

# 80 Zircon

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**Z**ircon ( $ZrSiO_4$ ) is found usually as a constituent in heavy mineral sand assemblages which include ilmenite, rutile, leucoxene, monazite and garnet in varying proportions. Zirconium and hafnium are extracted (via their salts) from zircon sand and baddeleyite (an oxide- $ZrO_2$ ). Normally, all zirconium compounds contain between 1.4% and 3% hafnium. Zircon is very stable at high temperatures 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.

## RESOURCES

Zircon occurs in close association with other heavy minerals, such as ilmenite, rutile and monazite, all along the coastal tracts of the country. Its concentration in the deposits is about 0.6-18.7% of the total heavy minerals. Indian zircons analyse 63-66%  $ZrO_2$ . The AMD has carried out reconnaissance investigations in parts of Maharashtra, Andhra Pradesh, Tamil Nadu, Kerala, Gujarat and Odisha during 2008-10. The resources estimation in these areas is almost complete. The resources of zircon have been enhanced from 28.29 million tonnes in 2005 to 32.28 million tonnes in August 2009. The statewise break-up of the resources is given in Table-1.

## EXPLORATION & DEVELOPMENT

Exploratory agencies comprising GSI; Directorate of Geology, Odisha and AMD carried out exploration in the beach sands deposits which contain heavy minerals, such as ilmenite, rutile, monazite, rare earths, zircon and garnet.

For details, the review on 'Ilmenite and Rutile' may be referred.

## PRODUCTION AND PRICES

Production of zircon dropped to 28,049 tonnes in 2009-10 from 29,158 tonnes in the preceding year. Tamil Nadu was the leading producer, contributing 41% to the total production, followed by Kerala (38%) and Odisha (21%) (Table-2). The value of production of zircon during 2009-10 was Rs. 112.84 crore against Rs. 96.97 crore during the preceding year. The prices of zircon as furnished by IREL, KMML and V.V. Mineral are given in Table - 3.

## MINING AND PROCESSING

IREL, a Government of India Undertaking, KMML, a Kerala State Government Undertaking and Beach Minerals Co. Pvt. Ltd (BMC), a private sector company, are engaged actively in mining and processing of beach sands in India. Zircon is recovered 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 worked 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. A project for enhancement of zircon capacity to 4,000 tpy is being implemented by KMML at Chavara. Plantwise capacity and production of zircon during 2007-08 to 2009-10 are given in Table-4.

ZIRCON

**Table – 1 : Resources of Zircon**

(In million tonnes)

State	Resources*
<b>Total</b>	<b>32.28</b>
Andhra Pradesh	12.60
Bihar	0.08
Kerala	6.52
Maharashtra	0.07
Odisha	3.16
Tamil Nadu	9.46
West Bengal	0.39

Source: Department of Atomic Energy, Mumbai.

\* Inclusive of indicated, inferred and speculative categories.

**Table – 2 : Production of Zircon**

**2007-08 to 2009-10**

(By States)

(In tonnes)

State	2007-08	2008-09	2009-10
<b>India : Total*</b>	<b>35977</b>	<b>29158</b>	<b>28049</b>
Kerala	14571	10217	10716
Odisha	5476	5807	5906
Tamil Nadu	15930	13134	11427*

Source: Department of Atomic Energy, Mumbai.

\* Besides, V.V. Mineral reported 7,900 tonnes production of zircon-sillimanite in 2009-10.

**Table – 3 : Prices of Zircon, 2007-08 to 2009-10**

(Rs. per tonne)

Period	Grade	Price	Remarks
<b>IREL</b>			
<b>2007-08</b>	Q & MK	40000	Ex-works, bagged
	OR	36000	Ex-works, bagged
w.e.f. 20.11.2007	Q & MK	34000	Ex-works, bagged
	OR	29000	Ex-works, bagged
w.e.f. 8.2.2008	Q & MK	32000	Ex-works, bagged
	OR	27000	Ex-works, bagged
<b>2008-09</b>			
	Q & MK	32000	Ex-works, bagged
	OR	27000	Ex-works, bagged
w.e.f. 29.5.2008	Q & MK	34000	Ex-works, bagged
	OR	29000	Ex-works, bagged
w.e.f. 1.7.2008	Q & MK	38000	Ex-works, bagged
	OR	35000	Ex-works, bagged
w.e.f. 1.9.2008	Q & MK	40000	Ex-works, bagged
	OR	37000	Ex-works, bagged
w.e.f. 15.11.2008	Q & MK	43000	Ex-works, bagged
	OR	40000	Ex-works, bagged
<b>2009-10</b>			
	Q & MK	43000	Ex-works, bagged
	OR	40000	Ex-works, bagged
w.e.f. 1.4.2009	Q & MK	48000	Ex-works, bagged
	OR	45000	Ex-works, bagged
w.e.f. 12.10.2009	Q & MK	44500	Ex-works, bagged
	OR	40000	Ex-works, bagged
<b>KMML</b>			
2007-08	NA	34252	–
2008-09	NA	39149	–
2009-10	NA	44500	–
		to	
		50000	
<b>V. V. Mineral</b>			
2007-08	66% min	32000	–
2008-09	66% min	30996	–
2009-10*	66% min	39546	–

