Indian Minerals Yearbook 2017

(Part- III : Mineral Reviews)

56th Edition

ILMENITE AND RUTILE

(FINAL RELEASE)

GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

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March, 2018

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 can not 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) Teris/Red sediments (368) River Channel (32) Inland alluvium (646) Lake & Sea Beds (38). The ilmenite resource estimation for the areas explored upto 2016 has been completed and the resources are up from 539.50 million tonnes (including leucoxene) of 2012 to 629.57 million tonnes in 2016. The resources include measured, indicated and inferred categories. The most significant deposits which are exploitable and that 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

State/Deposit	Ilmenite reserve (In million tonnes)
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	
Ratnagiri	3.68
Munge-Achra-Malvan	1.12
Vijayadura-Mithbav	0.70
Gujarat	
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 received from Department of Atomic Energy dated 26/07/2018.*

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 received from Department of Atomic Energy dated 26/07/2018.*
 # Inclusive of indicated, inferred and speculative categories.
** Including leucoxene.*

PRODUCTION AND PRICES

Ilmenite

The production of ilmenite at 595 thousand tonnes in 2016-17 increased by 14% as compared to that in the preceding year.

Rutile

The production of rutile at 14.89 thousand tonnes in 2016-17 registered a decrease by 11% as compared to that in the previous year.

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

Table – 2 : Production of Ilmenite and Rutile 2014-15 to 2016-17 (By States)

(In tonnes)

State	2014-15	2015-16	2016-17 (P)
ILMENITE			
India : Total	**643128**	**521801**	**594978**
Kerala	93059	8833	-
Odisha	191680	183402	-
Tamil Nadu	358389	250066	-
RUTILE			
India : Total	**15617**	**16723**	**14898**
Kerala	3630	3795	-
Odisha	7249	7403	-
Tamil Nadu	4738	5525	-

Source: *Department of Atomic Energy, Mumbai.*
Note*: State-wise data for the year 2016-17 is not available.*

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

(₹ per tonne)

Year	Grade	Price	Remarks
IREL			
2014-15	Q	54800-73500	Ex-works, Bagged
	MK	54800-73500	Ex-works, Bagged
	OR	54800-73500	Ex-works, Bagged
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
KMML			
2014-15	-	61333	Average
2015-16	-	54833	Average
2016-17	-	52083	Average
V.V. Mineral			
2014-15	-	55618	Average
2015-16	-	49266	Average
2016-17	-	45782	Average

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

Table – 4: Prices of Ilmenite 2014-15 to 2016-17

(₹ per tonne)

Period	Grade	Price	Remarks
IREL			
2014-15			
(Non-slag/SR/TiO_2)	Q	15120-17000	Ex-works, loose
	MK	14230-16000	Ex-works, loose
	OR	13340-15000	Ex-works, loose
(Slag/SR/TiO_2)	Q	6370-10500	Ex-works, loose
	MK	6070-10050	Ex-works, loose
	OR	5440-9000	Ex-works, loose
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
KMML			
2014-15		NA	
2015-16		NA	
2016-17		NA	
V.V. Mineral			
2014-15	-	5916	-
2015-16	-	5096	-
2016-17	-	5241	-
BMC			
2014-15	TiO_2 : 49-51%	8400	f.o.b.Thoothukudi
2015-16		NA	
2015-16		NA	
DCW Ltd			
2014-15	-	10955	
2015-16	-	7862	
2016-17	-	8423	

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 is 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 manufacture of 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.

IREL carried out trial runs for expansion of capacity of ilmenite to 2,00,000 tonnes at Chavara plant in Kerala and has commissioned it successfully. The Company has plan to expand MSP capacity at OSCOM to produce 4.7 lakh tonnes of ilmenite and associated minerals by the end of 2017. Trimex Group is understood to be gearing up to begin its 2,00,000 tpy ilmenite, 6,000 tpy zircon, 60,000 tpy garnet and 50,000 tpy sillimanite along with rutile project in Srikakulam district, Andhra Pradesh.

