46 Ilmenite & Rutile

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 found associated with ilmenite. India is endowed with large resources of heavy minerals which occur mainly along coastal stretches of the country and also in inland placers. Ilmenite is the major constituent of these heavy-mineral deposits. Other associated minerals are rutile, zircon, monazite, leucoxene, garnet, sillimanite, etc.

RESOURCES

Ilmenite and rutile along with other heavy minerals form ingredients of beach sand deposits found right from Ratnagiri coast in the west to Orissa coast in the east. These minerals are concentrated in three 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 Valliyar river to Colachal, Manavalakurichi and little beyond in Kanyakumari district, Tamil Nadu (known as MK deposit).

* On Chatrapur coast stretching for 18 km between Rushikulya river mouth and Gopalpur light house with an average width of 1.4 km in Ganjam district, Orissa (known as 'OSCOM' deposit after IREL's Orissa Sands Complex).

The AMD of the Department of Atomic Energy has been carrying out exploration of these mineral deposits. So far, about 2,740 km coastal tract has been investigated for over five decades by AMD. The ilmenite resource estimation for the areas explored during 2002-2005 has been almost completed and the resources are up from 374.62 million tonnes to 461.37 million tonnes, inclusive of indicated, inferred and speculative categories. Resource estimation for the areas explored during 2005 to 2008 is under progress. The most significant deposits which are readily available and attract attention of industry for large-scale operations are as follows:

State/Deposit	Ilmenite reserve (In million tonnes)
Andhra Pradesh	
1. Amalapuram	15.57
2. Bhavanapadu Hukumpet	10.18
3. Kakinada (Phase I-VI)	27.59
4. Kalingapatnam	7.63
5. Narasapur	2.92
6. Nizampatnam	19.26
7. Srikurman	14.18
8. Visakhapatnam	3.60
Kerala	
1. Chavara	13.00
2. Chavara Eastern Extension	17.00
3. Chavara (Phase II)	49.00
Maharashtra	
Ratnagiri	3.04
Orissa	
1. Brahmagiri	61.10
2. Chatrapur	26.72
Tamil Nadu	
1. Kudiraimozhi	23.00
2. Navaladi-Periatalai	24.00
3. Sattankulam	14.48

Source: *Department of Atomic Energy, Mumbai.*

The average grade of total heavy minerals in these deposits is 10-25% of which 30-35% is ilmenite. The overall statewise reserves of ilmenite, rutile and leucoxene which occur together in beach sand deposits are given in Table - 1.

As per the UNFC, total resources of titaniferous magnetite in the country as on 1.4.2005 are estimated at 40.68 million tonnes of which 1.29 million tonnes are placed under 'reserves' category and bulk i.e. 39.39 million tonnes under 'remaining resources' category. In addition, about 3.35 million tonnes resources of anatase are estimated in Meghalaya.

Table - 1 : Resources of Ilmenite, Rutile and Leucoxene

(In million tonnes)

State	Indicated (=Proved)	Inferred* (=Probable)	Total in situ
Ilmenite : Total	**178.93**	**282.44**	**461.37**
Andhra Pradesh	48.09	91.64	139.73
Bihar	-	0.73	0.73
Kerala	19.79	82.80	102.59
Maharashtra	3.68	-	3.68
Orissa	94.24	11.67	105.91
Tamil Nadu	13.13	93.55	106.68
West Bengal	-	2.05	2.05
Rutile : Total	**10.56**	**16.26**	**26.82**
Andhra Pradesh	3.03	5.77	8.80
Bihar	-	0.01	0.01
Kerala	1.63	5.19	6.82
Orissa	5.27	0.62	5.89
Tamil Nadu	0.63	4.48	5.11
West Bengal	-	0.19	0.19
Leucoxene : Total	**3.76**	**12.31**	**16.07**
Andhra Pradesh	1.68	3.52	5.20
Kerala	0.64	4.23	4.87
Maharashtra	0.06	-	0.06
Orissa	0.86	0.17	1.03
Tamil Nadu	0.52	4.39	4.91

Source: *Department of Atomic Energy, Mumbai.*
* *Inclusive of inferred and speculative resources.*

EXPLORATION & DEVELOPMENT

GSI carried out seabed mapping and placer mineral investigations within the territorial waters of India in 2006-07 and 2007-08. The surveys within Territorial Waters (TW) comprised Ganga Delta, off Chhatrapur and Chilka Puri in Orissa coast, seabed mapping off West Bengal, Tamil Nadu and Gujarat coasts and evaluation of placer minerals in TW off Andhra Pradesh in two years.

The survey and exploration carried out by AMD during 2006-07 and 2007-08 included parts of Orissa, Andhra Pradesh, Tamil Nadu, Kerala and Maharashtra. The details of exploration activities carried out by AMD during 2006-07 and 2007-08 are furnished in Table-2.