Source: Department of Atomic Energy, Mumbai.

Q: Quilon; MK: Manavalakurichi; OR: Odisha

\* Price of zircon-sillimanite is quoted by V. V. Mineral at Rs. 11,320 per tonne during 2009-10.

**Table – 4 : Plantwise Capacity and Production of Zircon, 2007-08 to 2009-10**

(In tonnes)

Company	Location	Specification	Installed capacity (tpy)	Production		
				2007-08	2008-09	2009-10
<b>Total</b>			<b>29500*</b>	<b>35977</b>	<b>29158</b>	<b>28049</b>
Indian Rare Earths Ltd	Manavalakurichi, Kanyakumari dist., Tamil Nadu	65% ZrO <sub>2</sub> +HfO <sub>2</sub> (min)	10000	8404	5813	4527
	Chavara, Kollam dist., Kerala	65% ZrO <sub>2</sub> +HfO <sub>2</sub> (min)	12000	12396	7772	8124
	Orissa Sand Complex, Ganjam dist., Odisha	64.25% ZrO <sub>2</sub> (min)	5000	5476	5807	5906
Kerala Minerals & Metals Ltd	Chavara, Kollam dist., Kerala	64.81% ZrO <sub>2</sub>	2500	2175	2445	2592
V. V. Mineral	Keeraikaranthattu, Tirunelveli dist., Tamil Nadu	66% min (ZrO <sub>2</sub> +HfO <sub>2</sub> )	NAS (450,000 - Total Heavy Minerals)	7526	7321	6900**

Source: IREL and Department of Atomic Energy, Mumbai.

\* Excluding V. V. Mineral.

\*\* Besides, 7,900 tonnes production of zircon-sillimanite is reported in 2009-10.

## 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. IREL, Chavara produced 1,686 tonnes and 4,183 tonnes Zirflour during 2008-09 and 2009-10, respectively, against an installed capacity of 6,000 tpy. In addition, a small chemical plant was set up 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, Hyderabad has different types of production facilities which include the zirconium oxide plants for processing of zircon to pure

zirconium oxide and zirconium sponge plants for conversion of zirconium oxide to pure sponge metal at NFC, Hyderabad and Zirconium Complex (ZC) at Pazhayakayal, near Tuticorin, Tamil Nadu. The latter was recently commissioned on 27.11.2009. Besides, facilities for reclamation of zircaloy mill-scrap; the Zircaloy Fabrication Plant for producing various zirconium alloy tubings and also sheet, rod and wire products. Zircon sand is processed through caustic fusion, dissolution, solvent extraction (to remove hafnium), precipitation and calcination to obtain zirconium oxide. The pure oxide is 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 arc 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 is furnished in Table - 5.

**Table – 5 : Production at Zirconium Oxide and Sponge Plants of DAE at NFC and ZC 2007-08 to 2009-10**

(In tonnes)

Plant/Location	Installed capacity (tpy)	Production		
		2007-08	2008-09	2009-10
Zirconium Oxide Plant, NFC, Hyderabad	500	437.11	543.60	527.61
Zirconium Sponge Plant, NFC, Hyderabad	250	325.80	340.12	375.84
Zirconium Oxide Plant, ZC, Pazhayakayal	500	–	–	18.50
Zirconium Sponge Plant, ZC, Pazhayakayal	250	–	–	0.73

*Source: Department of Atomic Energy, Mumbai.*

Besides, Bhalla Chemical Works Pvt Ltd operates three plants two of which are located at Gurgaon, Haryana to manufacture zirconium derivatives ( $ZrO_2$ ), based on imported zircon ore (capacity 10,000 tpy) and zirconium silicate opacifiers (capacity 5,000 tpy). One plant of the company in Rajasthan manufactures zirconium oxychloride crystals and special zirconias (capacity 10,000 tpy).

