

# Processing of Pigmentary Titanium Dioxide from Titaniferous Minerals

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**Abstract:** We consider sources of raw materials for producing pigmentary titanium dioxide in Russia. We found that Russia has huge balanced stocks of titan-containing ores, including ilmenite, titaniferous, and leucogene. We show the main fields and make recommendations about their development. We also give examples of pigmentary titanium dioxide production from different titaniferous ores from the Russian Federation, and suggest possible organization of production of pigmentary titanium dioxide in the Ural region of Russia.

**Key words:** Pigmentary titanium dioxide, titaniferous minerals, leucogene concentrate, deposit, processing.

## 1. Introduction

Russia possesses large stocks of titanium dioxide. However, production of pigmentary titanium dioxide in Russia is nonexistent, and per capita use is approximately 0.4 kg per year, compared with approximately 4 kg per capita in the United States, Finland and Germany. Thus, titanium dioxide consumption per capita in a country correlates with that country's specific internal gross product.

Approximately half of Russia's balanced stock of titanium dioxide is located in the Yaregsky field of petroliferous sandstones in the Komi Republic. A similar field of bituminous sandstones is located at the Athabasca oil sands in Canada. Neither field is developed because of a lack of effective technology.

The remaining Russian titanium dioxide stocks are located in magmatic fields, which also contain iron and vanadium. Currently, ores from the Kachkanarsky Deposit (16% of Fe, 0.13% of  $V_2O_5$ , 1.23% of  $TiO_2$ ) are the only combined source of iron and vanadium, and are processed on-site using the blast furnace and converter. The Medvedevsky field in Chelyabinsk

Oblast, in which 5% of the Russian stocks of titanium dioxide (7% of  $TiO_2$ ) are located, is of interest as an ore base of ferrous metallurgy (iron and vanadium).

In the Urals and further to the east, the iron ore base of Russia's ferrous metallurgy is provided mainly by ores of this kind from the Kopansky, Chineysky, Kruchininsky, Kuranakhsky, and Big Seyim Deposits, which contain over 30% of Russia's titanium stocks [1-4].

When developing these fields, the question exists of extracting not only the titanium, but also iron and vanadium from iron and vanadic ores. Besides, when processing ores according to the process in which a blast furnace and converter are required, improved blast furnace smelting technology is necessary that accounts for the increased titanium content in blast furnace slag. When using high titanium ores, development of ore processing technology according to the scheme metallization-electromelting is required.

## 2. Condition of Titanium Dioxide Ore Base in Russia

Russia holds large balanced and off-balanced stocks of titanium dioxide, at 600.45 million tons and 88.8 million tons, respectively. This quantity is second only to China's stock. Stocks of the categories  $A+B+C_1$

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comprise just under half of balanced stocks (261.4 million tons); therefore, only 45% from this quantity is located in developed, mastered, and reconnoitered fields. On active stocks, Russia is third in the world, with a global share of 13%. In addition to these abundant resources, more than a third this stock has a high degree of reliability [5].

Fig. 1 shows a placement schema of Russia's titanium-containing deposits [6]. For example, the Kachkanarsky Deposit, Sverdlovsk Oblast, near Ekaterinburg: Actually Kachkanarsky (6), Gusevogorsky (7); Chelyabinsk region: Medvedevsky (8), Kopansky (13), Kusinsky; Kola Peninsula-Kol'skiy Poluostrov: Africanda (2); Far East: Kuranakhsy (19).

Russian titanium resources are highly varied with a prevalence of radical fields in which 97% of Russia's titanium dioxide stocks are located: 46% of stocks are in buried lithified scatterings in the Yaregsky petrotitanic field (see Ukhta in Fig. 1), 37% in magmatogene deposits in gabbroids, and 14% in magmatogene deposits in alkaline breeds. The buried

coastal and sea scatterings of the Eastern European and Western Siberian alluvial provinces contain just 3% of Russia's titanium dioxide stocks.

The original ore of Yarega, Komi Republic, contains 58-73% quartz, 15-20% leucoxene, and 8-10% oil.

The oil is separated using an organic solvent that is regenerated in rectification columns. After separation, the concentrate is subjected to oxidizing roasting in a rotary kiln. Table 1 shows the composition of concentrate after roasting.