Table -2 : Exploration Activities by AMD for Ilmenite, Rutile, Monazite, Zircon and other Heavy Minerals, 2006-07 and 2007-08

Location	Activity: Reconnaissance survey (sq km)	Activity: Detailed survey (sq km)	Results
2006-07			
Parts of Orissa, Andhra Pradesh and Tamil Nadu.	45.65	12.94	(a) Continuation of detailed investigations in beach mineral sand deposit in Brahmagiri, Orissa to upgrade resource category, indicated 8-10% of total heavy minerals (THM).
			(b) Detailed investigations in Narsapur beach mineral sand deposit, East Godavari district, Andhra Pradesh, to upgrade resource category, indicated 5-10% of THM.
			(c) Survey in Athirampattinam area, Tamil Nadu indicated 2-5% of total heavy minerals in beach sand and 5-10% of THM in red sand.
2007-08			
Parts of Orissa, Maharashtra and Kerala.	134.58		(a) Exploration along the coastal tract in Sindhudurg district, Maharashtra resulted in identifying two stretches-one with 10-40% THM and second with 5-10% THM.
			(b) About 40 inland placer sand bodies identified in Puri district, Orissa contain 2-10% THM. Red sediments in Ganjam district, Orissa have 13-49% THM.
			(c) Survey along Ponnai-Beypore tract in Northern Kerala shows THM concentration varying from 4-25%.

Source*: Department of Atomic Energy, Mumbai.*

PRODUCTION AND PRICES

Ilmenite

The production of ilmenite at 678,772 tonnes in 2007-08 decreased by 2% as compared to that in the preceding year. Tamil Nadu was the leading producer of ilmenite during the year contributing 46% of the total production followed by Orissa 30% and Kerala 24%.

Rutile

The production of rutile at 20,518 tonnes in 2007-08 increased by 27% as compared to that in

the previous year. Kerala was the leading producer of rutile accounting for 40% of the total production followed by Orissa 34% and Tamil Nadu 26%.

Table - 3 : Production of Ilmenite and Rutile 2005-06 to 2007-08 (By States)

(In tonnes)

State	2005-06	2006-07(R)	2007-08 (p)
ILMENITE*			
India : Total	**703796**	**692906**	**678772**
Kerala	157849	132968	163141
Orissa	244160	207795	200845
Tamil Nadu	301787	352143	314786
RUTILE			
India : Total	**20299**	**16157**	**20518**
Kerala	7490	5069	8230
Orissa	8680	7394	6976
Tamil Nadu	4129	3694	5312

** Includes production of V.V.Mineral and Beach Sand Minerals.*
Source: *Department of Atomic Energy, Mumbai.*

Table - 5 : Prices of Rutile 2005-06 to 2007-08

(Rs. per tonne)

Year	Grade	Price	Remarks
IREL			
2005-06	Q/MK/OR	27500	Ex-works, bagged
2006-07	Q/MK/OR	31000	Ex-works, bagged
2007-08 (w.e.f. 1.4.2007 to 30.9.2007)	Q/MK/OR	31000	Ex-works, bagged
(w.e.f. 1.10.2007 to 19.11.2007)	Q/MK/OR	34000	Ex-works, bagged
(w.e.f. 20.11.2007 to 7.2.2008)	Q/MK/OR	30000	Ex-works, bagged
(w.e.f. 8.2.2008 to 31.3.2008)	Q/MK/OR	28000	Ex-works, bagged
KMML			
2005-06	NA	27500	-
2006-07	NA	30250	-
2007-08	NA	28722	-
V.V.Mineral			
2005-06	NA	-	-
2006-07	NA	-	-
2007-08	NA	23000	-

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

Table - 4 : Prices of Ilmenite 2005-06 to 2007-08

(Rs. per tonne)

Period	Grade	Price	Remarks
IREL			
1.4.2005 to	Q	3550	Ex-works, bagged
5.6.2006	Q	3225	Naked at works
	MK	3325	Ex-works, bagged
	MK	3000	Naked at works
	OR	3000	Ex-works, bagged
	OR	2675	Naked at works
6.6.2006 to	Q	3750	Ex-works, bagged
18.11.2007	Q	3425	Naked at works
	MK	3525	Ex-works, bagged
	MK	3200	Naked at works
	OR	3200	Ex-works, bagged
	OR	2875	Naked at works
19.11.2007 to	Q	4100	Ex-works, bagged
31.3.2008	Q	3775	Naked at works
	MK	3875	Ex-works, bagged
	MK	3550	Naked at works
	OR	3225	Naked at works
KMML			
2005-06	Not specified	3050	-
2006-07	Not specified	3050	-
2007-08	Not specified	3289	-
V.V.Mineral			
2005-06	Not specified	2787	-
2006-07	Not specified	3254	-
2007-08	Not specified	2950	-
BMC			
2005-06	TiO_2 : 48-50%	2250 (US$50)	f.o.b.Tuticorin
	TiO_2 : >51%	3150 (US$70)	
2006-07	TiO_2 : 48-50%	3010 (US$60)	f.o.b.Tuticorin
	TiO_2 : >51%	3250 (US$70)	
2007-08	TiO2 : 48-50%	4700 (US$100)	f.o.b.Tuticorin
	TiO2 : >51%	5640 (US$120)	

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

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, Tuticorin (Tamil Nadu) and M/s Beach Minerals Co. Pvt. Ltd, Kuttam (Tamil Nadu). IREL is exploiting beach sand deposits located at Chavara in Kerala, Gopalpur in Orissa and Manavalakurchi in Tamil Nadu.

