Indian Minerals Yearbook 2018

(Part- III : Mineral Reviews)

57th Edition

ILMENITE AND RUTILE

(FINAL RELEASE)

GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

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July, 2019

15 Ilmenite & Rutile

India is endowed with large resources of heavy minerals which occur mainly along coastal stretches of the country and also in inland placers. Heavy mineral sands comprise a group of seven minerals, viz, ilmenite, leucoxene (brown ilmenite), rutile, zircon, sillimanite, garnet and monazite. Ilmenite ($FeO.TiO_2$) and rutile (TiO_2) are the two chief minerals of titanium. Titanium dioxide occurs in polymorphic forms as rutile, anatase (octahedrite) and brookite. Though brookite is not found on a large-scale in nature, it is an alteration product of other titanium minerals. Leucoxene is an alteration product of ilmenite and is usually found associated with ilmenite.

RESOURCES

Ilmenite and rutile along with other heavy minerals are important constituents of beach sand deposits found right from Saurashtra coast (Gujarat) in the west to Digha coast, West Bengal in the east. These minerals are concentrated in five well-defined zones:

* Over a stretch of 22 km between Neendakara and Kayamkulam, Kollam district, Kerala (known as 'Chavara' deposit after the main mining centre).
* Over a stretch of 6 km from the mouth of River Valliyar to Colachal, Manavalakurichi and little beyond in Kanyakumari district, Tamil Nadu (known as MK deposit).
* On Chatrapur coast stretching to about 18 km between Rushikulya river mouth and Gopalpur lighthouse with an average width of 1.4 km in Ganjam district, Odisha (known as 'OSCOM' deposit after IREL's Orissa Sands Complex).
* Brahmagiri deposit stretches for 30 km from Girala nala to Village Bhabunia with an average width of 1.91 km in Puri district, Odisha.
* Bhavanapadu coast between Nilarevu and Sandipeta with 25 km length and 700 m average width in Srikakulam district, Andhra Pradesh.

The AMD of the Department of Atomic Energy has been carrying out exploration of these mineral deposits. Of the total coastal length of 5,921 km spread in Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra, Goa, Gujarat and West Bengal about 451 km, 1,873 km, and 112 km have been covered by detailed exploration, general exploration and preliminary exploration respectively. A coastal length of 2,272 km cannot be covered due to various reasons viz., mangrove, port activity etc. leaving an unexplored coastal length of 1,214 km. The distribution of area coverage (sq km) in different geological domains are Beach & Dune (1845), Inland Sand Body (180), Terrace sediments (368), River Channel (32), Inland alluvium (646), Lake & Sea Beds (38). The ilmenite resource estimation for the areas explored upto year 2016 has been completed and the resources are up from 539.50 million tonnes (including leucoxene) in the year 2012 to 629.57 million tonnes in year 2016. The resources include measured, indicated and inferred categories. The most significant deposits which are exploitable and which could attract the attention of Industry for large-scale operations are listed out in Table-1.

The average grade of total heavy minerals in these deposits is 10-25% of which 30-40% is ilmenite. The overall state-wise reserves of ilmenite and rutile which occur together in beach sand deposits are furnished in Table-1 A.

EXPLORATION & DEVELOPMENT

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

Table - 1 : Ilmenite Resources/Deposits in India

(In million tonnes)

State/Deposit	Ilmenite reserve
Andhra Pradesh	
1. Bhavanapadu	10.18
2. Kakinada (Phase I-VIII)	13.81
3. Kalingapatnam	7.03
4. Narasapur	2.92
5. Nizampatnam	19.26
6. Srikurman (South)	8.60
7. Visakhapatnam (Bhimunipatnam)	2.88
8. Amalapuram (Phase I-IV)	4.72
9. Pandurangapuram-Voderevu (Bapatla-Chirala coast)	10.38
10. Vetapalem Coast (Chirala coast)	5.31
Kerala	
1. Chavara Barrier beach	13.17
2. Chavara Eastern Extension (Phase-I)	17.02
3. Chavara Eastern Extension (Phase-II)	49.26
4. Trikkunnapuzha-Thotapally Beach & Eastern Extension	9.50
5. Alapuzha-Kochi	5.88
Maharashtra	
1. Ratnagiri	3.68
2. Munge-Achra-Malvan	1.12
3. Vijayadura-Mithbav	0.70
Gujarat	
1. Moti Daman-Umbrat coast	2.77
Odisha	
1. Brahmagiri (Phase I-V and NW extension)	86.04
2. Chatrapur	26.72
3. Gopalpur	6.42
Tamil Nadu	
1. Kudiraimozhi	22.86
2. Ovari-Periyatalai-Manapadu (Teri)	24.01
3. Sattankulam Teris	41.26
4. Cuddalore-Pudupattuchavadi (beach sand)	4.67
5. Vayakallur (beach sand)	4.52
6. Manavalakurichi (beach sand)	3.07
7. Midalam	1.64

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

Table – 1 A : Resources of Ilmenite and Rutile

(In million tonnes)

State	Total in situ #
Ilmenite* : Total	**629.57**
Andhra Pradesh	156.17
Jharkhand	0.73
Gujarat	2.77
Kerala	144.02
Maharashtra	5.50
Odisha	150.62
Tamil Nadu	167.70
West Bengal	2.06
Rutile : Total	**33.95**
Andhra Pradesh	10.55
Jharkhand	0.01
Gujarat	0.02
Kerala	8.74
Maharashtra	0.01
Odisha	6.58
Tamil Nadu	7.85
West Bengal	0.19

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

 # Inclusive of indicated, inferred and speculative categories

** Including leucoxene.*

PRODUCTION AND PRICES

Ilmenite

The production of ilmenite was 285 thousand tonnes in 2017-18.

Rutile

The production of rutile was 11.82 thousand tonnes in 2017-18.

Production and prices of ilmenite and rutile are furnished in Tables -2 to 4.