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, 2014-15 to 2016-17

(In tonnes)

Company/ Location	Mineral	Installed capacity (tpy)	Production		
			2014-15	2015-16	2016-17
Indian Rare Earths Ltd					
Manavalakurichi,	Ilmenite	90000	33287		
Distt. Kanyakumari,	Rutile	3500	1260		
Tamil Nadu.	Zircon	10000	3166		
	Sillimanite	8778	-		
	Monazite	6000	2825		
	Garnet	10000	10397		
	Zirflour	-	-		
	Rare Earth	-	-		
Chavara,	Ilmenite	200000	28009	242075	269966
Distt. Kollam,	Rutile	11400	992	9788	10641
Kerala.	Zircon	17500	1738	10785	11709
	Rare Earths	4500*	-	18796	24056
	Sillimanite	7000	6943	-	-
	Leucoxene	–	-	22515	27546
	Zirflour	6000	19	507	1097
	(includes Microzir)	500	848	956	2265
Orissa Sands Complex,	Ilmenite	220000	200102		
Distt. Ganjam,	Rutile	7400	7249		
Odisha.	Zircon	5000	5769		
	Sillimanite	13000	18311		
	Garnet	20000	11999		
	Monazite	4000	1403		
Kerala Minerals & Metals Ltd					
Chavara,	Ilmenite	61600	65050	65630	55404
Distt. Kollam.	Rutile	4400	2638	2775	2405
Kerala.	Zircon	6500	4768	5346	4784
	Sillimanite	3600	1012	472	600
V.V. Mineral					
Distt. Thoothukudi,	Ilmenite	450000	314917	318430	269608
Tamil Nadu.	Rutile	12000	2803	1505	1852
	Zircon	18000	8218	2306	12763
	Zircon-sillimanite	24000	4707	-	-
Beach Minerals Co. Pvt. Ltd					
Kuttam,	Ilmenite	150000	59786	-	-
Distt. Tirunelveli,					
Tamil Nadu.					
V.V. Titanium Pigments Pvt. Ltd	-	18000	13118	14465	16064
Distt.- Thoothukudi					
Tamil Nadu.					

Source: *Department of Atomic Energy, Mumbai and IREL.*
** In terms of rare earths chloride.*

INDUSTRY

For manufacture of 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 Synthetic Rutile Plants are 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 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 nano-titanium 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 Sillimnaite. 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 make the process outstanding. The proximity of the wet processing units to the sea shore makes transport easy and reliable. V.V. Mineral is the only Indian beach mining company to have obtained environment 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-art machinery.

V.V. Mineral have 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. These 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 also has 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 only has 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 2014-15 to 2016-17 are furnished in Table-6. Data for 2016-17 is not available hence it has not been given.

Table –6 : Installed Capacity of Synthetic Rutile/Titanium dioxide Pigment, 2014-15 to 2015-16

(In tonnes)

Plant	Location	Specification	Installed capacity (tpy)
IREL	Orissa Sands Complex, Distt. Ganjam, Odisha.	90.5% TiO_2 (min)	100000 (Synthetic rutile)
KMML	Chavara, Distt. Kollam, Kerala.	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)	13,000 (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 manufacture of 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 manufacture of 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 231,100 tonnes in 2016-17 which is marginally lower as compared to previous year. The bulk of ilmenite is consumed in the manufacture synthetic rutile (99%). Moderate proportions are consumed by welding electrode and ferroalloys Industry. The consumption of rutile in 2016-17 was 7,000 tonnes compared to 30,900 tonnes in 2015-16. Bulk consumption was in Electrode Industry (81%) followed by Paint Industry (19%) (Table - 7).

Table – 7 : Consumption* of Ilmenite and Rutile 2014-15 to 2016-17 (By Industries)

(In tonnes)

Industry	2014-15 (R)	2015-16 (R)	2016-17 (P)
Ilmenite			
All Industries	**195900**	**232200**	**231100**
Chemicals	194000	230600	230400
Electrode	1500	1200	700
Others (Ceramic, Ferroalloys, Paint & Refractories)	400	400	-
Rutile			
All Industries	**28300**	**30900**	**7000**
Electrode	11500	9700	5700
Paint	16200	17400	1300
Others (Cosmetic, Electrical, Paper & Ferroalloys)	600	600	-

Figures rounded off.