At Chavara, beach washings are inadequate to meet the full requirement of the plant. The unit, therefore, 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 richest in TiO_2 content (75.8% TiO_2) and has great demand in India and abroad for manufacture of pigments.

At Manavalakurichi, deposit is spread over 300 hectares at Thuthoor-Ezudesam villages, Vilavancode tehsil, Kanyakumari district, Tamil Nadu. All the raw sand required to operate the separation plant at its full capacity is collected from nearby beaches by the fishermen of surrounding villages and supplied to the unit at cost. 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 percent.

The sand deposits of OSCOM at Chatrapur in Ganjam district extend along the coast of Bay of Bengal with an average width of 1.4 km and average depth of 7.5m. 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 in comparision to Chavara and Manavalakurichi. The Synthetic Rutile Plant of OSCOM is presently not working. As a result, the majority of OSCOM ilmenite produced today is finding its way in the international market as feed stock for production of both slag 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. Dry mining is very simple as well economic. However, it is facing opposition by local people on the ground that removal of sand causes sea erosion. Therefore, collection of beach washings has reduced significantly in recent past.

As an alternate approach, IREL has adoptped 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) from DWC of beach washing plant 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 to Mineral Separation Plant in tippers. Kerala State Mineral Development Corp. Ltd. (KSMDC), also a Kerala Government Undertaking, has prepared and submitted a draft proposal to the Government for Heavy Mineral Concentrate Project & Mineral Park with an estimated cost of Rs. 20 crore in February 2007. The proposal is under consideration.

The mineral separation plants use variety of equipment such as gravity concentrators, high tension 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 weakly 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 has plans to expand MSP capacity at OSCOM to produce 5 lakh tonnes of ilmenite and associated minerals by the end of 2010. Recently,

the IREL has called international bids for implementation of design, supply and installation of a floating Wet Upgradation Plant (WUP) capable of processing 600 tph of beach sand, as also for design, supply and execution of capacity augmentation of Mineral Separation Plant (MSP) to process 130 tph heavy minerals from the current level of 50 tph. At Manavalakurichi, Tamil Nadu, IREL was to expand capacity of ilmenite from 90,000 tpy to 150,000 tpy by 2007-08 in the first phase and to 250,000 tpy by 2009-10 in the second phase, subject to acquisition of land, other clearances, etc. The Chavara Phase I expansion is to be completed to enhance the plant output to 200,000 tpy ilmenite and other minerals. Installed capacity and production of ilmenite, rutile and other heavy minerals by various separation plants are furnished in Table-6.

Table - 6 : Installed Capacity & Production of Ilmenite, Rutile and Other Heavy Minerals, 2005-06 to 2007-08

(In tonnes)

Company/ Location	Mineral	Specification	Installed capacity (tpy)	Production		
				2005-06	2006-07	2007-08
Indian Rare Earths Ltd						
Manavalakurichi,	Ilmenite	55% TiO_2	90000	103027	96551	89355
Kanyakumari dist.,	Rutile	94% TiO_2	4000	4129	3694	3577
Tamil Nadu	Zircon	65% ZrO_2	10000	10311	9180	8404
	Sillimanite	58% Al_2O_3	1500	446	200	NA
	Monazite	96% pure	6000	-	-	-
	Garnet	97% pure	4230	14108	14949	NA
Chavara, Kollam dist.,	Ilmenite	58% TiO_2(min)	154000	106419	80468	113916
Kerala	Rutile	95% TiO_2(min)	10000	4701	2393	5233
	Zircon	65% ZrO_2+HfO_2(min)	12000	8287	4033	12394
	Rare earths	-	4500*	93**	45**	35**
	Sillimanite	58% Al_2O_3(min)	7080	10715	NA	NA
Orissa Sands Complex,	Ilmenite	50.25% TiO_2(min)	220000	244160	207795	200845
Ganjam dist., Orissa.	Rutile	94.25% TiO_2(min)	10000	8680	7394	6976
	Zircon	64.25% ZrO_2+HfO_2(min)	2000	6671	5558	5477
	Sillimanite	56.50% Al_2O_3(min)	30000	13207	11168	NA
	Garnet	-	12000	567	3681	NA
Kerala Minerals & Metals Ltd						
Chavara,	Ilmenite	NA	50000	51430	52500	49225
Kollam dist.,	Rutile	NA	3500	2789	2676	2997
Kerala	Zircon	65% ZrO_2	1500	1864	1764	2175
	Leucoxene	NA	300	-	-	-
	Monazite	NA	240	-	-	-
V.V. Mineral						
Tuticorin,	Ilmenite	46-56% TiO_2	392000	144953	196427	165541
Tamil Nadu.	Rutile	95% TiO_2	(Total Heavy	-	-	1735
	Zircon	NA	Minerals)	-	-	7526
Beach Minerals Co. Pvt. Ltd						
Kuttam, Tirunelveli dist., Tamil Nadu.	Ilmenite	52% TiO_2	150000	53807	59165	59890

