TITANIUM AND IRON PROBABLE RESERVES IN THE LUNAR SOIL. O. I. Turchinskaya[1], E. N. Slyuta[1], [1]Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, Kosygina Str. 19, Russia, olgaturch@yandex.ru

Introduction: Because of meteorite bombardment, which lasted throughout the entire geological history of the Moon, a cover of loose material, regolith, was formed on its surface, which consists of fragments of underlying rocks, fragments of minerals and secondary particles: breccias, agglutinates and glass particles. All the most promising lunar resources are either concentrated in a loose regolith layer (volatile components), or are already in the regolith in an enriched form (minerals Al, Ti, Fe, etc.), which no longer requires crushing for their further separation and extraction.

The predominant type of mare rocks on the Moon are basalts. According to the bulk chemical composition, mare basalts correspond to the rocks of the gabbro-basalt group and are usually defined as ilmenite, olivine, cristobalite basalts (gabbro), etc. The petrographic specificity of mare basalts consists in the smaller grain size (hundreds of microns) and the practical absence of volcanic glass. The main rock-forming minerals are clinopyroxenes and plagioclase (An50-95), sometimes olivine (Fo50-75). The main ore mineral in mare basalts is ilmenite (FeTiO3), which is also the main ore mineral of titanium and iron on the Moon. Among the samples delivered to Earth, low-titanium (TiO_2<6 wt%) and high-titanium (TiO_2>8 wt%) mare basalts are distinguished, which are further divided by the content of K and Al. The formation of mare basalts is associated with the processes of partial melting of the mantle. Crystallization age of low-titanium basalts is 3.15-3.45 billion years, high-titanium basalts - 3.55-3.85 billion years [1].

Ilmenite in lunar soil: Maps of the distribution of the TiO2 content on the lunar surface, which reflects the ilmenite content in the regolith, were obtained from the optical survey of the Moon Near Side. The method is based on the correlation of the main chromophore elements content for albedo Fe and Ti with albedo and color indices in the visible and near IR spectrum ranges [2-4]. The percentage of TiO_2 varies from 0.01 in the mainland regions to 10% or more in the mare regions (Fig. 1). The areas of spread of the increased content of Ti oxides (5-10%) actually reflect the distribution of high-titanium mare basalts, which are widespread in the Mare Tranquillitatis, the Mare Imbrium, the Oceanus Procellarum, as well as in subordinate numbers are present in the Mare Fecunditatis, the Mare Humorum and the Mare Nubium (Fig. 1). In some areas of high-titanium basalt distribution, the ilmenite content can reach 20 wt%. Low-titanium basalts are widespread in the Mare Serenitatis, the Mare Crisium, the Mare Frigoris, the Mare Cognitum and in subordinate numbers are present on the periphery in the Mare Imbrium.

Probable reserves estimation: Based on the distribution of TiO2 content according to the spectral survey of Clementine spacecraft, four main categories were identified and contoured - A (> 8.0 wt%), B (5.0-8.0 wt%), C (3.0-5.0 wt%) and D (1.0-3.0 wt%) (Fig. 1). The most rich in titanium content is category A, which is of most practical interest. The total area of category A is 732477 km^2. The two largest deposits with a TiO_2 content of more than 8% are distinguished, which are located in Oceanus Procellarum and in Mare Tranquillitatis (Fig. 2). The rest of the deposits are much smaller in terms of their territory and, accordingly, in terms of predicted reserves. They are located in the northwestern part of the Mare Imbrium, Mare Humorum, Mare Nubium, Mare Insularum, Mare Vaporum and Mare Fecunditatis (Fig. 2).

The regolith thickness in maria areas with the maximum ilmenite concentration, primarily in the Mare Tranquillitatis and in the Oceanus Procellarum, was estimated from instrumental measurements at landing sites [5], from crater size and morphology [6], and from the regolith thickness distribution map for various geomorphological formations and stratigraphic divisions [7], and was assumed to be 4.4 m. Knowing the average thickness of regolith and the total area of the A category deposits and taking the content of the main ore mineral ilmenite ($FeTiO_3$) equal to 8 wt. %, the density of regolith equal to 1.9 g cm^{-3} [8], we can estimate the probable reserves. Thus, the total probable reserves of ilmenite in the deposits of A category are estimated at 4.9×10^{11} tons. Ilmenite contains 31.6 wt % titanium and 36.8 wt % iron, the rest is oxygen. Accordingly, the probable reserves of Ti in the A category deposits are estimated at 1.5×10^{11} tons, and Fe at 1.8×10^{11} tons.

