Titanium minerals for new materials

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Abstract. The mineral composition of titanium minerals of modern coastal-marine placer in Stradbroke Island (Australia) and Pizhma paleoplacer in Middle Timan (Russia) has been presented. The physical features of titanium minerals and their modification methods were shown. Photocatalysts on the basis of the Pizhma leucoxene were developed for water purification.

1. Introduction
Titanium is related to strategic mineral resources. The mineral composition of placer titanium ores and localization pattern of ore minerals determine their processing and enriching technologies. The paper presents new data on the mineralogy of placer titanium ores on an example of modern coastal-marine placer in Stradbroke Island, Eastern Australia, and Pizhma pale placer in Middle Timan, Russia, and materials on their basis.

2. Experimental
The ore sand samples of modern coastal-marine placer originate from the Enterprise Mine related to East-Australian ore province stretching to 13 km with average width 3 km along the eastern coast of Queensland.

Titanium-containing mineral samples were collected from the Pizhma placer in Middle Timan. The Pizhma placer is one of the greatest titanium deposits. The reserves are evaluated at 2.5 billion tons. The open mining of titanium can function during 150 years. The resources of the deposit can support titanium mining during 500 years.

The samples were studied by the following methods: optical-mineralogical (stereomicroscope MBS-10, polarizing microscope POLAM L-311), semiquantitative x-ray phase analysis (x-ray diffractometer X’Pert PRO MPD). Besides microprobe (VEGA 3 TESCAN) and x-ray fluorescent analysis (XRF-1800 Shimadzu) were used.

3. Results and discussion
Earlier on an example of Australian titanium placer the process of transformation of ilmenite into rutile was shown. By the mineralogical composition ores of both deposits are complex: enriched by valuable minerals [1, 2]. Apart from main ore concentrates it is possible to obtain accompanying nonmetallic products. This will increase the efficiency of deposit exploitation.

The mineral composition and occurrence structures of minerals in ore, products, concentrates, wastes are changing during utilization of mineral raw. The main method of monitoring of composition
and features of titanium ores and technological products is x-ray phase analysis. The mineral compositions of the samples (Fig.1) are represented in Table 1.

Ilmenite dominates in ore sands of Stradbroke Island, and leucoxene dominates in the ores of the Pizhma titanium deposit. Australian ilmenite and its altered varieties are mainly characterized by a very high MnO content (from 5.24 to 11.08 %). The irregular distribution of iron oxides, titanium and manganese in the altered ilmenite was shown in the paper [3]. E.g., in the areas of substitution of ilmenite by pseudorutile the concentrations of the given elements are greatly various due to various ratios of basic components in each grain. Their ratios are equal in the area of rutile evolution.

Titanium ores and quartz sandstones are two basic types of raw of the Pizhma deposit. Moreover, the high content of gold, diamonds and also rare earth elements (REE) and rare metals (their forms are not determined) were studied. We found native copper on the surface of minerals composing titanium-bearing sandstones of the Pizhma placer.

![Figure 1. Titanium minerals of modern coastal-marine placer in Stradbroke Island, Eastern Australia (A) and Pizhma paleoplacer in Middle Timan (B)](image)

Figure 1. Titanium minerals of modern coastal-marine placer in Stradbroke Island, Eastern Australia (A) and Pizhma paleoplacer in Middle Timan (B)
Table 1. Mineral composition of ore sands

| Mineral          | Theoretical formula | Content weight % |
|------------------|---------------------|------------------|
| Stradbroke Island|                     |                  |
| Ilmenite         | FeTiO$_3$           | 39               |
| Brookite         | TiO$_2$             | 3                |
| Rutile           | TiO$_2$             | 8                |
| Pseudorutile     | Fe$_2$Ti$_3$O$_8$   | 19               |
| Zircon           | Zr(SiO$_4$)         | 6                |
| Quartz           | SiO$_2$             | 2                |
| Kyanite          | Al$_2$O(SiO$_4$)    | 1                |
| Epidote          | Ca$_2$Al$_2$Fe$_3$+$$(SiO$_4$)_3$OH | 1.5 |
| Tourmaline       | NaFe$_{2+}$Al$_6$Si$_6$O$_{18}$$(BO_3)_3$(OH)$_4$ | 4 |
| Garnets          | R$_2^+$R$_3^+$$[SiO_4]_3$, R$^{2+}$ – Mg, Fe, Mn, Ca; R$^{3+}$ – Al, Fe, Cr | 1.5 |
| Chromespinelides | (Mg, Fe)Cr$_2$O$_4$ | 6                |
| Amphibole        | R$_7$$[Si_4O_{11}]_2$(OH)$_2$, R – Ca, Mg, Fe | 5 |
|                  | Crystal phase total: | 96               |
| Pizhma placer    |                     |                  |
| Ilmenite         | FeTiO$_3$           | 7.5              |
| Anatase          | TiO$_2$             | 1                |
| Rutile           | TiO$_2$             | 18               |
| Pseudorutile     | Fe$_2$Ti$_3$O$_8$   | 45               |
| Hematite         | Fe$_2$O$_3$         | 1.5              |
| Quartz           | SiO$_2$             | 10               |
| Pyrite           | Al$_2$O(SiO$_3$)    | 1                |
| Mica             | K$_5$Al$_3$(OH)$_2$$(AlSi$_3$O$_10$)$^n$H$_2$O | 4 |
|                  | X-ray amorphous phase | 12               |
|                  | Total:              | 100              |

The native copper up to 12 μm occurs both on the surface of quartz, covered by iron hydroxides, and on leucoxene. Two copper occurrence forms found are as:

1) inclusions of monocrystals of isometric (Fig.2A) or angular irregular shape (Fig.2B) in cavities of quartz grains covered by iron hydroxides;
2) intergrowths of plate (Fig.2C) or dendrite-like (Fig.2D) polycrystals.

Apart from native copper there is cuprite.

The treatment methods and mineral processing depends on the mineral composition of the sands. According to the technological features of rocks (density and magnetic) studied placers are close. The obtained results of physical studies, mineral composition features, morphostructural characteristics and degree of alteration of titanium minerals from the placers specify a high potential of physical methods of processing (gravitational and magnetic separation, flotation) and possible application of combined methods of processing [3].

Production of pigment titanium dioxide for further production of titanium white, paper, plastics etc is the usual application area of titanium concentrates. Titanium dioxide of high chemical purity is used to produce optically transparent glass, fiber optics, electronics (iPad), piezoceramics, in medical and food industry.

We designed photocatalysts based on leucoxene from Pizhma placer [5]. The results showed that the photocatalysts based on rutile, synthesized from leucoxene from Pizhma deposit, can be applied to
decay phenols in water. The dependence of photocatalyst activity from specific surface area and presence of noble metal atoms (Au, Pt) was shown.

![Figure 2](image)

**Figure 2.** Inclusion of copper of isometric (A), angular irregular (B) shapes, intergrowth of plate (C) and dendrite-like copper with quartz crystal (D)

4. Conclusion
The mineralogical features of titanium minerals from modern coastal-marine placer in Stradbroke Island, Eastern Australia and Pizhma pale placer, Russia, have been studied. Their physical and chemical features (magnetic, electrical, sorption etc.) and their modification methods were studied. New areas of application of leucoxene concentrate were suggested: photocatalysts for water purification.

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