** Includes actual reported consumption and/or estimates made wherever required.Paucity of data, hence, 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 the Foreign Trade Policy, 2015-2020 and the policy on exports and imports, titanium ores and concentrates under heading 2614 (comprising ilmenite unprocessed and upgraded, i.e., beneficiated ilmenite including ground ilmenite) and rutile sand can be imported/exported freely.

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 872 million tonnes in terms of TiO_2 content. Major reserves are in Australia (29%), China (25%), India (10%), South Africa (7%), Brazil and Madagascar (5% each), Norway (4%) 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 10.2 million tonnes and 0.70 million tonnes, respectively, in 2016. Canada and China contributed 18% each of ilmenite production, followed by South Africa (13%), Mozambique (9%) and Australia (7%). Australia produced 35% of world rutile output, followed by Sierra Leone (21%), South Africa (19%), and Ukraine (14%). 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) : 934500		
World: Total (Rounded)	**872500**	**62000**
Australia	250000	29000
Brazil	43000	-
Canada	31000	–
China	220000	–
India	85000	7400
Kenya	54000	13000
Madagascar	40000	-
Mozambique	14000	880
Norway	37000	–
South Africa	63000	8300
Ukraine	5900	2500
USA*	2000	–
Vietnam	1600	–
Other countries	26000	890

***Source**: Mineral Commodity Summaries, 2018.*

**** Includes rutile***

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

(In '000 tonnes)

Country	2014	2015	2016
World: Total	**11600**	**10900**	**10200**
Australia*			
Ilmenite	1138	1147	764
Canada [(e) bc]	2500	1900	1800
China	1902	1900(e)	1800(e)
India	641	641(e)	641(e)
Kenya	282	445	466
Korea, Rep. of	241	204	167
Madagascar	334	166	268
Mozambique	855	764	903
Norway	864	630	630(e)
Russia	178	193	60
Senegal	101	428	416
South Africa(e)	1105	1280	1300
USA	100	200	100(e)
Ukraine(e)	600	600	600
Vietnam	558	238	102
Other countries	176	196	157

***Source**:World Mineral Production, 2012-2016,BGS.*
***Note**: Some ilmenite is converted to synthetic rutile in Australia, India, Japan, Taiwan and USA.*
1:- The figures in this table refer to gross tonnage of titanium concentrates.
**:- Australia also produced 241, 246 and 250 thousand tonnes of Leucoxene during 2014, 2015 & 2016 respectively.*
b:- It is believed that the majority of this is processed in to slag.
c:- Canada produces some ilmenite which is sold as such and not processed into slag, but tonnages are small.

Table – 10 : World Production of Rutile[1] (By Principal Countries)

(In '000 tonnes)

Country	2014	2015	2016
World: Total (rounded) (wt. of conc.)	**800**	**800**	**700**
Australia	341	295	244
India	16	16e	16e
Kenya	52	79	88
Sierra Leone	115	126	149
South Africae	133	131	130
Ukraine e	100	100	100
Other countries	24	15	21

***Source**: World Mineral Production, 2012-2016, BGS.*
1:- *The figures in this table refer to gross tonnage of titanium concentrates.*

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 0.53 million tonnes in 2016-17 as compared to 0.79 million tonnes in the preceding year. Exports in 2016-17 comprised ilmenite (529,822 tonnes), rutile (2,048 tonnes) and others (334 tonnes). Main destinations were China (58%), Netherlands (17%), Japan (16%) and Malaysia (8%).

Exports of titanium and alloys (including waste & scrap) were 114 tonnes in 2016-17 as compared to 171 tonnes in the previous year. Exports were mainly to USA (80%). Exports of titanium oxide and dioxide (total) decreased to 34,042 tonnes in 2016-17 from 40,820 tonnes in 2015-16. Out of the total exports in 2016-17, those of titanium dioxide were 8,157 tonnes and exports of titanium oxides (other than titanium dioxides) were 25,885 tonnes (Tables-11 to 18).

Imports

Imports of titanium ores & conc. decreased substantially to 39,444 tonnes in 2016-17 as compared to 1,06,422 tonnes in the preceding year. Out of the total imports of titanium ores & conc. in 2016-17, those of ilmenite were 25,121 tonnes, rutile 9,322 tonnes and other titanium ores were 5,001 tonnes. Main suppliers were Mozambique (79%), Malaysia (16%) and Ukraine (5%).