Source: *Department of Atomic Energy, Mumbai.*

** In terms of rare earths chloride.*

*** Mainly Rare Earths Fluoride, Cerium Oxide and Cerium Hydrate from conversion of Rare Earths Chloride.*

INDUSTRY

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 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 Dhrangdhra Chemical Works Ltd (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 economically not viable.

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 stage. The KMML is proposing to commence manufacture of titanium sponge to maximize value-addition and also to make the country self-sufficient in this product.

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 and washing in filter presses is marketed as Utox. The company has plans to increase the capacity of plant to 36,000 tpy and also to install facilities for the manufacture of ferrite grade iron oxide from the effluent of the ilmenite plant.

The CMRL, which began production at its 10,000 tpy synthetic rutile plant in Kerala in 1990, has gradually raised the production capacity to around 36,000 tpy in 2005-06 for exports.

The Travancore Titanium Products Ltd (TTPL), a Kerala State Govt. Undertaking, manufactures titanium dioxide pigment by sulphate process at its plant at Kochuveli, Thiruvananthapuram district. 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 tianium oxysulphate along with other metallic ingredients in ilmenite as their sulphate. The liquor is reduced using scrap iron, when ferric iron gets completly 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 proposals to expand its capacity to 27,000 tpy, modernise and diversify in stages 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 ilmentie mined from beach sands of Tirunelveli and Tuticorin districts in South Tamil Nadu.

The 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 Orissa, 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. Titanium sponge is imported by Midhani for further processing in the country.

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.

The plantwise capacities and production of synthetic rutile from 2005-06 to 2007-08 are given in Table-7.

Table - 7 : Installed Capacity and Production of Synthetic Rutile, 2005-06 to 2007-08

(In tonnes)

Plant	Location	Specification	Installed capacity (tpy)	Production		
				2005-06	2006-07	2007-08
IREL	Orissa Sands Complex, Dist. Ganjam, Orissa.	90.5% TiO_2 (minimum)	100000	-	-	-
KMML	Chavara, Kerala	92%-93% TiO_2	40000	33191	34373	35221
DCW Ltd	Sahupuram, Dist. Tuticorin, Tamil Nadu	-	42000	33536	35841	37934
CMRL	Kerala	96.5% TiO_2	36000	28250	32691	32660
TTPL	Thiruvananthapuram, Kerala	97.5% TiO_2	24000	17111	15767	12607

Source: *Department of Atomic Energy, Mumbai.*

USES

Ilmenite is used mainly for the manufacture of ferro-titanium and synthetic rutile; i.e., titanium dioxide, a white pigment. Because of a unique combination of its superior properties of high refractive index, low specific gravity, high hiding power and opacity and non-toxicity, titanium dioxide finds application for 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 cosmetic products, etc. Because of its non toxic nature, it is used in cosmetics, pharmaceuticals, and even added to foodstuffs as well as in toothpastes to improve their brightness. 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 and for manufacture of titanium tetrachloride which in turn is used in making titanium sponge. 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 reported ilmenite consumption of ilmenite decreased to 244,967 tonnes in 2007-08 as compared to 254,198 tonnes in 2006-07. Bulk ilmenite was consumed for manufacturing of synthetic rutile (53%), followed by pigment industry (44%). Remaining 3% consumption was by steel plants, ferro-alloys and welding electrode manufacturers. The reported consumption of rutile in 2007-08 decreased to 15,957 tonnes from 17,165 tonnes in 2006-07. Bulk consumption was in electrode industry. In 2007-08, the reported consumption of ferro-titanium was 967 tonnes. About 76% consumption was in iron and steel industry and 24% in alloy steel and foundry industries (Table - 8).