### 3. Experimental Results

Thermal activation of leucoxene concentrate has been developed and tested in industrial conditions [7]. The technology transforms  $TiO_2$  into  $Ti_3O_5$ . Periodical furnaces such as a combustion box furnace are recommended during the first stage. However, it remains necessary to develop a continuous process using other furnaces.

The pigment obtained from the activated Yaregsky concentrate corresponds to Russian State Standard

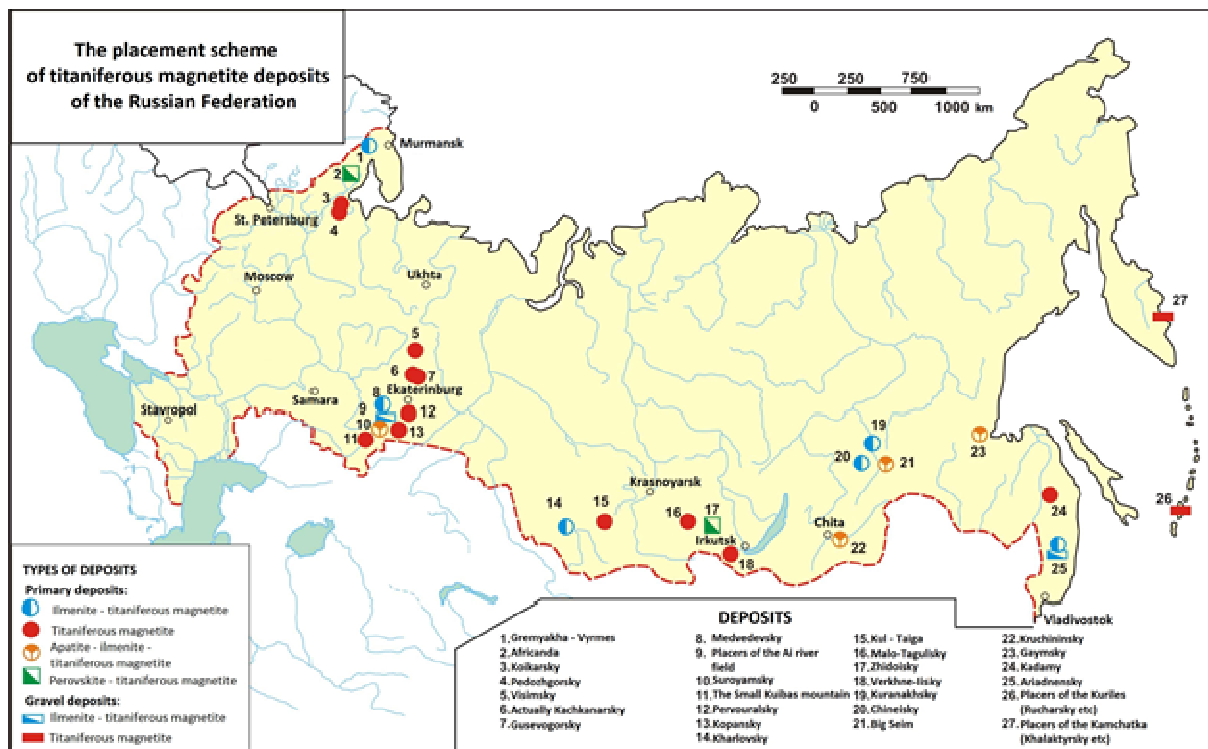


Fig. 1 Placement schema of Russia's titanium-containing deposits.

GOST 9808-84; it has a whiteness indicator of 96.0-96.8 standard units, whitewash ability 1,750-1,820 standard units, coverage 32 g/m<sup>2</sup>, and reflection coefficient 95.0-96.5 standard units [8].

The Institute of Metallurgy of the Ural branch of the Russian Academy of Sciences studies various raw materials for producing pigmentary titanium dioxide. We conducted preliminary investigations in this direction with the Chelyabinsk branch of JSC Scientific and Production Company "Pigment".

Table 2 gives indicators of quality of pigmentary titanium dioxide from different titanium-containing raw materials.

The major task—beginning production of pigmentary titanium dioxide in the Urals—can be

solved as follows.

#### 4. Solution of Problem

Option 1: Processing Yuzhnyy Ural titanium-containing deposits to pigmentary titanium dioxide can begin using Ai river scatterings (the Kopansky deposit), where ilmenite stocks—1.755 million tons, titaniferous magnetite—1.488 million tons.