Conclusion: Because of the analysis of the distribution of TiO_2 content on the surface of the visible hemisphere of the Moon, according to the optical survey of Clementine spacecraft, areas with different contents of the main ore mineral ilmenite were isolated and contoured. Estimated total area of A category deposits with maximum titanium content is more than 700,000 km. The main concentration of ilmenite is observed in Oceanus Procellarum and in Mare Tranquillitatis. The probable reserves of titanium in the lunar soil in the A category deposits are estimated at 1.5×10^{11} tons, and iron at 1.8×10^{11} tons.

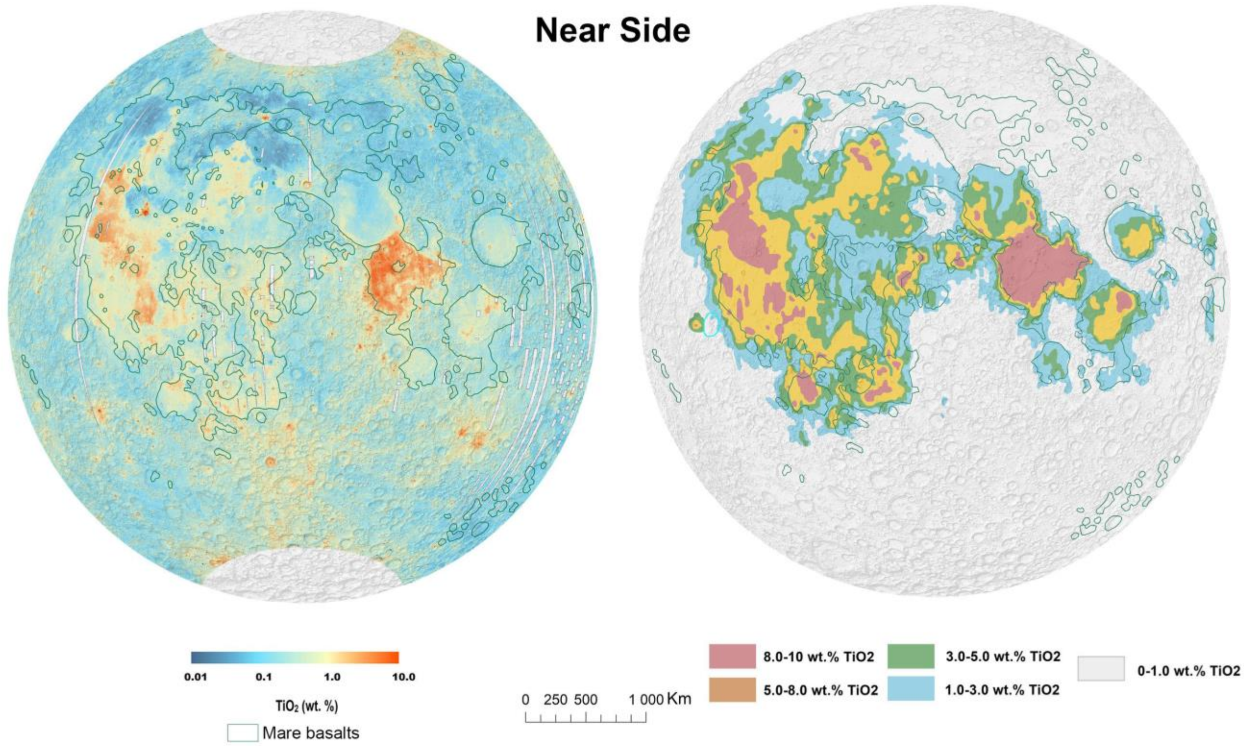

Fig. 1 Maps of the TiO2 (wt.%) distribution in the lunar soil on the Moon Near Side according to the Clementine spacecraft (left) [3] and of outlined categories of metal deposits (right).

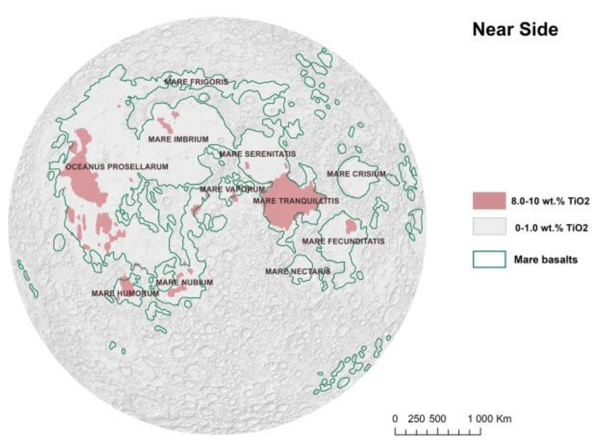

Fig. 2. Map of the distribution of the A category deposits with the content of TiO2 >8 wt.% on the Moon Near Side.

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