Table - 8 : Consumption of Ilmenite, Rutile and Ferro-Titanium, 2005-06 to 2007-08 (By Industries)

(In tonnes)

Industry	2005-06	2006-07	2007-08
ILMENITE*			
All Industries	**239433**	**254198**	**244967**
Synthetic rutile	112463	128538	129592
Pigment (TiO_2)	115359	112486	106639
Others (steel plants, ferro-alloys and welding electrode)	11611	13174	8736
RUTILE**			
All Industries	**21289**	**17165**	**15957**
FERRO-TITANIUM@			
All Industries	**764**	**842**	**967(p)**
Alloy steel & foundry	230	256	230
Iron & steel	534	586	737

Source: *Department of Atomic Energy, Mumbai (for ilmenite & rutile).*

* *Relates to sales figures of IREL and captive consumption of KMML in pigment unit.*

** *Relates to sales figures of IREL and KMML along with captive consumption in pigment unit.*

@ *Reported consumption data collected on non-statutory basis by IBM.*

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 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 which hitherto was 74%, has recently been raised to 100 percent.

Joint ventures with foreign participation are 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 are 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 the 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 the 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, 2004-2009 and the policy on export and import effective from 1.4.2008, 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 feed stocks because it affects the marketability of beach sand ilmenite. Titanium alloys may be replaced in aerospace applications by lithium-aluminium alloys or carbon-epoxy composites.

WORLD REVIEW

The world reserve base for ilmenite is estimated at 1,400 million tonnes in terms of TiO_2 content. Major resources occur in China (25%), South Africa (16%), India (15%), Australia (11%), Brazil (6%),Norway and USA (4% each), Mozambique (2%) and Ukraine (1%). The world reserve base of rutile is 87 million tonnes in terms of TiO_2 content. Major rutile resources occur in Australia (36%), followed by South Africa (28%)

and India (23%). World resources and production of titanium minerals; viz, ilmenite and rutile, are furnished in Tables - 9 to 11, respectively.

Australia

Australian mineral sands deposits hold the world's largest resources of the titanium-bearing minerals rutile and ilmenite, and the zirconium-bearing mineral. BeMax began production from the Pooncarie project in Murray Basin from the Ginkgo mines in February 2006. Capacity at Pooncarie project is to be 250,000 tpy.

Iluka's Douglas project was fully commissioned in early 2007. Mindarie project of Australian Zircon NL in the Murray Basin was under construction with initial production slated for late 2007 with 40,000 tpy TiO_2 content as ilmenite. The 100,000 tpy Goondicum ilmenite project of Monto Minerlas Ltd in Queensland was also under way.

Canada

In Canada, a progressive expansion at Sorel for upgraded slag in Quebec facility added 125,000 tpy of TiO_2 capacity. The total capacity would be at 400,000 tpy of TiO_2 by the end of 2007. The total slag production capacity at Sorel will be 1.4 million tpy by 2007.

Madagascar

Rio Tinto's Madagascar Minerals project and port construction were under way. The 70,000 tpy of ilmenite produced would be despatched to Sorel for smelting. The start of production is slated for 2009.

Mozambique

The Moma project of Kenmare Resources plc began commissioning in mid-2007. The project would produce 800,000 tpy of ilmenite and 20,000 tpy of rutile. Ultimate capacity is planned to be 1.2 million tpy of ilmenite, thus becoming one of the largest capacity additions in the recent past.

Sierra Leone

Sierra Rutile Ltd's operations halted in 1995 were recommissioned in early 2006. At capacity, the operation was to produce 200,000 tpy of natural rutile, plus ilmenite by-products in 2007.

Titanium Metal

More than half of the world's titanium sponge production capacity is located in the CIS. Revival of the titanium metal industry is continuing since 2003. The main sources of growth in demand have been the industrial applications, aerospace industry and military applications. Companies have been increasing output of titanium sponge from existing facilities as well as adding new production capacity. The main capacity expansion/ new additions of sponge are: Allegheny Technologies, Oregon, USA (4,500 tpy) and Allegheny Technologies, Utah, USA (10,900 tpy), In addition, Fushun has already commissioned a 5,000 tpy sponge plant and another in Liaoning province with 10,000 tpy capacity is under expansion. Sumitomo Titanium, Japan has completed expansion to 24,000 tpy from 18,000 tpy in 2006. By mid-2009, the capacity is planned to be 38,000 tpy. Toho Titanium is expanding capacity to 15,700 tpy and has plans for a new 12,000 tpy plant. Titanium Metals Corp. is expanding the 9,500 tpy Henderson, Nevada facility to 13,500 tpy.

Synthetic Rutile

The titanium dioxide pigment accounts for more than 90% world consumption of titanium minerals. It is the brightest among white pigments and main applications are in paints, paper and plastics. North America and Europe account for more than half the world demand of this pigment. Present Chinese demand has increased to 14%.