Table 3 presents the chemical compositions of ilmenite concentrates and titanium slag from Ai River basin sands [9].

Development stages are as follows.

First stage—construction of a titano-ilmenite scatterings production pit based on a mobile concentrating complex. This produces 50 thousand

**Table 1** Chemical composition of concentrate (%).

TiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	MgO	CaO	MnO	P <sub>2</sub> O <sub>5</sub>	V <sub>2</sub> O <sub>5</sub>	Cr <sub>2</sub> O <sub>3</sub>	ZnO
48.0	2.5	40.7	2.4	0.5	0.28	0.037	0.15	0.1	0.006	0.23
Nb <sub>2</sub> O <sub>5</sub>	Ta <sub>2</sub> O <sub>5</sub>	ΣTR	Sr	Ce	La	Eu	Te	Th	Sc	Hf
0.063	0.0053	0.2	< 0.08	0.073	0.031	0.0003	0.0006	0.008	0.0022	0.0043

**Table 2** Indicators of pigmentary titanium dioxide quality.

No.	Raw material	Whiteness, standard units	Whitewash ability, standard units	Covering power, g/m <sup>2</sup>	Reflection coefficient, standard units
1	Ukhta (Yarega)	96.0-96.8	1,750-1,820	32.0	95.0-96.5
2	Africanda (2)	> 96.0	> 1,600	< 40.0	-
3	Ukhta + Africanda (2)	92-96	-	-	-
4	Medvedevsky (8)	96.4	1,700-1,750	-	-
5	Kopansky (Ai River)	96.4-96.5	1,660-1,680	-	-
6	Kusinsky	96.2-96.5	1,700-1,750	-	95.9-96.1
7	Norwegian concentrate	96.1-96.4	1,650-1,700	-	96.2

**Table 3** Chemical composition of ilmenite concentrates and titanium slag from Ai River basin sands.

Element	Mass fraction, %	
	Concentrate	Slag
TiO <sub>2</sub>	46.0	84.0-85.0
Fe	36.0	6.5
Fe <sub>2</sub> O <sub>3</sub>	7.2	-
CaO	0.5	1.01
MgO	0.9	1.68
SiO <sub>2</sub>	0.7	1.4
MnO	1.3	1.8
V <sub>2</sub> O <sub>5</sub>	0.13	0.15
Cr <sub>2</sub> O <sub>3</sub>	0.01	0.01
P <sub>2</sub> O <sub>5</sub>	0.03	0.05
Al <sub>2</sub> O <sub>3</sub>	-	2.3

tons of ilmenite concentrate per year. A 33-MVA capacity ore-thermal furnace will also be constructed at Zlatoust Metallurgical Plant, which will enable processing of the scatterings into titanium slag and metal to increase operating capacities.

Second stage—construction of an ore mining and processing enterprise at the Medvedevsky deposit. This will include a clotting factory that will produce briquettes and pellets.

Third stage—construction of a chemical processing complex in Zlatoust that converts titanium slag into pigmentary titanium dioxide .

Option 2: Processing Medvedevsky deposit ores.  $\text{TiO}_2$  stocks—30.209 million tons, Fe—63.235 million tons [5].

First stage—in an initial stage of Medvedevsky deposit pigmentary titanium dioxide production, ilmenite concentrate from the Kuranakhsky deposit, Amurskaya Oblast ( $\text{TiO}_2$  content 47.5–48.0%) is exported to pigmentary plants in China and Japan. Approximately 160 thousand tons per year are delivered to these plants.

Second stage—design and development of a processing plant for the Medvedevsky deposit. This will yield the final products: ilmenite concentrate (42.5%  $\text{TiO}_2$ ), iron-and-vanadium concentrate (60% Fe, 0.9%  $\text{V}_2\text{O}_5$ ). This plant will produce 50 thousand tons of pigment, 232 thousand tons of concentrate iron and vanadium, and 1.113 million tons of titanium rolling per year.

The Medvedevsky deposit is also of interest as an ore base of ferrous metallurgy (iron and vanadium). It is important to note that in the Urals and further to the east, Russia's iron ore base of ferrous metallurgy is represented mainly by ores of this kind.

## 5. Conclusions

In this study, we considered the problem of providing raw materials for producing pigmentary titanium dioxide and related questions. We found that

mineral raw materials should be transported to the Ural region to produce pigmentary titanium dioxide, titanium, iron, and vanadium by mining the many deposits found there.

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