Table – 2 : Production of Ilmenite and Rutile (By States)

(In tonnes)

State	2015-16	2016-17	2017-18 (P)
ILMENITE			
India : Total	**626135**	**594978**	**284667***
Kerala	8833	113323	100010
Odisha	183402	183015	184657
Tamil Nadu	250066	298640	-
RUTILE			
India : Total	**16723**	**14898**	**11829***
Kerala	3795	4724	3969
Odisha	7403	7372	7860
Tamil Nadu	5525	2803	-

Source: *Department of Atomic Energy, Mumbai.*
** Data is incomplete as Tamil Nadu production figures are not available*

Table – 3 : Prices of Rutile 2015-16 to 2017-18

(` per tonne)

Year	Grade	Price	Remarks
IREL			
2015-16	Q	50000-54800	Ex-works, Bagged
	MK	50000-54800	Ex-works, Bagged
	OR	50000-54800	Ex-works, Bagged
2016-17	Q	50000-52000	Ex-works, Bagged
	MK	50000-52000	Ex-works, Bagged
	OR	50000-52000	Ex-works, Bagged
2017-18	NA		
KMML			
2015-16	-	54833	Average
2016-17	-	52083	Average
2017-18	-	66916	Average
V.V. Mineral			
2015-16	-	49266	Average
2016-17	-	45782	Average
2017-18	-	-	-

Source: *Department of Atomic Energy, Mumbai.*
Note: *Q: Quilon; MK: Manavalakurichi; OR: Odisha*

Table – 4: Prices of Ilmenite 2015-16 to 2017-18

(` per tonne)

Period	Grade	Price	Remarks
IREL			
2015-16			
(Non-slag/SR/TiO_2)	Q	11000-15120	Ex-works, loose
	MK	10000-14230	Ex-works, loose
	OR	9000-13340	Ex-works, loose
(Slag/SR/TiO_2)	Q	5850-6370	Ex-works, loose
	MK	5500-6070	Ex-works, loose
	OR	5000-5440	Ex-works, loose
2016-17			
(Non-slag/SR/TiO_2)	Q	11500-13000	Ex-works, loose
	MK	10500-12000	Ex-works, loose
	OR	9500-11000	Ex-works, loose
(Slag/SR/TiO_2)	Q	7400-8100	Ex-works, loose
	MK	7050-7900	Ex-works, loose
	OR	6350-7725	Ex-works, loose
2017-18		NA	
KMML			
2015-16		NA	
2016-17		NA	
2017-18		NA	
V.V. Mineral			
2015-16	-	5096	-
2016-17	-	5241	-
2017-18	-	-	-
BMC			
2015-16		NA	
2016-17		NA	
2017-18		NA	
DCW Ltd			
2015-16	-	7862	
2016-17	-	8423	
2017-18	-	14489	

Source: *Department of Atomic Energy, Mumbai.*
Note: *Q: Quilon; MK: Manavalakurichi; OR: Odisha*
Ilmenite is usually sold on NAW (naked at works) basis from all production center.

MINING & PROCESSING

Mining and processing of beach sand are carried out by the IREL, a Government of India Undertaking; KMML, a Kerala State Government Undertaking and two Private Sector producers viz, M/s V. V. Mineral, Thoothukudi (Tamil Nadu) and M/s Beach Minerals Co. Pvt. Ltd, Kuttam (Tamil Nadu). Exploitation work of beach sand deposits located at Chavara in Kerala, Gopalpur in Odisha and Manavalakurichi in Tamil Nadu by IREL is under progress.

At IREL, Chavara, Beach Sand was collected over a stretch of 22 km between Neendakara and Kayamkulam in Kerala and was transported to plant site. The unit has adopted wet mining operations involving use of two Dredge and Wet Concentrator (DWC) of 100 tph capacity each to exploit the inland deposits away from the beaches. Chavara ilmenite is the richest in TiO_2 content (75.8% TiO_2) and has great demand in India and abroad for manufacturing pigments.

At Manavalakurichi, the deposit is spread over 300 hectares at Thuthoor-Ezudesam villages, Vilavancode tehsil, district Kanyakumari, Tamil Nadu. All the raw sand required for the mineral separation plant to operate to its full capacity is collected from nearby beaches. Deposits are also exploited by DWC of 100 tph capacity. Manavalakurichi is next to Chavara in terms of TiO_2 content which is more than 55%.

The sand deposits of OSCOM at Chatrapur in district Ganjam extend along the coast of Bay of Bengal with an average width of 1.4 km and average depth of 7.5 m. Mining operations involve suction dredging to 6 m depth below water level on a much larger scale (500 tph) augmented by a smaller sized (100 tph) supplementary. The ilmenite from OSCOM is inferior in grade in terms of TiO_2 content (50%) in comparison to Chavara and Manavalakurichi. The Synthetic Rutile Plant of OSCOM is presently not working. As a result, the majority of OSCOM ilmenite produced of late is routed to the international market as feedstock for production of both slag grade and anatase grade pigment.

In dry mining, beach washings laden with 40-70% Heavy Minerals (HM) are collected through front-end loaders and bulldozers for further concentration to 90% HM at land-based concentrators. Though dry mining is very simple and economic, there is considerable opposition by local people for this form of mining for reasons that removal of sand would expose the land area to sea erosion. Therefore, collection of beach washings has reduced significantly in recent past.

As an alternate approach, IREL has adopted wet mining involving dredging and wet concentration (DWC) from inland areas away from the beach lines. In this mode, an artificial pond is created, the sand bed is cut and the slurry is pumped to spiral concentrator for removal of quartz. Manavalakurichi was the first plant to install a DWC (100 tph) followed by one (500 tph) at OSCOM and two (each 100 tph) at Chavara. The concentrate (90% HM) of beach washing plant from DWC is further upgraded to 97% HM grade at a Concentrate Upgradation Plant (CUP) before sending it to Mineral Separation Plant (MSP).