## USES & CONSUMPTION

Zircon's exceptional qualities of hardness and durability makes 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 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°C, zircon is found to be an outstanding refractory material.

In foundry industry, zircon is used as facing for foundry moulds as it increases the resistance to metal penetration and affords 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%  $ZrO_2$  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%  $ZrO_2$  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 automobiles in sensors for the microprocessor controls 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.

Zirconium and zirconium powders are used in ammunition, primers, detonation caps, flashlight mixtures, radio tubes and in various heating elements. It is also used as cladding material in atomic reactors due to its low absorption cross section for thermal neutron. Zircon is used as a natural gemstone and also processed to produce cubic zirconia - a synthetic gemstone resembling diamond.

Consumption of zircon/zirflor dropped to 15,556 tonnes in 2009-10 from 24,846 tonnes in 2008-09. Consumption of zircon/zirflor during 2007-08 to 2009-10 is furnished in Table - 6.

**Table – 6 : Consumption of Zircon/Zirflor  
2007-08 to 2009-10  
(By Industries)**

Industry	(In tonnes)		
	2007-08	2008-09	2009-10
<b>All Industries</b>	<b>19925</b>	<b>24846</b>	<b>15556</b>
Ceramic	12339	17019	10184
Foundry	3997	3293	2855
Refractory	1048	1410	1125
Chemical	1403	2329	698
TV face plates/glass	601	470	497
Others*	537	325	197

*Source: Department of Atomic Energy, Mumbai.*

*Note: Consumption relates to sales figures of IREL. In addition, sales by KMMML are 2,065 tonnes, 2,533 tonnes and 2,601 tonnes, respectively, in 2007-08, 2008-09 and 2009-10 for which industrywise break-up is not available. Domestic sales figures of M/s V.V.Mineral are also not available.*

*\* Include electrode, abrasive and other industries.*

## POLICY

Zircon was 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.

As per the Foreign Trade Policy 2009-2014 and the effective policy on export and import, zirconium ores and concentrates under HS Code 26151000 can be imported/exported freely.

## WORLD REVIEW

The world reserves of zirconium and hafnium are placed at 56 million tonnes and 0.66 million tonnes in terms of  $ZrO_2$  and  $HfO_2$ , respectively. Australian mineral sands deposits hold the world's largest reserves of zirconium and hafnium. The world production of zirconium minerals was estimated at 1.3 million tonnes in 2009. Australia, South Africa and China are the principal producers of zirconium minerals. Besides, USA, Vietnam and Ukraine are also important producers (Tables - 7 and 8). Zircon finds its application in ceramics (54%) and refractory (14%) which accounts for 68% of zircon's total world consumption of about 1 million tonnes. The rest 32% is consumed in foundry & casting, zirconia and chemicals, etc.

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

Country	(In '000 tonnes of $ZrO_2$ ) (In '000 tonnes of $HfO_2$ )	
	Reserves	
	Zirconium	Hafnium
<b>World : Total (rounded)</b>	56000	660
Australia	25000	230
Brazil	2200	44
China	500	NA
India*	3400	42
South Africa	14000	280
Ukraine	4000	NA
USA	3400	68
Other countries	3500	NA

*Source: Mineral Commodity Summaries, 2010.*

*\* As per Department of Atomic Energy, Mumbai, the total resources of zircon are estimated at 32.28 million tonnes.*

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

(In '000 tonnes)			
Country	2007	2008	2009
<b>World : Total</b>	<b>1523</b>	<b>1418</b>	<b>1320</b>
Australia	600	528	474
Brazil #	27	25	25 <sup>(e)</sup>
China <sup>(e)</sup>	140	140	140
India* <sup>(e)</sup>	36	36	36
South Africa	389	404	392
Ukraine <sup>(e)</sup>	35	35	35
USA	121	122	100 <sup>(e)</sup>
Vietnam <sup>(e)</sup>	22	24	8
Other countries	153	104	110

Source: World Mineral Production, 2005-2009.

# Including caldasite rock containing zircon and baddeleyite.

\* As per Department of Atomic Energy, Mumbai, India's production of zircon in 2007-08, 2008-09 and 2009-10 was 35,977 tonnes, 29,158 tonnes and 28,049 tonnes, respectively.

