

ZIRCON



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ZIRCON

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GOVERNMENT OF INDIA
MINISTRY OF MINES
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29 Zircon

Zircon ($ZrSiO_4$) is found usually as a constituent in heavy mineral sand assemblages, which include ilmenite, rutile, leucoxene, monazite and garnet in varying proportions. Zircon sand and baddeleyite (an oxide- ZrO_2) are used via their salts to extract zirconium and hafnium. Normally, all zirconium compounds contain between 1.4% and 3% hafnium. Zircon is very stable at high temperature and has excellent thermal shock resistance, low thermal conductivity and chemical inertness. It finds use chiefly in industries like ceramic, refractory, abrasive, foundry, chemical and speciality alloys. Gem variety of zircon is used in jewellery. Ministry of Mines vide notification No. S.O. 2356(E) dated 11.7.2016 inserted entry 12 beach sand minerals (which includes zircon) in Part B of the First Schedule to the MMDR Act, 1957.

RESERVES/RESOURCES

Zircon occurs in close association with other heavy minerals such as ilmenite, rutile and monazite in beach sands, along the coastal tracts

Table – 1: Resources of Zircon

(In million tonnes)

State	Resources [#]
Total	35.75
Andhra Pradesh	11.91
Gujarat	0.007
Jharkhand	0.08
Kerala	7.96
Maharashtra	0.03
Odisha	5.49
Tamil Nadu	9.89
West Bengal	0.38

Source : As per letter received from Department of Atomic Energy dated 26/07/2018.

: Inclusive of measured, indicated and inferred categories.

of the country. Its concentration in the deposits is about 0.6-18.7% of the total heavy minerals. Indian zircons analyse 63-66% ZrO_2 . AMD has carried out reconnaissance investigation in parts of Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, Odisha and West Bengal during 2008-16. The resource estimation in these areas have been carried out up to 2016. The resources of zircon are placed at 35.75 million tonnes as per Department of Atomic Energy (DAE). The statewise break-up of the resources is given in Table-1.

EXPLORATION & DEVELOPMENT

The exploration and development details, if any, are given in the review on Exploration & Development in "General Reviews".

PRODUCTION AND PRICES

Production of zircon increased to 29,256 tonnes in 2016-17 from 18,437 tonnes in the preceding year. The production of zircon is given in Table-2. Prices of zircon as furnished by IREL, KMML and V. V. Minerals are given in Table- 3.

**Table – 2: Production of Zircon
2014-15 to 2016-17**

(In tonnes)

Year	Production of Zircon*
2014-15	23,659
2015-16	18,437
2016-17	29,256

* Indian Rare Earths Ltd reported production of zircon 10,673 tonnes, 10,785 tonnes and 11,709 tonnes during 2014-15 , 2015-16 and 2016-17, respectively.

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Table – 3: Prices of Zircon, 2014-15 to 2016-17

(₹ per tonne)			
Period	Grade	Price	Remarks
IREL			
2014-15	Q	67750	Ex-works, bagged
	MK	67750	Ex-works, bagged
	OR	60500	Ex-works, bagged
2015-16	Q	63800	Ex-works, bagged
	MK	63800	Ex-works, bagged
	OR	57000	Ex-works, bagged
2016-17	Q	63500	Ex-works, bagged
	MK	63500	Ex-works, bagged
	OR	60800	Ex-works, bagged
KMML			
2014-15	Zircon Gr.I	68000	-
	Zircon Gr.II	64000	-
	Zircon Gr.III	58000	-
2015-16	Zircon Gr.I	73000	-
	Zircon Gr.II	69000	-
	Zircon Gr.III	65000	-
2016-17	Zircon Gr.I	76000	-
	Zircon Gr.II	71000	-
	Zircon Gr.III	52000	-
V.V. Mineral			
2014-15	NA	59036	-
2015-16	NA	34565	-
2016-17	NA	35416	-

Source: Department of Atomic Energy, Mumbai.

MINING AND PROCESSING

Indian Rare Earths Ltd (IREL), a Government of India Undertaking, KMML, a Kerala State Government Undertaking and V.V. Mineral, a Private Sector company are engaged actively in mining and processing of beach sands in India. Zircon is recovered by these companies as a co-product of mining/dredging of heavy mineral sands which include ilmenite, rutile, leucoxene, monazite, sillimanite and garnet. Beach sand deposits containing these minerals are obtained from coastal tracts of Manavalakurichi in Tamil Nadu, Chavara in Kerala and Gopalpur in Odisha. As such, no deposit is being worked exclusively for zircon alone. For details regarding mining and processing, etc., review on 'Ilmenite and Rutile' may be referred. Plantwise capacity and production of zircon during 2014-15 to 2016-17 are given in Table- 4.