KMML collects seasonal accretions of heavy mineral sand from the beach front. The pit so formed gets filled by fresh accretions of heavy mineral sand. The mineral sand is collected using bulldozers and wheel loaders and transported in tippers to Mineral Separation Plant.

The mineral separation plants use variety of equipment, such as, gravity concentrators, high tension electrostatic separators and magnetic separators. Making use of difference in physical properties like electrical conductivity, magnetic susceptibility and difference in specific gravity, etc., individual minerals like ilmenite, rutile, zircon, sillimanite and garnet are separated. The mined beach sands are pre-concentrated and dried after sieving (30-mesh) to separate the heavies from rejects. The heavy minerals are passed through electrostatic separators where conducting minerals – ilmenite and rutile – are separated from other non-conducting minerals. Ilmenite and rutile are further subjected to low-intensity magnetic separators where magnetic fraction - ilmenite is separated from rutile. Similarly, non-conducting fractions are subjected to high-intensity magnetic separators where weak magnetic fraction (monazite and garnet) is separated from non-magnetic fraction (zircon and sillimanite). The fractions are further processed on wind tables to separate garnet from monazite and sillimanite from zircon.

Installed capacity and production of ilmenite, rutile and other associated heavy minerals by various separation plants are furnished in Table-5.

Table – 5 : Installed Capacity & Production of Ilmenite, Rutile and Other Heavy Minerals, 2015-16 to 2017-18

(In tonnes)

Company/ Location	Mineral/ Product	Installed capacity (tpy)	Production		
			2015-16	2016-17	2017-18
Indian Rare Earths Ltd					
Manavalakurichi[#]	Ilmenite	90000	-	29032	-
Distt. Kanyakumari,	Rutile	3500	-	951	-
Tamil Nadu.	Zircon	10000	-	2606	-
	Sillimanite	8778	-	-	-
	Monazite	6000	-	-	-
	Garnet	10000	-	10618	-
Chavara,	Ilmenite	200000	242075	57919	43253
Distt. Kollam,	Rutile	11400	9788	2319	1515
Kerala.	Zircon	17500	10785	4502	2649
	Rare Earths	4500*	18796	-	-
	Sillimanite	7000	6943	8654	6826
Orissa Sands Complex,	Ilmenite	220000	-	183015	184657
Distt. Ganjam,	Rutile	7400	-	7372	7860
Odisha.	Zircon	5000	-	5696	6458
	Sillimanite	13000	-	15435	16698
	Garnet	20000	-	17405	34170
Kerala Minerals & Metals Ltd					
Chavara,	Ilmenite	61600	65630	55404	56757
Distt. Kollam,	Rutile	4400	2775	2405	2454
Kerala.	Zircon	6500	5346	4784	4844
	Sillimanite	3600	472	600	701
V.V. Mineral					
Distt. Thoothukudi,	Ilmenite	450000	318430	269608	-
Tamil Nadu.	Rutile	12000	1505	1852	-
	Zircon	18000	2306	12763	-
	Zircon-sillimanite	24000	-	-	-
Beach Minerals Co. Pvt. Ltd					
Kuttam,	Ilmenite	150000	-	-	-
Distt. Tirunelveli,					
Tamil Nadu.					
V.V. Titanium Pigments Pvt. Ltd	Titanium Dioxide	18000	14465	16064	13801
Distt. Thoothukudi,					
Tamil Nadu.					

Source: *Department of Atomic Energy, Mumbai and IREL*
** In terms of rare earths chloride. '-' Not Available # During the year 2017-18, Manavalakurichi Plant was non-operative from Jan. 2017 because of non-availability of environmental clearance (EC)*

INDUSTRY

For manufacturing titanium dioxide pigment, ilmenite is first treated chemically to obtain upgraded ilmenite, commonly called as synthetic rutile. There are two major pigment production processes namely chloride process and sulphate process depending on different operating characteristics and feedstock requirements. Plants employing chloride process consume high TiO_2 content feedstocks like synthetic rutile and chloride slag. On the other hand, plants employing the sulphate process use lower grade ilmenite and sulphate slags.

Ilmenite obtained from Mineral Separation Plant (MSP) is chemically treated to remove impurities, such as, iron to obtain synthetic rutile (90% TiO_2) in Synthetic Rutile Plant (SRP). Indian SRP is based on reduction roasting followed by acid leaching with or without generation of hydrochloric acid. Plants of IREL (OSCOM) and KMML depend on acid regeneration from the leach liquor while those of Cochin Minerals & Rutile Ltd (CMRL) and DCW use fresh acid and recover ferric chloride from the leach liquor for its use in water purification.

At OSCOM plant of IREL, reduction-roasting of ilmenite with coal is followed by leaching with HCL to separate iron as soluble ferrous chloride. The leached ilmenite is calcined to yield synthetic rutile and the acidic leach liquor is treated in an acid regeneration plant to recover HCL for recycling with iron oxide as waste. The unit stopped production in 1997 as it was not viable economically. IREL intends to set up titanium slag plant based on OR grade ilmenite at Odisha and has signed an MoU with NALCO for this purpose. Depending upon feasibility, further value addition to TiO_2 pigment and Ti sponge shall be taken up subsequently.

The KMML is manufacturing rutile grade titanium dioxide pigment by chloride route at its Sankaramangalam plant near Chavara in Kerala. The project for the production of one lakh tonnes of TiO_2 in a phased manner is under implementation. The Company also has plans to enhance pigment capacity to 60,000 tpy for which detailed project report is under preparation. In 2009, the Company had developed Nano Titanium Dioxide particles on laboratory scale and in July 2011, India's first commercial plant for synthesis of Nanotitanium Dioxide was commissioned. KMML has set up a plant for producing 500 tpa of Titanium sponge with technology from DMRL.