In Saudi Arabia, National Titanium Dioxide Co. completed expansion to 120,000 tpy from 90,000 tpy. In China, Jinzhou chloride plant of Pangang Group expanded capacity by 14,000 tpy. In Australia, Kemerton plant of Lyondell Chemical Co. added 10,000 tpy capacity. In the USA, DuPont recommissioned the 340,000 tpy capacity DeLisle plant in Mississippi. The said plant - second largest in the world - was closed in 2005 following damage due to hurricanes. DuPont is also expanding titanium tetrachloride production facility at New Johnsonville in USA by 45,000 tpy. The product will feed the Allegheny's new sponge facility to come up in Utah.

Table - 9 : World Resources of Ilmenite and Rutile (By Principal Countries)

(In '000 tonnes of contained TiO_2)

Country	Reserve base	
	Ilmenite	Rutile
World Total (Ilmenite+Rutile) : 1487000		
World : Total (Rounded)	**1400000**	**87000**
Australia	160000	31000
Brazil	84000	2500
Canada	36000	-
China	350000	-
India*	210000	20000
Mozambique	21000	570
Siera Leone	-	3600
Norway	60000	-
South Africa	220000	24000
Ukraine	13000	2500
USA	59000	1800
Vietnam	14000	-
Other countries	150000	1000

***Source**: Mineral Commodity Summaries, 2008.*

** As per Department of Atomic Energy, Mumbai, the total resources of ilmenite in India are estimated at about 461 million tonnes; rutile at 27 million tonnes; and leucoxene at 16 million tonnes.*

Table - 10 : World Production of Ilmenite (By Principal Countries)

(In '000 tonnes)

Country	2005	2006	2007
World:Total(wt. of conc.)	**10600**	**11900**	**12400**
All form of TiO_2 [e]	**5500**	**6300**	**6600**
Australia Ilmenite	2034	2378	2339
Leucoxene	62	135	164
Canada [e#@]	2100	2400	2500
China [e]	1015	1300	1300
India*	712	657 [e]	730 [e]
Norway	807	850	882
South Africa [e#]	1904	2070 [e]	2248 [e]
Ukraine [e]	550	600	600
USA [e]	500	500	500
Other countries	916	1010	1137

***Source**: World Mineral Production, 2003-2007.*

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

** As per Department of Atomic Energy, Mumbai, India's production of ilmenite in 2005-06, 2006-07 and 2007-08 was 703,796 tonnes, 692,906 tonnes and 678,772 tonnes, respectively.*

 # Processed into slag. In 2007 South Africa produced an estimated 1,110 thousand tonnes (85% TiO_2) and Canada produced 1,010 thousand tonnes (80-95% TiO_2).

@ Canada produces some ilmenite which is sold as such and not processed in to slag; but tonnages are small.

Table - 11 : World Production of Rutile (By Principal Countries)

(In '000 tonnes)

Country	2005	2006	2007
World Total (wt. of conc.)	**434**	**570**	**638**
Australia	177	232	312
India*	20	16	22e
South Africa [e]	130	125	112
Ukraine [e]	90	100	100
Other countries	17	97	92

Source : World Mineral Production, 2003-2007.

** As per Department of Atomic Energy, Mumbai, India's production of rutile in 2005-06, 2006-07 and 2007-08 was 20,299 tonnes, 16,157 tonnes and 20,518 tonnes, respectively.*

FOREIGN TRADE

Exports

Exports of titanium ores & conc. declined to 255,337 tonnes in 2007-08 compared to 311,489 tonnes in the preceding year. Out of total exports in 2007-08, those of ilmenite were 254,805 tonnes, rutile 521 tonnes and other titanium ores were 11 tonnes. Main destinations were China (29%), Malaysia (24%), Japan (23%) and Rep. of Korea (8%).

Exports of titanium and alloys (including waste & scrap) increased to 154 tonnes in 2007-08 from 121 tonnes in the previous year. Exports were mainly to Saudi Arabia, South Africa, Singapore, UK, etc. Exports of tiatinum oxide and dioxide increased to 35,772 tonnes in 2007-08 from 16,682 tonnes in 2006-07. Out of total exports in 2007-08, those of titanium dioxide were 12,799 tonnes and other titanium oxides were 22,923 tonnes . Exports were mainly to Japan (31%), Singapore (27%), USA (8%) and Iran (7%) (Tables - 12 to 19).

Imports

Imports of titanium ores & conc. increased to 17,356 tonnes in 2007-08 as compared to 13,589 tonnes in the preceding year. Out of total imports of titanium ores & conc. in 2007-08, those of ilmenite were 1,177 tonnes, rutile 13,432 tonnes and other titanium ores were 2,747 tonnes. Main suppliers were Australia (35%), Sri Lanka (25%), South Africa (20%), Ukrain (12%) and Malaysia (4%).

Imports of titanium and alloys (including waste & scrap) increased to 577 tonnes in 2007-08 from 466 tonnes in the previous year. Imports were mainly from China, Italy, Austria, Russia, USA,

UK, etc. Imports of titatinum oxide and dioxide increased to 19,425 tonnes in 2007-08 from 17,584 tonnes in 2006-07. Out of total imports in 2007-08, those of titanium dioxide were 18,304 tonnes and other titanium oxides were 1,121 tonnes. Imports were mainly from USA (21%), China (15%), Germany (11%), Rep. of Korea, (10%) and Japan (6%) (Tables - 20 to 27).

