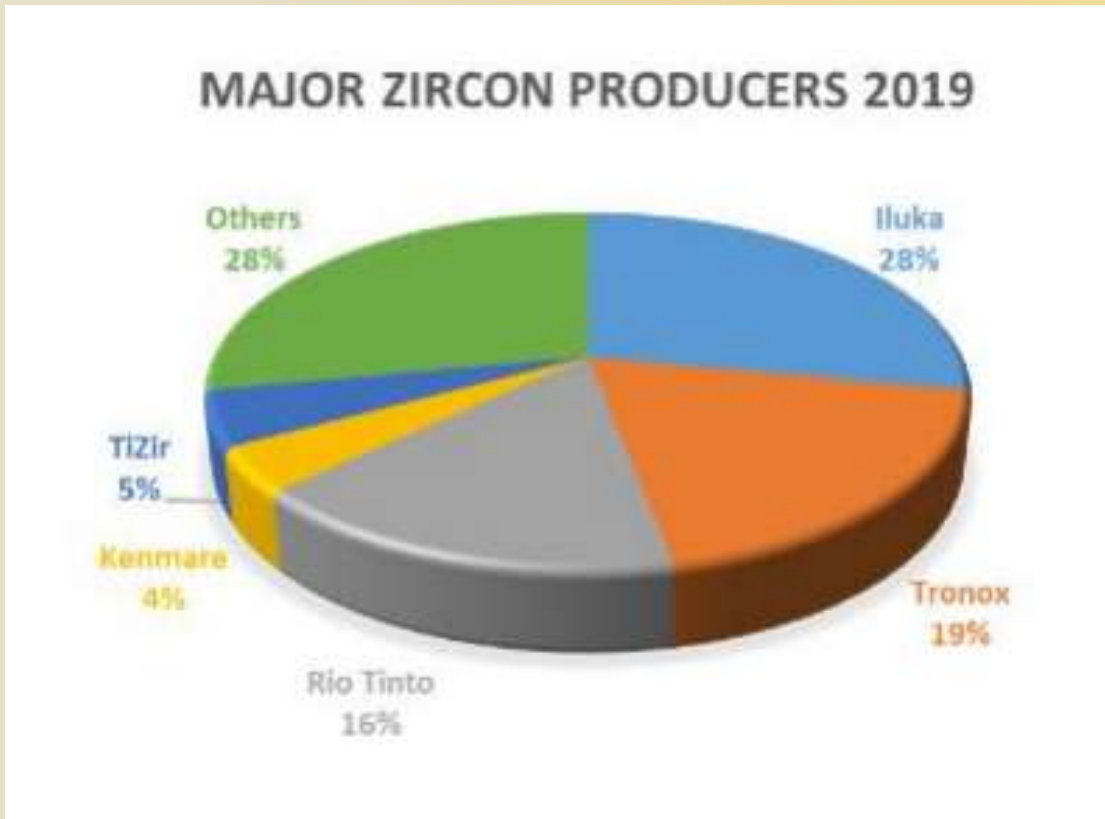
The top five businesses account for over 70% of the world's use of zirconium, which is a result of market consolidation.

1. South Australia- Ambrosia owned by Iluka's zircon
2. Tronox/Cristal mine -in South Africa and Australia
3. Eramet
4. Kenmare Resources PLC
5. South Africa – Richards Bay Minerals which is owned by Rio Tinto
6. Exxaro- South Africa
7. Mozambique- Moma mine which is owned by Kenmare
8. Senegal- TiZr mine
9. Other production is from mainland China and Indonesia

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ZIRCONIUM REVIEW



South Africa

Zirconium placer deposits are located along the eastern, southern, and north-eastern coasts. Richards Bay Minerals, Exxaro's KwaZulu-Natal Sands, and Namakwa Sands are significant zircon mining operations in South Africa. South Africa was supplying 40% of the world's zircon output in 2006 during that year Geratech company in Krugersdorp became South Africa's only beneficiation of zircon and still, today is the largest.

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ZIRCONIUM REVIEW

Richard bay minerals (RBM)

The largest mineral sand producer in South Africa and a global leader in the extraction and refinement of heavy mineral sands. Started operating in 1976, reserves are along the KwaZulu-Natal coastlines situated along the eastern coast. A joint venture between Rio Tinto (74%) and Blue Horizon (24%) which is a consortium of several BEE companies or investors and the 2% held in an employee trust. Richard bay minerals have invested \$463 million to expand its resources. Ilmenite, rutile, titania slag, high-purity iron, and zircon are the main elements that RBM extracts from the vast mineral-rich sands of the northern KwaZulu-Natal region. The mine has four operations in the Zulti North lease area, with a mineral separation plant and smelting facility

Hillendale mine (Tronox)

Situated on the north coast of KwaZulu-Natal in South Africa near the towns of Empangeni and Richards Bay. Formerly known as Ticor SA (Kumba iron ore). Exxaro Resources Limited (Exxaro sands) used to own 100% of the mine before it sold it to Tronox Pty Ltd. The Hillendale mine currently is in the closure phase and rehabilitation activities have commenced. The mine resources are exhausted. During the mining operation the heavy minerals rutile, ilmenite, zircon, and leucoxene were extracted. First production began in 2001 with a designed production rate of 830 000t/m of concentrate of heavy minerals (Celest, 2011).