The V. V. Mineral is the only company in India with a 40 km stretch of beach area under a mining lease for 30 years and another 440 acres for 30 years and 26 fully owned patta lands. In addition to this, V. V. Mineral owns multiple mining leases. The geological characteristics of the Gulf of Mannar like typical wind and wave action and beach structure make it a highly valuable zone for continuous deposition of heavy minerals, viz. Garnet, Ilmenite, Rutile, Zircon and Sillimanite. This ensures a continuous deposition of placer minerals from Gulf of Mannar. V. V. Mineral inland deposits also add to its total output of 70,000 tonnes of heavy minerals.

As the leading mining company of India their mining process revolves around scientific and eco-friendly methodology. Manual mining in beaches ushers in job facilities to the downtrodden and sophisticated equipment employed in inland mining makes the process outstanding. The proximity of the wet processing units to the sea shore makes transport easy and reliable. M/s V.V. Mineral is the only Indian beach mining company to have obtained environmental clearance from Government of India.

There are 9 wet plants situated close to the mining areas for upgrading the mining ore in mining area itself. There are 8 dry plants situated close to the mining areas and equipped with state-of-the-art machinery.

M/s V.V. Mineral has separate washing unit to enrich the quality and purity of Super Garnet near warehouse, dedicated to fix the quality in general and purity in particular. Water for the washing process is taken from the river and converted to pure water using reverse osmosis process. This Super Garnet is washed with great care to make it chloride and silica free. The washing unit ensures below 25 ppm chloride and 1000 TSS after the process.

The DCW Ltd procures ilmenite from Manavalakurichi which is then roasted with coke fines to convert Fe_2O_3 into FeO. The reduced ore is leached with concentrated hydrochloric acid to remove oxides of iron and other metals. The leached ore is washed and calcined to get upgraded ilmenite which contains more than 95% TiO_2. The upgraded ilmenite is micronised to 2 microns by using high-pressure steam. This is marketed as Titox. The liquor from ilmenite leaching process contains fine TiO_2 particles and chlorides. The TiO_2 recovered by filtration & washing in filter process is marketed as Utox. The Company has plans to increase the plant capacity to 48,000 tpy and also to install facilities for the manufacture of ferrite grade iron oxide from the effluent of the ilmenite plant.

Cochin Minerals and Rutile Ltd (CMRL), which began production at its 10,000 tpy synthetic rutile plant in Kerala in 1990 as a 100% EOU has gradually raised the production capacity to around 45,000 tpy since 2008-09 for exports. It has also ferric chloride & ferrous chloride plants having capacities 24,000 tpy & 72,000 tpy, respectively.

The Travancore Titanium Products Ltd (TTPL), a Kerala State Govt. Undertaking, manufactures titanium dioxide pigment by sulphate process at its plant at Kochuveli, Thiruvananthapuram. Ilmenite is reacted with sulphuric acid in digesters and a porous cake is formed. The mass in the solid form is dissolved in dilute sulphuric acid to get titanium in solution as titanium oxysulphate along with other metallic ingredients in ilmenite as their sulphate. The liquor is reduced using scrap iron, when ferric iron gets completely reduced to the ferrous state. The liquor is clarified, concentrated and boiled to precipitate the titanium content as hydrated titania which is then filtered by vacuum filters and calcined. Sulphuric acid required for captive consumption is produced at site using elemental sulphur. Till recently, TTPL was the only unit producing anatase grade titanium dioxide pigment in India. TTPL has capacity to produce 17,000 tpy of titanium dioxide and with plans to modernise and diversify in stages the Company has chalked out targets to produce both anatase and rutile grades titanium dioxide pigment.

Tata Steel has proposed a project to produce 1,00,000 tonnes per year titanium dioxide from ilmenite mined from beach sands of Tirunelveli and Thoothukudi districts in southern Tamil Nadu.

NMDC has signed an MoU with KSIDC and IREL for setting up a synthetic rutile plant in Kerala. The Company has applied for prospecting licences in various areas in Odisha, Kerala and Tamil Nadu and sought Swedish technology for mineral separation plant. The Beach Minerals Co. Pvt. Ltd also has plans for production of synthetic rutile from ilmenite. Presently, it has only facility of pilot plant. M/s V. V. Mineral has plans to set-up a 5 lakh tpy titanium pigment plant. The project is at approval stage.

Present domestic titanium metal production is negligible. KMML has set-up a 500 tpy titanium sponge plant with Defence Metallurgical Research Laboratory (DMRL) technology and first batch of titanium was delivered in September 2011. The plant will be further expanded to 1,000 tpy. IREL is to set - up a 10,000 tpy titanium sponge plant at OSCOM for which proposals have been invited on build, operate and own basis. IREL intends to set-up titanium slag plant based on ilmenite from OSCOM, Odisha and has signed an MoU with NALCO for this purpose. Depending upon feasibility, further value addition to TiO_2 pigment and titanium sponge will be taken up subsequently. Titanium sponge is imported by Mishra Dhatu Nigam Ltd (MIDHANI) for further processing in the country.

The available data on plantwise capacities of synthetic rutile and TiO_2 pigment from 2015-16 to 2017-18 are furnished in Table-6. Data for 2017-18 is not available except VVTi Pigments Pvt Ltd.