Table - 12 : Exports of Titanium Ores & Conc. : Total (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**311489**	**1745588**	**255337**	**1667759**
Japan	39505	778107	58891	838313
China	24271	87597	73083	327582
Malaysia	68640	244081	62011	195113
Korea, Rep. of	56270	178364	21381	98237
Singapore	3040	69083	3500	77932
Finland	26000	88651	12740	44731
Netherlands	24040	80936	12250	40328
Spain	-	-	10976	33410
Australia	29000	110815	-	-
Norway	40400	105210	-	-
Other countries	323	2744	505	12113

***Source**: DGCI&S, Kolkata.*

Table - 13 : Exports of Titanium Ores and Conc. (Ilmenite) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**300401**	**1468763**	**254805**	**1654667**
Japan	31556	571284	58889	837973
China	24271	87597	73083	327582
Malaysia	68640	244081	61984	194448
Korea, Rep. of	56270	178364	21381	98237
Singapore	-	-	3500	77932
Finland	26000	88651	12740	44731
Netherlands	24040	80936	12250	40328
Spain	-	-	10976	33410
Australia	29000	110815	-	-
Norway	40400	105210	-	-
Other countries	224	1825	2	26

***Source**: DGCI&S, Kolkata.*

Table - 14 : Exports of Titanium Ores and Conc. (Rutile) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**10068**	**254404**	**521**	**12726**
Iran	-	-	494	12061
Malaysia	-	-	27	665
Japan	7449	194655	-	-
Kenya	19	672	-	-
Singapore	2600	59077	-	-

***Source**: DGCI&S, Kolkata.*

Table - 15 : Exports of Titanium Ores and Conc. (Others) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**1020**	**22421**	**11**	**366**
Japan	500	12168	2	340
New Zealand	-	-	8	24
Nepal	80	229	1	2
Singapore	440	10006	-	-
USA	++	18	-	-

***Source**: DGCI&S, Kolkata.*

Table - 16 : Exports of Titanium & Alloys (Incl. Waste & Scrap) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**121**	**90626**	**154**	**313275**
Saudi Arabia	1	3042	66	156050
Singapore	1	3421	10	46375
South Africa	++	1253	28	14386
UK	42	24428	9	11676
Sweden	-	-	5	10496
Chinese Taipei/ Taiwan	-	-	5	9413
Poland	17	1409	3	8688
USA	38	15603	1	8103
UAE	2	7743	3	4830
Canada	10	8569	1	1855
Other countries	10	25158	23	41403

***Source**: DGCI&S, Kolkata.*

Table 17 : Exports of Titanium Oxide & Dioxide : Total (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**16682**	**1239198**	**35722**	**1612908**
Japan	552	16934	10922	272997
Singapore	1	2825	9690	233860
Iran	2040	167041	2520	185698
USA	4590	279551	2778	184507
UAE	859	63081	2171	157146
China	1440	118702	1660	123302
Italy	1376	121127	1262	103764
Korea, Rep. of	904	69828	820	60509
Turkey	460	40560	501	43616
Spain	847	71068	330	27057
Other countries	3613	288481	3068	220452

***Source**: DGCI&S, Kolkata.*

Table - 18 : Exports of Titanium Dioxide (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**13311**	**1072318**	**12799**	**971781**
Iran	2040	167041	2520	185698
UAE	758	60628	2165	156801
China	1440	118702	1640	122712
Italy	1376	121127	1262	103764
USA	2014	136219	1030	77553
Korea, Rep. of	904	69828	820	60509
Turkey	460	40560	501	43616
Syria	695	52665	360	27217
Spain	847	71068	330	27057
UK	216	19886	237	20679
Other countries	2561	214594	1934	146175

***Source**: DGCI&S, Kolkata.*

Table - 19 : Exports of Titanium Oxides (Other than Titanium Dioxide) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**3371**	**166880**	**22923**	**641127**
Brazil	-	-	80	2237
China	-	-	20	590
Japan	500	12567	10848	267414
Malaysia	-	-	432	28718
Nigeria	18	228	23	689
Saudi Arabia	140	5296	10	177
Singapore	1	2825	9420	214390
Thailand	-	-	288	18876
UAE	101	2453	6	345
USA	2576	143332	1748	106954
Other countries	35	179	48	737