INDUSTRY

IREL has set up a dry grinding mill at Chavara, Kerala to produce Zirflour for its application in the ceramic industry. A wet grinding mill was also set up at Chavara to produce micro-zir for its specialised

application as opacifier. Besides, IREL established a small chemical plant at Manavalakurichi, Tamil Nadu to produce zircon frit, zirconium chloride, etc., primarily for making supply of zircon frit to Department of Atomic Energy's Nuclear Fuel Complex (NFC), Hyderabad. A pilot plant (3.5 tpy capacity) was set up at Orissa Sand Complex (OSCOM) to produce a whole range of zirconia stabilised with CaO, MgO and rare earths.

The NFC manufactures and supplies fuel bundles for Pressurised Heavy Water Reactors (PHWRs) and Boiling Water Reactors (BWRs) of NPCIL. Highest ever production of PHWR fuel bundles, Zirconium Oxide, Zirconium sponge and Niobium metal was achieved during the period. The NFC, Hyderabad has different types of production facilities which include the zirconium oxide plant for processing of zircon to pure zirconium oxide and zirconium sponge plant for conversion of zirconium oxide to pure sponge metal and Zirconium Complex (ZC) at Pazhayakayal, near Thoothukudi, Tamil Nadu. NFC Hyderabad produced 542 tonnes, 625 tonnes and 651 tonnes of zirconium oxide during 2014-15, 2015-16 and 2016-17, respectively. ZC, Pazhayakayal, produced 259 tonnes, 502 tonnes and 503 tonnes of ZrO₂ in 2014-15, 2015-16 and 2016-17, respectively. Besides, the Zircaloy Fabrication Plant produces various zirconium alloy tubings and sheet, rod and wire products. The plant also has facilities for reclamation of zircaloy mill-scrap. Zircon sand is processed through caustic fusion, dissolution, solvent extraction (to remove hafnium), precipitation and calcination to obtain zirconium oxide. The pure oxide is then subjected to high temperature chlorination, reactive metal reduction and vacuum distillation to obtain homogeneous zirconium sponge. The sponge is briquetted with alloying ingredients and melted in vacuum to produce zircaloy ingots. The alloy ingots are extruded to convert into seamless tubes, sheets and bars. The total installed capacity and production of zirconium oxide and zirconium sponge plants at NFC and ZC are furnished in Table-5.

Besides, Bhalla Chemical Works Pvt. Ltd operates three plants; two of which are located in Gurgaon, Haryana to manufacture zirconium derivatives (ZrO₂), based on imported zircon ore (capacity 10,000 tpy) and zirconium silicate opacifiers (capacity 5,000 tpy). The third plant of the company in Rajasthan manufactures zirconium oxychloride crystals and special zirconias (capacity 10,000 tpy).

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Table – 4: Plantwise Capacity and Production of Zircon ore, 2014-15 to 2016-17

(In tonnes)

Company	Location	Specification	Installed capacity (tpy)	Production		
				2014-15	2015-16	2016-17 (P)
Total			57000	23659	18437[#]	29256[#]
Indian Rare Earths Ltd	Manavalakurichi, Kanyakumari distt., Tamil Nadu	65% ZrO ₂ +HfO ₂ (min)	10000	10673	10785	11709
	Chavara, Kollam distt., Kerala	65% ZrO ₂ +HfO ₂ (min)	17500			
	Orissa Sand Complex, Ganjam distt., Odisha	64.25% ZrO ₂ (min)	5000			
Kerala Minerals & Metals Ltd	Chavara, Kollam distt., Kerala	Zircon Gr.I 64.0% (min) Zircon Gr.II 62% (min)	6500	4768	5346	4784
V. V. Mineral	Keeraikarantattu, Tirunelveli distt.,Tisaiyanvilai, Tamil Nadu	66% min (ZrO ₂ +HfO ₂)	18000 (654,000 - of heavy minerals)	8218	2306	12763

Source: Respective Producers and Department of Atomic Energy, Mumbai.

Total includes 10,785 tonnes & 11,709 tonnes of Zircon during the year 2015-16& 2016-17 from IREL, Plantwise break up is not available.