Imports of titanium and alloys (including waste & scrap) were 2,397 tonnes in 2016-17 as compared to 1,869 tonnes in the previous year. Imports were mainly from USA,China, Japan and Ukraine. Imports of titanium oxide and dioxide (total) were 14,181 tonnes in 2016-17 as compared to 17,192 tonnes in the preceding year. Imports were mainly from China (42%),Germany (16%), Korea, Rep. of (15%), USA (7%) and Japan (6%). Bulk of these imports were of titanium dioxide (13,902 tonnes) and titanium oxides (other than titanium oxides) were 279 tonnes in 2016-17 (Tables - 19 to 26).

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**790489**	**6644935**	**532204**	**5716719**
China	422913	2667402	311126	2794493
Japan	108222	1926431	82757	1706429
Netherlands	160890	1218911	92196	701222
Malaysia	54167	405206	43590	404223
Iran	1317	70576	784	42423
Bangladesh	261	13831	389	23266
USA	78	4273	190	12853
Belgium	240	12718	155	7900
Indonesia	141	7587	113	6011
Canada	-	-	504	4721
Other countries	42260	318000	400	13178

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**783656**	**6302008**	**529822**	**5586178**
China	422913	2667402	310510	2765640
Japan	103596	1707574	82587	1697754
Netherlands	160786	1213818	92168	699934
Malaysia	54166	405150	43590	404223
USA	78	4273	160	9143
Canada	-	-	504	4721
Jamaica	-	-	42	2042
Mexico	468	4323	156	1210
Bangladesh	80	2575	56	1004
Iran	1	34	28	252
Other countries	41568	296859	21	255

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**6722**	**336087**	**2048**	**108327**
Iran	1316	70542	756	42171
China	-	-	616	28853
Japan	4626	218857	170	8675
Belgium	234	12661	155	7900
Indonesia	141	7587	113	6011
USA	-	-	22	3128
Korea, Rep. of	3	219	51	2570
Egypt	-	-	25	1441
Sweden	-	-	26	1298
Netherlands	104	5093	28	1288
Other countries	298	21128	86	4992

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**111**	**6840**	**334**	**22214**
Bangladesh	79	4648	317	21197
USA	-	-	8	582
Uganda	-	-	6	243
Chile	-	-	2	113
Pakistan	6	491	1	79
Kenya	24	1551	-	-
Ireland	1	76	-	-
Malaysia	1	56	-	-
Brazil	++	18	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**171**	**195611**	**114**	**201474**
USA	124	43628	91	127907
Israel	1	21330	1	32686
Malaysia	++	761	3	6679
Germany	1	3983	3	5034
Saudi Arabia	2	7562	1	3532
UAE	4	6203	1	3127
UK	3	30766	1	2574
Australia	1	3640	++	2520
Oman	++	263	1	2418
Korea, Rep. of	1	431	1	2299
Other countries	34	77044	11	12698

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**40820**	**2296618**	**34042**	**2346322**
Japan	33664	1563366	22446	1126817
USA	1498	166132	2525	329212
Italy	1159	175933	1212	181593
Thailand	320	32578	1321	132168
Malaysia	2656	157973	1825	131813
UK	7	78	2002	88081
UAE	139	18826	462	56976
Indonesia	165	19731	284	33736
Spain	-	-	260	33427
Nigeria	190	24618	269	31573
Other countries	1022	137383	1436	200926

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**4438**	**558233**	**8157**	**1018032**
USA	1258	149365	2398	319989
Italy	977	132273	1072	147667
Thailand	320	32495	1321	132168
Japan	496	55831	832	87726
UAE	138	18315	462	56976
Indonesia	163	19296	283	33570
Spain	-	-	260	33427
Sri Lanka	204	25600	222	28350
Nigeria	142	21741	195	27647
Iran	35	8527	92	21566
Other countries	705	94790	1020	128946

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**36382**	**1738385**	**25885**	**1328290**
Japan	33168	1507535	21614	1039091
Malaysia	2652	157535	1820	131378
UK	-	-	2002	88048
Italy	182	43660	140	33926
Egypt	-	-	48	16715
USA	240	16767	127	9223
Nigeria	48	2877	74	3926
Bangladesh	2	511	10	1933
Turkey	42	3020	18	1342
Latvia	-	-	20	1156
Other countries	48	6480	12	1552