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ZIRCONIUM REVIEW

Namakwa sand

Namakwa sands was previously owned by Anglo American placed as one of the world's top three suppliers of zircon. In 2006, it was sold to Exxaro Resources Limited at ZAR 2billion (US\$245 million), and later around 2011 was sold to Trenox. Till today Trenox has been the one exploiting Namakwa sand deposits on the west Coast of South Africa. The open pit mine and concentration plant is situated at Brand-se-Baai, 385 Km north of Cape Town. Categorized as a mega resource with 1.17 billion tons (Bt) of ore, containing 92.6 million metric tons (Mt) of total heavy minerals and the equivalent of 23.9 Mt TiO₂ units and 9.4 Mt zircon. The mine is permitted to mine deeper Orange Feldspathic Sand and beneficiate heavy minerals to produce titanium dioxide, zircon, rutile, and high-purity iron products. The mine only produces ore concentrate, and the concentrates are further transported 60km to the Mineral Separation Plant where zircon, rutile, and ilmenite are produced. The smelt is located a further 270km at Saldanha Bay where ilmenite is processed in a furnace to produce pig iron and titanium dioxide slag (Philander et al, 2015).

Iluka Resources Limited

Founded in 1998, Iluka Resources is a leading global mineral sands mine headquartered in Perth, Western, Australia, and operations in Australia and Virginia, the United States. Iluka Resources Limited is the largest global zircon producer and third producer of titanium dioxide products of rutile and synthetic rutile behind Rio Tinto and Tronox. It is involved in the exploration, project development, operation, and marketing of mineral sand products. In 2021, the company had revenue of \$175M, \$2B in assets, profits of \$1.7B, and over 3,252 employees (Forbes, 2022). It is involved in the exploration, project development, operation, and marketing of mineral sand products.

2022



ZIRCONIUM REVIEW

Moma mine (Mozambique)

Located 160 km from the city of Nampula in Mozambique. It is the world's biggest titanium mineral deposit, owned and operated by Kenmare Resources. The mine employed over 1.420 people at the end of 2019. The mine contains the titanium minerals ilmenite, rutile, and zircon which are used as feedstock to produce titanium dioxide pigment. In 2020, shipped over 853.100t of finished products. From 2013, the mine is expected to have a life span of more than 100 years. Several heavy mineral deposits of sand of Moma have been identified which include, Namalope, Mualadi, Nataka, Congolone, Marrua, and Quinga South and North. As of December 2019, the combined proven and probable reserves of the Namalope, Pilivili, and Nataka zones were 1,584Mt, consisting of 2.7% ilmenite, 18% zircon, and 0.06% rutile. The heavy mineral sands are mined through dredging (Mining technology, 2021).

TiZir mine (Senegal)

The company is jointly owned 50/50 by Mineral Deposits Limited of Australia and Eramet of France. Mineral Deposit Limited has extensive mineral sand mining experience and development expertise, over 50 years of mining sands. Eramet is a leading global producer of alloying metals like manganese and nickel and high-performance steels and alloys. Eramet group employs approximately 15.000 people in 20 countries. The 2011-founded firm TiZir has two locations: TiZir Titanium and Iron (TTI) in Norway (Tyssedal), which uses ilmenite from Senegal to manufacture titanium dioxide slag and high-purity pig iron, and Grande Côte Operations located in Senegal, north of Dakar, near Diogo, which produces high-grade mineral sands, chiefly ilmenite, and zircon and small amounts of rutile and leucoxene. World number 4 producer of zircon and with over 25 years of resources. The mining concession is over 103Km along the coastal line. 50 million tons of sand are expected to be extracted annually, producing 85,000 tons of zircon, 15,000 tons of rutile and leucoxene, and 570,000 tons of ilmenite, making Senegal one of the major producers of these minerals in the world. In 2021, over 1540 jobs were recorded, and 804KT of mineral sand was produced (TiZr Limited, Nd).

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ZIRCONIUM REVIEW

Extraction and Mineral Concentration of Zirconium

Excavators and scrapers are employed to dig out the ore if the deposit is shallow or contains tougher elements, the method is referred to as dry mining. When using dry mining, the ore is normally dumped nearby the actual mining area into a mining machine or hopper. Front-end loaders, dozers, scrapers, or vehicles feed the ore into the hopper. If the ore is beneath the water table or in a location with high dunes, dredge (wet) mining techniques are used. A dredge is used in this procedure, which takes place in a man-made pond. Sand is collected by the scraper and then sent to a wet concentrator attached to the dredge for first processing. The dredge keeps moving while dumping the tailings of sand behind it.

The ore concentrate is fed to the hopper and from the hopper to the conveyor belt into the trommel screen which sieves things bigger than 2mm such as rocks, shells, and branches to ensure uniform and stable feeding to the spiral chute. The spiral chute removes most of the silica sand to get minerals concentrate of heavy minerals and discard light minerals. The heavy minerals concentrate goes to the high-intensity magnetic separator to separate the ilmenite (titanium) from others. Tailing of the magnetic separator goes into the shaking table for zircon, rutile monazite concentrator. Because of the density difference between the minerals clear zones if formed on the shaking table

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2022