Table –6 : Installed Capacity of Synthetic Rutile/Titanium dioxide Pigment,

(In tonnes)

Plant	Location	Specification	Installed capacity (tpy)
IREL	Orissa Sands Complex, Distt. Ganjam, Odisha.	90.5% TiO_2 (min)	100000 (Synthetic rutile)
KMML Kerala.	Chavara, Distt. Kollam,	92%-93% TiO_2	50,000 (Synthetic rutile) 40000 (TiO_2 - Chloride Process)
DCW Ltd	Sahupuram, Distt. Thoothukudi, Tamil Nadu.	95% TiO_2	48,000 (Synthetic rutile)
CMRL	Edayar, Distt. Ernakulam, Kerala.	96.5% TiO_2	50,000 (Synthetic rutile)
TTPL	Kochuveli, Distt. Thiruvananthapuram, Kerala.	97.5% TiO_2	17,000 (TiO_2-Sulphate Process)
VVTi Pigments Pvt. Ltd* (formerly Kilburn Chemicals)	Thoothukudi, Tamil Nadu.	98% TiO_2 (min)	18,000 (TiO_2-Sulphate Process)
Kolmark Chemicals Ltd	Kalyani, Distt. Nadia, West Bengal.	NA	4,800 (TiO_2-Sulphate Process)

Source: *Department of Atomic Energy, Mumbai and individual companies*
Note: *KMML captively consumes synthetic rutile while CMRL and DCW export synthetic rutile*
**Including Kilburn Chemicals*

USES

About 90% of the world's titanium mineral production is used in the manufacturing of white titanium dioxide pigment. The unique combination of superior properties of high refractive index, low specific gravity, high hiding power and opacity and non-toxicity enable titanium dioxide in its application in the manufacture of all types of white and pastle shades of paints, white-walled tyres, glazed papers, plastics, printed fabrics, flooring materials like linoleum, pharmaceuticals, soaps, face powders and other cosmetic products. Besides, its non-toxic nature facilitate its use in cosmetics, pharmaceuticals and even in foodstuffs as well as in toothpastes. Titanium dioxide is used in the manufacturing many sunscreen lotions and creams because of its non-toxicity and ultra violet absorption properties. Synthetic rutile is used for coating welding electrodes as flux component and for manufacturing titanium tetrachloride which in turn is used in making titanium sponge. Synthetic rutile is also used as ingredient of special abrasives. Titanium metal is a versatile material with exceptional characteristics. The lightness, strength and durability of the metal make it an essential metal for the Aerospace Industry. It is also used in desalination and power generation plants and corrosive chemical industries because of its inertness and resistance to corrosion and high thermal conductivity. Its non-reactive property makes titanium metal one of the few materials that can be used in the human body for orthopaedic use and in pacemakers.

CONSUMPTION

The ilmenite consumption is placed at 2,22,000 tonnes in 2017-18 which is marginally lower as compared to previous year. The bulk of ilmenite is consumed in the manufacture of synthetic rutile (99%). Moderate proportions are consumed by welding electrode and ferroalloys Industry. The consumption of rutile in 2017-18 was 5,800 tonnes as compared to 7,500 tonnes in 2016-17. Entire consumption was reported from electrode Industry (Table - 7).

Table – 7 : Consumption* of Ilmenite and Rutile 2015-16 to 2017-18 (By Industries)

(In tonnes)

Industry	2015-16 (R)	2016-17 (R)	2017-18 (P)
Ilmenite			
All Industries	**232200**	**241100**	**222000**
Chemicals	230600	240200	221200
Electrode	1200	900	700
Others (Ceramic, Ferroalloys, Paint & Refractories)	400	-	100
Rutile			
All Industries	**27700**	**7500**	**5800**
Electrode	9700	6200	5800
Paint	17400	1300	-
Others (Cosmetic, Electrical, Paper & Ferroalloys)	600	-	-

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

POLICY

The Government of India had notified in October 1998 a policy on exploitation of beach sand minerals in the country, which inter alia allows participation of the Private Sector with or without foreign companies subject to conditions stipulated. This will encourage further exploitation of mineral deposits through a judicious mix of Public & Private Sector participation including foreign collaboration. The ceiling on FDI on mining of titanium minerals has been raised to 100 percent.

Joint ventures with foreign participation were being pursued by IREL for production of value-added products, keeping in view the Beach Sand Mineral Policy of the Government.

The minerals, ilmenite and rutile, were grouped as 'prescribed substances' as per notifications issued under the Atomic Energy Act, 1962. However, as per the revised list of Prescribed Substances, Prescribed Equipment and Technology notified by Department of Atomic Energy vide S.O.No.61(E), dated 20.1.2006, the titanium ore minerals like ilmenite, rutile and leucoxene have been delisted as prescribed substances by the Department of Atomic Energy subject to the note as below:

"These minerals shall remain prescribed substances only till such time the policy on Exploration of Beach Sand Minerals notified vide Resolution No.8/1(1)/97-PSU/1422, dated 6.10.1998, is adopted/revised/modified by the Ministry of Mines or till 1.1.2007, whichever occurs earlier and shall cease to be so thereafter".

As per notification No 26/2015-2020, dated 21 August 2018 the export of Beach Sand Minerals has been brought under State Trading Enterprise (STE) shall be canalised through Indian Rare Earths Limited (IREL). Beach Sand Minerals, permitted anywhere in the export policy will now be regulated in terms of policy under Sl. No. 98A of Chapter 26 of schedule 2 Export Policy.

SUBSTITUTES

There are no cost-effective substitutes for titanium dioxide pigments. Synthetic rutile made from ilmenite can be substituted for natural rutile. Nickel steels, stainless steels and some non-ferrous metal alloys can sometimes replace titanium alloys in industrial uses although at the expense of performance or economics. Tungsten carbide competes with titanium carbide for surface cutting machine tools. Titanium slag competes with ilmenite and rutile.

Environmental awareness indicates that titanium dioxide plants are likely to use chloride technology in future as it produces much less quantity of waste products. Synthetic rutile or slag (made from ilmenite) is likely to be used as feed in increasing amount. There is also a strong pressure to reduce the radioactive content of feedstocks because it affects the marketability of beach sand ilmenite. Titanium alloys could be replaced in aerospace applications by lithium-aluminium alloys or carbon-epoxy composites.

WORLD REVIEW

World resources of anatase, ilmenite and rutile are more than 2 billion tonnes. World reserves of ilmenite are estimated at 882 million tonnes in terms of TiO_2 content. Major reserves are in Australia (28%), China (26%), India (10%), South Africa (7%), Kenya (6%), Brazil and Madagascar (5% each), Norway and Canada (4% each) and Mozambique (2%). The world reserves of rutile are 62 million tonnes in terms of TiO_2 content. Major rutile reserves are located in Australia (47%), followed by Kenya (21%), South Africa (13%), India (12 %) and Ukraine (4%).