** Besides, 886 tonnes, 507 tonnes & 1097 tonnes of zirflour is reported in 2014-15, 2015-16 & 2016-17, respectively.*

Table – 5 : Production at Zirconium Oxide and Sponge Plants of DAE at NFC and ZC 2014-15 to 2016-17

(In tonnes)

Plant/Location	Installed capacity (tpy)	Production		
		2014-15	2015-16	2016-17
Zirconium Oxide Plant, NFC, Hyderabad	600	541.808	625.089	651.125
Zirconium Sponge Plant, NFC, Hyderabad	400	-	-	-
Zirconium Oxide Plant, ZC, Pazhayakayal	500	258.285	502.000	503.200
Zirconium Sponge Plant, ZC, Pazhayakayal	250	115.140	-	-

Source: Department of Atomic Energy, Mumbai.

USES & CONSUMPTION

Zircon's exceptional qualities of hardness and durability make it a must-use for the manufacture of ceramics and refractory tiles and also for a range of other high-tech applications such as armour plating on military aircraft, heat shield in space shuttles and potentially as solid oxide fuel cells in hydrogen powered vehicles and in many industrial and chemical applications. Owing to its chemical inertness, very low heat conductivity, high specific gravity, low expansion, good resistance to abrasion, high melting point and no shrinkage on being heated up to 1750^oC, zircon is found to be an outstanding refractory material. Zircon finds its application in ceramics, zirconia, chemicals, refractory and foundry & castings which accounts for zircon's total world estimated consumption. Zirconia and Zirconium chemicals can be used for a variety of uses. Yttria-stabilised zirconia (YSZ) is used in the manufacture of oxygen sensors that control combustion in automobile engines and furnaces. In Foundry Industry, zircon is used as facing for foundry moulds as it increases the resistance to metal penetration and accords a uniform finish to castings. Zircon sand is preferred to silica sand because of its uniform size, higher melting point, low thermal expansion and resistance to molten metal, acidic chemicals, slag, etc. Zircon containing 64% ZrO₂ is used generally for foundry applications. In Ceramic Industry, finely ground high-grade zircon and zirconium dioxide are used as opacifier in melts for vitreous enamelling and as pigment in ceramic glazes. Zirconium oxide is considered as a potential ceramic material for high temperature applications like engine components. Usually, zircon containing 65% ZrO₂ is preferred in ceramics. The toughened zirconia finds its use in ceramic coatings in jet aircraft engines and in other applications where strength and high temperature oxidation resistance are important. Zirconia ceramics are also used in automobile sensors for the microprocessor control of engines.

In Chemical Industry, its property of high resistance to corrosion is used where dry chlorine, hydrochloric acid and caustic alkalies are involved. Abrasive and grinding wheels made from zircon sands are used for polishing optical glasses. Zircon powder is used as a medium in waterjet cutting machines.

Zirconium and zirconium powders are used in ammunition, primers, detonation caps, flashlight mixtures, radio tubes and in various heating elements. Hafnium-free zirconium metal is used as cladding material in atomic reactors due to its low absorbing cross section for thermal neutron. Green, blue, indigo, red, orange coloured zircon is used as a natural gemstone and also processed to produce cubic zirconia - a synthetic gemstone resembling diamond. Zircon compounds have a very low toxicity and are not perceived as a potential environmental hazard. They are even said to have some medicinal properties and are now increasingly preferred in the manufacture of food products and pharmaceuticals too. It is also widely used in television and computer screens, resistance to corrosion and erosion makes zircon products ideal for use in the Chemical Industry and in desalination plants. Zircon flour is manufactured by milling zircon sand. It is used in ceramic frits, foundry mould coatings, ceramic shells for investments casting, refractories, friction products, insulating fibres and glass. Zircon opacifier are used in refractories and friction products. Zirconium metal, or sponge is used mainly in the Nuclear Industry with a requirement for minimum content of hafnium.

Consumption of zircon/zirflour decreased to 23,500 tonnes in 2016-17 from 29,800 tonnes in 2015-16. Consumption of zircon/zirflour during 2014-15 to 2016-17 is furnished in Table- 6. Ceramic Industry was a major consumer of zircon/zirflour accounting for 63% consumption in 2016-17, followed by Refractory Industry (30%).

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**Table – 6: Estimated Consumption * of Zircon Zirconium
2014-15 to 2016-17
(By Industries)**

Industry	(In tonnes)		
	2014-15	2015-16 (R)	2016-17 (P)
All Industries	12200	29800	23500
Ceramic	5700	15700	14800
Chemicals	1400	1400	-
Foundry	1100	2400	1600
Refractory	4000	10300	7100
Others (Alloy steel, iron & steel, & paint)	++	++	++

Figures rounded off.