***Source**: DGCI&S, Kolkata.*

Table - 20 : Imports of Titanium Ores & Conc. : Total (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**13589**	**370939**	**17356**	**424265**
Australia	5521	164889	6072	161817
Sri Lanka	1962	44313	4327	88850
South Africa	2832	74797	3547	84760
Ukraine	1882	56397	2047	57566
Malaysia	834	16246	669	13276
China	518	13910	326	9723
UAE	++	16	243	4829
Cyprus	-	-	40	1130
Vietnam	-	-	40	1043
Unspecified	-	-	25	735
Other countries	40	371	20	536

***Source**: DGCI&S, Kolkata.*

Table - 21 : Imports of Titanium Ores and Conc. (Ilmenite) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**1167**	**17544**	**1177**	**26409**
Australia	577	14088	716	18182
South Africa	-	-	217	4637
Sri Lanka	510	2814	54	1458
Ukraine	-	-	40	1108
Malaysia	40	282	150	1024
Thailand	40	360	-	-

***Source**: DGCI&S, Kolkata.*

Table - 22 : Imports of Titanium Ores and Conc. (Rutile) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**11707**	**334220**	**13432**	**343994**
Australia	4575	140832	4670	128355
Sri Lanka	1452	41499	3765	84357
South Africa	2564	67692	2228	55186
Ukraine	1854	55572	1839	51720
Malaysia	794	15964	519	12252
China	468	12634	326	9723
Cyprus	-	-	40	1130
Italy	-	-	20	536
UAE	++	16	-	-
Unspecified	-	-	25	735
Other countries	++	11	-	-

***Source**: DGCI&S, Kolkata.*

Table - 23 : Imports of Titanium Ores and Conc. (Others) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**715**	**19175**	**2747**	**53862**
South Africa	268	7105	1102	24937
Australia	369	9969	686	15280
UAE	-	-	243	4829
Ukraine	28	825	168	4738
Sri Lanka	-	-	508	3035
Vietnam	-	-	40	1043
China	50	1276	-	-

***Source**: DGCI&S, Kolkata.*

Table - 24 : Imports of Titanium & Alloys (Incl. Waste & Scrap) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**466**	**1045056**	**577**	**1138852**
China	60	150979	90	194577
Italy	51	127545	77	170314
Russia	121	169253	61	141658
USA	104	246519	59	97417
France	19	53781	42	92984
Austria	10	28743	75	82085
UK	14	50242	57	78826
Germany	12	27958	24	67188
Korea, Rep. of	26	55473	37	60274
Japan	7	13711	23	51890
Other countries	42	120852	32	101639

***Source**: DGCI&S, Kolkata.*

Table - 25 : Imports of Titanium Oxide and Dioxide : Total (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**17584**	**1550819**	**19425**	**1599624**
Australia	1342	121818	783	64566
China	4513	247343	2820	140762
Chinese Taipei/ Taiwan	1504	144526	874	76721
Germany	2685	328930	2061	247357
Italy	599	53916	544	41855
Japan	873	83718	1163	111934
Korea, Rep. of	341	24019	1869	135102
Malaysia	545	49299	1079	86781
Singapore	416	37530	822	68115
USA	3374	325718	4129	358311
Other countries	1392	134002	3281	268120

***Source**: DGCI&S, Kolkata.*

Table - 26 : Imports of Titanium Dioxide (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**17166**	**1513512**	**18304**	**1540659**
USA	3358	324581	4120	357745
Germany	2644	324123	2040	244016
Korea, Rep. of	341	24019	1869	134878
Japan	853	81387	1142	110094
China	4393	241583	1971	104145
Malaysia	545	49299	1079	86731
Chinese Taipei/ Taiwan	1504	144526	874	76721
Singapore	416	37530	822	68115
Australia	1342	121818	783	64566
Italy	599	53916	524	41408
Other countries	1171	110730	3080	252240

Table - 27 : Imports of Titanium Oxides, (Other than Titanium Dioxide) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**418**	**37307**	**1121**	**58965**
China	120	5760	849	36617
Ukraine	94	8261	200	15476
Germany	41	4807	21	3341
Japan	20	2331	21	1840
USA	16	1137	9	566
Italy	-	-	20	447
Korea, Rep. of	-	-	++	224
Switzerland	20	1793	++	158
UK	7	2984	1	72
Thailand	100	9918	-	-
Other countries	++	316	++	224

***Source**: DGCI&S, Kolkata.*

FUTURE OUTLOOK

The world demand of titanium dioxide is recovering slowly. The feedstock markets (viz, ilmenite, rutile, titanium slag, etc.) are in deficit supply. Global TiO_2 pigment consumption is on the rise in countries like USA and China. New capacities are adding up through expansion/ restoration. Feedstock prices rose modestly during 2006 while 2007 prices were rising more rapidly. Worldover, preference was for high TiO_2 chloride feedstock and for sulphate markets, preference was for ilmenite over slag.

Indian heavy-mineral resources (for titanium) are one of the largest in the world. Moreover, ilmenite of higher grades are available in the world in large quantities. With the steady industrial growth in the country, domestic titania sector is also expected to grow suitably.