World production of ilmenite and rutile concentrates was 10.3 million tonnes and 0.69 million tonnes, respectively, in 2017. Canada and China contributed 22% and 14% of ilmenite production, followed by South Africa (13%), Mozambique (10%) and Australia (7%). Australia produced 33% of world rutile output, followed by Sierra Leone (24%), Ukraine (13%) and South Africa (9%). World reserves and production of titanium minerals, viz, ilmenite and rutile are furnished in Tables - 8 to 10.

Table – 8 : World Reserves of Ilmenite and Rutile (By Principal Countries)

(In '000 tonnes of contained TiO_2)

Country	Reserves	
	Ilmenite	Rutile
World: Total (Ilmenite+Rutile) : 944470		
World: Total (rounded off)	**882500**	**61970**
Australia	250000	29000
Brazil	43000	-
Canada	31000	–
China	230000	–
India	85000	7400
Kenya	54000	13000
Madagascar	40000	-
Mozambique	14000	880
Norway	37000	–
Sierra Leone	-	490
South Africa	63000	8300
Ukraine	5900	2500
USA*	2000	–
Vietnam	1600	–
Other countries	26000	400

***Source**: Mineral Commodity Summaries, 2019.*

** Includes rutile*

Table – 9 : World Production of Ilmenite[1] (By Principal Countries)

(In '000 tonnes)

Country	2015	2016	2017
World: Total	**10291**	**9288**	**10329**
Australia			
Ilmenite	1147	765	684
Leucoxene	246	73	55
Canada (e) bc	1900	1800	2300
China	1400(e)	1400(e)	1400
India	522(e)	522(e)	522(e)
Kenya	445	466	470
Korea, Rep. of	204	167	167
Madagascar	166	256	430
Mozambique	764	903	998
Norway	630	630(e)	630(e)
Russia	193	60	-
Senegal Ilmenite	428	416	492
Leucoxene m	5	10	10
South Africa(e)	1280	1020	1300
USA	200	100(e)	100(e)
Ukraine(e)	350	350	350
Vietnam	238	211	225
Other countries	173	139	194

***Source**:World Mineral Production, 2013-2017,BGS.*

***Note**: Some ilmenite is converted to synthetic rutile in Australia, India, Japan and USA.*

1:- The figures in this table refer to gross tonnage of titanium concentrates.

b:- It is believed that the majority of this is processed into slag.

c:- Canada produces some ilmenite which is sold as such and not processed into slag, but tonnages are small.

m : - Including natural rutile.

Table – 10 : World Production of Rutile (By Principal Countries)

(In '000 tonnes)

Country	2015	2016	2017
World: Total (rounded off)			
(wt. of conc.)	**705**	**733**	**696**
Australia	295	285	226
India	17e	17e	17e
Kazakhstan e	17	17	17
Kenya	79	88	91
Sierra Leone	126	149	166
South Africa e	67	67	65
Ukraine e	90	90	90
Other countries	32	38	40

***Source**: World Mineral Production, 2013-2017, BGS.*

***Note:** 1) The figures in this table refer to gross tonnage of titanium concentrates*

2) Some ileminate is converted to synthetic rutile in Australia, India, Japan and USA.

World production of TiO_2 contained in titanium mineral concentrates was 9.85 million tonnes in 2014, which reportedly decreased by 8% from that of 2013. The leading sources of world imports of titanium mineral concentrates were Australia, South Africa, China and Canada.

Metal

Commercial production of titanium metal involves the chlorination of titanium-containing mineral concentrates to produce titanium tetrachloride ($TiCl_4$), which is reduced with magnesium (Kroll process) or sodium (Hunter process) to produce a commercially pure form of titanium metal. The metal formed has a porous appearance and is referred to as sponge. Titanium ingot and slab are produced by melting titanium sponge or scrap or a combination of both, usually with various other alloying elements.

Pigment

Global TiO_2 pigment production capacity was estimated to be 5.7 million tonnes per year. TiO_2 pigment produced is categorised by crystal form as either anatase or rutile. Rutile pigment is less reactive with the binders in paint when exposed to sunlight than the anatase pigment and is preferred substance in outdoor paints. Anatase pigment has a bluer tone than rutile, is somewhat softer, and is used mainly in indoor paints and in paper manufacturing. Depending on the manner in which it is produced and subsequently finished, TiO_2 pigment can exhibit a wide range of functional properties, including dispersion, durability, opacity and tinting.

FOREIGN TRADE

Exports

Exports of titanium ores & conc. decreased to 0.35 million tonnes in 2017-18 as compared to 0.53 million tonnes in the preceding year. Exports in 2017-18 comprised ilmenite (3,53,384 tonnes), rutile (2,038 tonnes) and others (52 tonnes). Main destinations were China (51%), Japan (21%), Germany (18%), Korea, Rep. of (6%) and Malaysia (4%).

Exports of titanium and alloys (including waste & scrap) were 272 tonnes in 2017-18 as compared to 114 tonnes in the previous year. Exports were mainly to USA (67%). Exports of titanium oxide and dioxide (total) increased to 38,679 tonnes in 2017-18 from 34,042 tonnes in 2016-17. Out of the total exports in 2017-18, those of titanium dioxide were 9,562 tonnes and exports of titanium oxides (other than titanium dioxides) were 29,117 tonnes (Tables-11 to 18).

Imports

Imports of titanium ores & conc. increased substantially to 1,63,690 tonnes in 2017-18 as compared to 39,444 tonnes in the preceding year. Out of the total imports of titanium ores & conc. in 2017-18, those of ilmenite were 135,224 tonnes, rutile 21,049 tonnes and other titanium ores were 7,417 tonnes. Main suppliers were Mozambique (64%), Sri Lanka (20%) and Australia (4%).