* Includes actual reported consumption and/or estimates made wherever required. Due to paucity of data, coverage may not be complete.

POLICY

Zircon was earlier classified as a 'prescribed substance', as per notifications issued under Atomic Energy Act, 1962. From the revised list notified vide S. O. No. 61(E), dated 20.1.2006, zircon has been deleted, subject to the condition that the mineral shall remain a prescribed substance till the policy on exploration of beach sand minerals notified on 6.10.1998, is adopted/ revised/modified by Ministry of Mines or till 1.1.2007, whichever occurs earlier and shall cease to be so thereafter. Recently, vide notification No.S.O.2356(E) dated 11.07.2016, zircon covered under beach sand minerals and being inserted after entry 11 of Part B of the First Schedule to the MMDR Act, 1957. As per the Foreign Trade Policy, 2015-20, the export and import of zirconium ores and concentrates under ITC (HS) Code 26151000 are freely allowed.

WORLD REVIEW

World reserves of zirconium are placed at 74 million tonnes in terms of ZrO₂. The world's largest reserves are with Australia (64%), South Africa(19%) & India (5%). The world production of zirconium minerals was estimated at 1.34 million tonnes in 2015. Australia, South Africa, USA and Mozambique are the principal producers of zirconium minerals (Tables- 7 & 8).

**Table – 7: World Reserves of Zirconium
(By Principal Countries)**

(In '000 tonnes of ZrO₂)

Country	Reserves
World: Total (rounded)	74000
Australia	47000
China	500
India	3400
Mozambique	1800
South Africa	14000
USA	500
Other countries	7200

Source: Mineral Commodity Summaries, 2018.

**Table – 8 : World Production of
Zirconium Minerals
(By Principal Countries)**

(In '000 tonnes)

Country	2014	2015	2016
World: Total	1323	1325	1368
Australia	582	608	608
Brazil ^b	24	25 ^e	25 ^e
China ^e	34	34	34
India	19	10 ^e	5 ^e
Indonesia ^e	21	31	35
Kenya	40	26	35
Madagascar	27	9	12
Mozambique	51	52	68
Senegal	9	45	53
South Africa ^e	393	390	390
USA ^e	70	50	50
Ukraine ^e	35	35	35
Other countries	19	11	19

Source: World Mineral Production, 2012-16.

^b Including caldasite rock containing zircon and baddelyite.

Australia

Iluka Resources produced 351,000 tonnes of zircon from its operations in Australia, an increase of 6% compared with that of 2014. Production was 297,000 tonnes from its operations in the Eucla Basin, South Australia, and the Perth Basin, Western Australia, and 54,000 tonnes from its operations in the Murray Basin.

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MZI Resources Ltd completed construction of its Keysbrook project and began mining heavy-mineral concentrates in October. By year end, Keysbrook had produced 1,775 t of zircon and had shipped 1,000 tonnes to China.

In New South Wales, Alkane Resources Ltd continued to develop its Dubbo Zirconia project and planned to produce hafnium, niobium, rare-earth, tantalum and zirconium products. Based on recoveries developed from the demonstration pilot plant, 25,200 tonnes per year of combined output was expected, including zirconium carbonate (equivalent to 16,300 t/yr of ZrO₂) and more than 200 t/yr of hafnium oxide. Ore reserves were sufficient to support a 35-year mine life. Alkane received State and Federal environmental approvals in 2015 and was expecting to begin construction in 2016 with production to begin in 2018.

China

China imported 1.05 tonne of zircon concentrates in 2015, an increase of 30% from that of 2014, but the average value decreased by 10% to \$752 per tonne.

By the end of 2015, major zirconium metal producers were reportedly operating at reduced capacity due to overcapacity issues. Other producers had stopped producing zirconium sponge and were liquidating existing stock. The Shanghai Hafeng New Materials Science and Technology Co., Ltd applied for a national patent based on a new zirconium and hafnium separation technology. Shanghai Hafeng also announced the planned construction of a new operation with an annual capacity of 200,000 t/yr of zirconium and 3,000 t/yr of hafnium, to be built in Jiangsu. No timetable was given for start of construction.

Kenya

Base Resources Ltd reported that it produced 26,000 tonnes of zircon from its Kwale operation in 2015, the first full year of production. The production target for 2016 was 27,000 to 30,000 tonnes of zircon.

Mozambique

Kenmare Resources plc produced 51,800 tonnes of zircon at its Moma Mine in 2015, an increase of 2% from that of 2014.