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**106422**	**1637170**	**39444**	**867776**
Australia	10017	401529	4961	226611
Mozambique	72777	702208	19902	188890
South Africa	2660	122150	2928	127408
Ukraine	908	48122	2971	97862
Thailand	1500	62246	1850	70407
Malaysia	462	8939	4398	66714
Senegal	478	17640	1103	42222
China	124	6266	390	17311
Sierra Leone	364	20083	269	13947
Germany	4	493	516	9237
Other countries	17128	247494	156	7167

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**90991**	**916146**	**25121**	**252948**
Mozambique	72777	702208	19902	188890
Malaysia	337	3207	4048	51705
Ukraine	-	-	1157	10839
Germany	4	493	14	1514
Macao	10423	100276	-	-
Sri Lanka	5540	88310	-	-
Australia	1910	21652	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**11649**	**557798**	**9322**	**427599**
Australia	6477	303975	3505	163838
South Africa	2548	117065	2928	127408
Ukraine	908	48122	1764	84363
China	124	6266	390	17311
Malaysia	125	5732	350	15009
Sierra Leone	364	20083	269	13947
Netherlands	-	-	96	4941
Senegal	-	-	20	782
Sri Lanka	923	48906	-	-
Austria	130	5437	-	-
Other countries	50	2212	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**3782**	**163226**	**5001**	**187229**
Thailand	1500	62246	1850	70407
Australia	1630	75902	1456	62773
Senegal	478	17640	1083	41440
Germany	-	-	502	7723
Ukraine	-	-	50	2660
UAE	60	2226	60	2226
South Africa	112	5085	-	-
Chinese Taipei/Taiwan	++	68	-	-
UK	1	36	-	-
USA	1	23	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1869**	**3062798**	**2937**	**2914906**
USA	538	852504	1224	747261
China	514	574682	554	625650
UK	169	362235	68	304265
Germany	63	149769	137	216165
Japan	171	163303	189	198563
Russia	65	102569	61	151821
Ukraine	123	268620	172	119372
Korea, Rep. of	16	24075	56	115798
Italy	81	222475	71	113040
Kazakhstan	15	5776	180	91354
Other countries	114	336790	225	231617

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**17192**	**2768565**	**14181**	**2380145**
China	6804	894413	5951	819216
Germany	2398	505965	2225	475450
Korea, Rep. of	2580	408698	2140	349258
Japan	944	232371	912	209837
USA	1157	204659	944	176620
Czech Republic	1700	200964	701	81182
Mexico	-	-	199	35774
France	422	134393	89	32861
Netherlands	3	426	126	28531
Finland	27	8622	52	27000
Other countries	1157	178054	842	144416

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**16421**	**2570934**	**13902**	**2294281**
China	6491	856721	5778	798578
Germany	2382	500827	2224	469819
Korea, Rep. of	2540	404758	2140	349143
Japan	922	221219	895	194237
USA	1157	203977	941	172563
Czech Republic	1700	200724	701	81182
Mexico	-	-	199	35774
Netherlands	-	-	126	28531
Belgium	20	4400	141	26826
France	148	18389	74	26270
Other countries	1061	159919	683	111358

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**771**	**197631**	**279**	**85864**
China	313	37692	173	20638
Japan	22	11152	17	15600
Finland	1	1710	8	15054
Italy	40	9466	40	9875
France	274	116004	15	6591
Germany	16	5138	1	5631
USA	++	682	3	4057
Switzerland	++	356	1	2562
Saudi Arabia	40	5566	20	2551
UK	1	461	1	1128
Other countries	64	9404	++	2177

FUTURE OUTLOOK

The major chunk of consumption of ilmenite is for the manufacture of synthetic rutile. The future demand of ilmenite during the 12th Plan Period at the GDP growth rate of 8%, 9% and 10% is estimated at 3.19 lakh, 3.27 lakh and 3.35 lakh tonnes, respectively, as per the Report of Working Group on Mineral Exploration and Development (other than coal & lignite) for the 12th Five Year Plan (2012-17), Planning Commission of India.

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 are 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 gap, therefore, will remain. 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.