Imports of titanium and alloys (including waste & scrap) were 4,394 tonnes in 2017-18 as compared to 2,937 tonnes in the previous year. Imports were mainly from USA,China, Japan and Ukraine. Imports of titanium oxide and dioxide (total) were 13,785 tonnes in 2017-18 as compared to 14,181 tonnes in the preceding year. Imports were mainly from China (41%),Germany and Korea, Rep. of (18% each), Japan (9%) and USA (4%). Bulk of these imports was of titanium dioxide (13,699 tonnes) and titanium oxides (other than titanium oxides) was 86 tonnes in 2017-18 (Tables - 19 to 26).

Table – 11 : Exports of Titanium Ores & Conc. (By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**532204**	**5716719**	**355474**	**6010134**
China	311126	2794493	179698	2758165
Japan	82757	1706429	75333	1783481
Germany	++	8	62500	763000
Malaysia	43590	404223	14422	323680
Korea, Rep. of	51	2570	22073	301772
Iran	784	42423	588	33756
Indonesia	113	6011	218	13773
Netherlands	92196	701222	192	5078
Belgium	155	7900	156	9882
USA	190	12853	80	4506
Other countries	1242	38587	214	13041

Table – 12 : Exports of Titanium Ores & Conc. (Ilmenite) (By Countries)

Country	2016-17 Qty (t)	2016-17 Value (`’000)	2017-18 Qty (t)	2017-18 Value (`’000)
All Countries	**529822**	**5586178**	**353384**	**5889530**
China	310510	2765640	178914	2716512
Japan	82587	1697754	75233	1777491
Germany	++	4	62500	763000
Malaysia	43590	404223	14422	323680
Korea, Rep. of	-	-	22000	297143
USA	160	9143	80	4506
Ukraine	-	-	50	2646
Mexico	156	1210	26	1331
Netherlands	92168	699934	140	2601
Bangladesh	56	1004	13	491
Other countries	595	7266	6	129

Table – 13 : Exports of Titanium Ores & Conc. (Rutile) (By Countries)

Country	2016-17 Qty (t)	2016-17 Value (`’000)	2017-18 Qty (t)	2017-18 Value (`’000)
All Countries	**2048**	**108327**	**2038**	**118116**
China	616	28853	784	41653
Iran	756	42171	588	33756
Indonesia	113	6011	218	13773
Belgium	155	7900	156	9882
Japan	170	8675	100	5987
Korea, Rep. of	51	2570	73	4629
Sweden	26	1298	48	3007
Pakistan	9	707	33	2663
Kenya	5	284	18	1279
Bangladesh	16	1065	14	1014
Other countries	131	8793	6	473

Table – 14 : Exports of Titanium Ores & Conc. (Others) (By Countries)

Country	2016-17 Qty (t)	2016-17 Value (`’000)	2017-18 Qty (t)	2017-18 Value (`’000)
All Countries	**334**	**22214**	**52**	**2488**
Netherlands	-	-	52	2477
Pakistan	1	79	++	8
Japan	-	-	++	3
China	-	-	-	-
Uganda	6	243	-	-
Bangladesh	317	21197	-	-
USA	8	582	-	
Chile	2	113	-	-

Table – 15 : Exports of Titanium & Alloys (Incl. Waste & Scrap) (By Countries)

Country	2016-17 Qty (t)	2016-17 Value (`’000)	2017-18 Qty (t)	2017-18 Value (`’000)
All Countries	**114**	**201474**	**272**	**371051**
USA	91	127907	183	196232
Indonesia	++	250	36	48215
Korea, Rep. of	1	2299	19	21135
Venezuela	-	-	6	17361
Israel	1	32686	++	13401
Germany	3	5034	3	8895
Qatar	-	-	3	6871
Netherlands	-	-	2	6706
Finland	-	-	1	6599
Singapore	0	409	8	5926
Other countries	18	32889	11	39710

Table – 16 : Exports of Titanium oxide & Dioxide : Total (By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**34042**	**2346322**	**38679**	**2945091**
Japan	22446	1126817	19196	952831
USA	2525	329212	3748	570133
Italy	1212	181593	1508	286171
China	1	466	4952	242395
Chinese Taipei/Taiwan	15	2484	4007	189787
Spain	260	33427	911	163623
Malaysia	1825	131813	1338	76894
UAE	462	56976	330	51189
Nigeria	269	31573	294	44741
Nepal	130	19077	214	41828
Other countries	4897	432884	2181	325499

Table – 17 : Exports of Titanium dioxide (By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**8157**	**1018032**	**9562**	**1537655**
USA	2398	319989	3693	566025
Italy	1072	147667	1428	267579
Spain	260	33427	911	163623
Japan	832	87726	721	99276
UAE	462	56976	330	51189
Nigeria	195	27647	269	43374
Nepal	122	18067	212	41598
Indonesia	283	33570	295	35406
Iran	92	21566	126	35117
Turkey	182	20445	246	35771
Other countries	2259	250952	1331	199697

Table – 18 : Exports of Titanium oxide (Other than Titanium Dioxide) (By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**25885**	**1328290**	**29117**	**1407436**
Japan	21614	1039091	18475	853555
China	-	-	4940	238172
Chinese Taipei/Taiwan	-	-	4000	188671
Malaysia	1820	131378	1326	75779
Italy	140	33926	80	18592
Egypt	48	16715	36	13961
USA	127	9223	55	4108
Turkey	18	1342	72	3509
Tanzania	2	175	43	3120
Bangladesh	10	1933	10	2188
Other Countries	2106	94507	80	5781