Senegal

Mineral Deposits Ltd reported that it produced 45,200 tonnes of zircon at its Grande Cote project in 2015, the first full year production. The company planned to increase zircon production in 2016. At full production levels, Mineral Deposits expected to produce 85,000 t/yr of zircon over a 25-year mine life.

South Africa

Tronox Ltd expected to begin operations at its Fairbreeze Mine in 2016. During a 12-year mine life, the Fairbreeze Mine was expected to produce 60,000 t/yr of zircon.

Mineral commodities Ltd reported that it produced 44,489 tonnes of zircon-rutile concentrate, grading 72.88% zircon and 13.44% rutile, at their Tormin Mine in 2015, an increase of 4% from that of 2014.

FOREIGN TRADE

Exports

Exports of zirconium ores and concentrates decreased to 1,693 tonnes in 2016-17 from 4,859 tonnes in the previous year. Exports were mostly to Japan (45%), China (26%) and Netherlands (17%). Exports of zirconium and scrap sharply decreased to 11 tonnes in 2016-17 as against 236 tonnes in 2015-16. Exports were mostly to Nepal (73%). While, exports to Canada, Ethiopia, etc. were negligible (Tables-9 & 10).

Imports

Imports of zirconium ores and concentrates increased to 73,932 tonnes in 2016-17 from 53,208 tonnes in the previous year. Main suppliers were Australia (67%) and South Africa (19%). Imports of zirconium and scrap were at 27 tonnes in 2016-17 against 37 tonnes in 2015-16. Imports were mainly from China (59%), Germany (19%) and USA (7%) (Tables-11 & 12).

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Table – 9: Exports of Zirconium Ores & Conc. (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	4859	241900	1693	95182
Japan	1026	68516	755	46973
China	2944	113742	448	17889
Netherlands	560	37810	280	16924
Belgium	130	8783	154	9216
UK	-	-	26	1669
Oman	24	1777	18	1609
Bangladesh	-	-	5	405
UAE	5	346	4	250
Iran	-	-	3	214
France	78	5328	++	33
Other countries	92	5598	-	-

Table – 10: Exports of Zirconium & Scrap (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	236	25879	11	6661
USA	++	22	++	2569
Canada	-	-	2	1919
Nepal	-	-	8	974
Ethiopia	-	-	1	580
Italy	-	-	++	283
Australia	++	55	++	142
France	-	-	++	107
Bahrain	-	-	++	53
Thailand	-	-	++	34
Iran	234	20827	-	-
Other countries	2	4975	-	-

FUTURE OUTLOOK

The development of digital printing of ceramic tile pattern has the potential to increase demand since higher zircon content of the base tile is required to impart greater aesthetic appeal and optimize the cost of the digital printing process.

The Working Group on Mineral Exploration & Development (other than coal & lignite) for the 12th Five Year Plan (2012-17) has estimated the projected demand for next five years between 86,000 and 90,000 tpy at the GDP growth rate of 8%, 9% and 10%. The projected production is

Table – 11: Imports of Zirconium Ores & Conc. (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	53208	3691649	73932	4569039
Australia	49056	3421394	49174	3073405
South Africa	1935	132219	14261	868582
Ukraine	78	5250	2272	133584
Kenya	314	19584	2346	133465
Senegal	108	7467	2142	127992
Indonesia	225	16162	1506	95215
USA	198	40855	319	45907
Sri Lanka	664	10519	1375	41059
China	40	8894	100	22027
Thailand	156	10323	234	14309
Other countries	434	18982	203	13494

Table – 12: Imports of Zirconium & Scrap (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	37	74880	27	51750
China	21	10021	16	20146
Germany	6	13612	5	15357
Italy	2	8270	1	6677
USA	4	25953	2	4355
Malaysia	2	4304	1	2668
UK	++	377	2	1849
France	1	7958	++	450
Czech Republic	-	-	++	128
Singapore	++	67	++	116
Korea, Rep. of	++	43	++	4
Other countries	1	4275	-	-

expected to remain at the level of 30,000-35,000 tpy with the balance to be met by way of imports.

As a major producer, Iluka expected the zircon market would continue to remain over supplied and that production would decrease in 2016. TZ Minerals International Pty Ltd, a major industry analyst of the zircon and Titanium Mineral Sands Industry, expected global zircon demand to increase by 3% to 4% per year from 2015 to 2020.

In the IREL's Annual Report, 2016-17 it was mentioned that the way of Chinese Industry copes with the regulations is likely to impact the demand - supply dynamics of two major products produced by IREL viz. Ilmenite and Zircon.