## Australia

Coburn heavy minerals project of Gunson Resources Ltd in Western Australia was ready to go into mine development after feasibility study. The mine is expected to have over 23 years life span with most of revenue expected from zircon production. A zircon-rich heavy minerals deposit of Matilda Zircon Ltd was under development in Tiwi Islands, Northern Territory. A new mine at the Lethbridge deposit in Melville Island was expected to go into production by mid-2010.

## China

Of the total zircon production, China consumes more than one lakh tonnes and produces around 36% of world ceramic tiles. State Nuclear Power Technology Co. Ltd (SNPT) was to construct a nuclear grade zirconium sponge plant at Nantong, Jiangsu Province with Westinghouse Electric Co's collaboration. The plant was expected to produce 1,000 tpy nuclear grade sponge within 3 years and would supply to Westinghouse and domestic markets.

## Russia

Lukoyanovskoye heavy mineral sands deposit of ARMZ Uranium Holding Co. was under development. The mine would have 1.5 million tpy ore sands processing plant by 2014.

## FOREIGN TRADE

### Exports

Exports of zirconium ores and concentrates rose sharply to 8,015 tonnes in 2009-10 from 25 tonnes in the previous year. Exports were mostly to China. Exports of zirconium and scrap were 76 tonnes in 2009-10 as against 138 tonnes in 2008-09 (Tables - 9 and 10).

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	<b>25</b>	<b>692</b>	<b>8015</b>	<b>112724</b>
China	–	–	7940	109415
Thailand	18	675	42	1882
UAE	–	–	27	1117
Bahrain	–	–	5	249
Sweden	–	–	1	38
Kenya	–	–	++	12
France	–	–	++	11
Australia	++	1	–	–
Djibouti	++	1	–	–
Iran	7	15	–	–

Source: DGCI&S, Kolkata.

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	<b>138</b>	<b>28632</b>	<b>76</b>	<b>12701</b>
Saudi Arabia	102	6131	2	5048
Germany	12	17378	35	3104
Norway	–	–	1	2470
Thailand	–	–	++	784
USA	++	88	2	408
UAE	1	768	3	210
Australia	++	590	++	189
China	1	479	10	151
Bangladesh	10	889	–	–
Switzerland	1	476	–	–
Other countries	11	1833	23	337

Source: DGCI&S, Kolkata.

### Imports

Imports of zirconium ores and concentrates increased to 34,724 tonnes in 2009-10 from 30,477 tonnes in the previous year. Main suppliers were Australia, South Africa, Ukraine and Sri Lanka in 2009-10. Imports of zirconium and scrap were 10 tonnes in 2009-10 against 12 tonnes in the previous year. Imports were mainly from Italy (Tables - 11 and 12).

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	<b>30477</b>	<b>1268366</b>	<b>34724</b>	<b>1517772</b>
Australia	22121	929101	23933	1077871
South Africa	3840	159150	5203	214134
Ukraine	58	2221	1520	64982
Sri Lanka	1269	46330	1230	49920
Malaysia	296	11099	584	23443
Nigeria	771	10538	746	15074
Spain	694	37014	231	13651
China	321	21355	112	6308
Vietnam	835	37976	135	6140
Italy	208	10502	78	4698
Other countries	64	3080	952	41551

Source: DGCI&S, Kolkata.

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	<b>12</b>	<b>34709</b>	<b>10</b>	<b>16979</b>
USA	4	19306	1	8399
Italy	5	4816	6	4399
China	1	3167	2	1649
South Africa	-	-	1	634
Japan	++	407	++	587
Germany	1	4570	++	441
Chinese Taipei/ Taiwan	-	-	++	363
Singapore	-	-	++	188
UK	1	1185	++	76
France	++	928	++	68
Other countries	++	330	++	175

Source: DGCI&S, Kolkata.

## FUTURE OUTLOOK

The problem of zircon is its being inextricably linked to titanium minerals. The heavy mineral sands mining has always centred more on titanium ore recovery than zircon, the latter being considered as by-product. The challenge becomes more compounded when the endeavour is to produce premium grade zircon.

Demand for zircon in refractory is decreasing, because the refractory consumption in steel mills has come down, as the steel industry is now stressing for increased performance. The demand in foundry has remained static. In chemical/zirconia sector, the demand is on the rise. About 70% refractories produced worldwide are used in steel industry and 4-6% each in cement, chemical, ceramic, glass and other industries.