Table – 19 : Imports of Titanium Ores & Conc. : Total (By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**39444**	**867776**	**163690**	3297466
Mozambique	19902	188890	104702	1539413
Sri Lanka	-	-	33135	468945
Australia	4961	226611	5796	300600
Sierra Leone	269	13947	4396	267327
South Africa	2928	127408	5390	257837
Thailand	1850	70407	2620	137475
Ukraine	2971	97862	2019	118055
Senegal	1103	42222	1740	68605
China	390	17311	916	50358
USA	-	-	598	35844
Other countries	5070	83118	2378	53007

Table – 20 : Imports of Titanium Ores & Conc. (Ilmenite)
(By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**25121**	**252948**	**135224**	**1923741**
Mozambique	19902	188890	104602	1533784
Sri Lanka	-	-	30566	388750
Ukraine	1157	10839	56	1163
South Africa	-	-	++	40
Sweden	-	-	++	4
Germany	14	1514	-	-
Malaysia	4048	51705	-	-

Table – 21 : Imports of Titanium Ores & Conc. (Rutile)
(By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**9322**	**427599**	**21049**	**1132193**
Sierra Leone	269	13947	4344	264340
South Africa	2928	127408	4842	230229
Australia	3505	163838	4054	218131
Thailand	-	-	2590	127755
Ukraine	1764	84363	1782	106518
Sri Lanka	-	-	1074	62346
China	390	17311	864	47809
USA	-	-	598	35844
Senegal	20	782	500	18840
Malaysia	350	15009	193	8484
Other countries	96	4941	208	11897

Table – 22 : Imports of Titanium Ores & Conc. (Others)
(By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**5001**	**187229**	**7417**	**241532**
Australia	1456	62773	1742	82469
Senegal	1083	41440	1240	49765
South Africa	-	-	548	27568
Germany	502	7723	1542	26856
Sri Lanka	-	-	1495	17849
Ukraine	50	2660	181	10374
Thailand	1850	70407	30	9720
UK	-	-	500	8353
Sierra Leone	-	-	52	2987
China	-	-	52	2549
Other countries	60	2226	35	3042

Table – 23 : Imports of Titanium & Alloys
(Incl. Waste & Scrap)
(By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**2937**	**2914906**	**4394**	**4466987**
USA	1224	747261	1473	1167313
China	554	625650	665	814763
Russia	61	151821	170	361623
Ukraine	172	119372	439	345032
UK	68	304265	158	344884
Germany	137	216165	162	326115
Japan	189	198563	317	311716
France	40	87027	47	164213
Italy	71	113040	109	116817
Kazakhstan	180	91354	195	101776
Other countries	241	260388	659	412735

Table – 24 : Imports of Titanium oxide & Dioxide : Total
(By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**14181**	**2380145**	**13785**	**2520426**
China	5951	819216	5700	878365
Germany	2225	475450	2452	558720
Korea, Rep. of	2140	349258	2500	409158
Japan	912	209837	1254	282616
USA	944	176620	509	88169
France	89	32861	181	68087
Mexico	199	35774	259	47935
Belgium	141	26863	236	47263
Canada	41	12860	80	24930
Russia	220	23260	160	24848
Other countries	1319	218146	454	90335

Table – 25 : Imports of Titanium dioxide (By Countries)

Country	2016-17 Qty (t)	2016-17 Value (`'000)	2017-18 Qty (t)	2017-18 Value (`'000)
All Countries	**13902**	**2294281**	**13699**	**2477077**
China	5778	798578	5632	865991
Germany	2224	469819	2447	546767
Korea, Rep. of	2140	349143	2500	409158
Japan	895	194237	1248	274508
USA	941	172563	509	87020
France	74	26270	179	63403
Mexico	199	35774	259	47935
Belgium	141	26826	235	46986
Canada	41	12856	80	24930
Russia	220	23260	160	24848
Other countries	1249	184955	450	85531

Table – 26 : Imports of Titanium oxide (Other than Titanium Dioxides) (By Countries)

Country	2016-17 Qty (t)	2016-17 Value (`'000)	2017-18 Qty (t)	2017-18 Value (`'000)
All Countries	**279**	**85864**	**86**	**43349**
China	173	20638	68	12374
Germany	1	5631	5	11953
Japan	17	15600	6	8108
France	15	6591	2	4684
Finland	8	15054	2	2700
USA	3	4057	++	1149
Poland	++	896	++	757
Thailand	-	-	1	634
UK	1	1128	1	447
Belgium	++	37	1	277
Other countries	61	16232	++	266

FUTURE OUTLOOK

The major chunk of consumption of ilmenite is for the manufacture of synthetic rutile.

The demand for titanium in India would be approximately 1,000 tonnes by 2035. The contribution by Space Sector (100 tonnes), General Engineering (50 tonnes), Atomic Energy (125 tonnes), Aeronautical (50 tonnes), Power Generation (150 tonnes), Petroleum Refinery (50 tonnes) and Chemical industry (475 tonnes) as per Technology Vision Document-2035.

As per data available for the defence, atomic energy and space research allocations, the critical sector is given encouragement to increase communication set-up, safeguard India's security with modern arms, ammunitions and control and a three fold increase in power generation. For meeting these targets, Indian engineering industry is dependent on input materials like titanium sponge, which was not available in India till 2012. The first ever commercially indigenously made Ti-sponge was released as late as 2013 at KMML, Kerala with the support of ISRO. The present capacity of this titanium sponge plant is 500 tpa. However, with the successful commissioning of the titanium sponge plant, India has joined the elit club of seven countries capable of producing aerospace grade titanium sponge. The plant has the basic infrastructure for increasing the capacity of 1,000 tpa in future with sponge to metal yield at 35%, the requirement of titanium sponge on a conservative estimate would be 2,500 tpa for India. The plant capacity now will be just sufficient to serve strategic industry like the indigenous space & defence programmes.

Global demand growth for TiO_2 is expected to trend with the prospects of economic growth and production of paint, paper and plastics.

Aerospace, defence and industrial uses are expected to strongly influence the consumption of titanium metal in the near future.