GEOLGY AND MINERAL RESOURCES OF THE MANKHAMBOVSKY BLOCK (SUBPOLAR URALS)

Vladimir Aleksandrovich Dushin, Vladimir.Dushin@m.ursmu.ru
Denis Igorevich Prokopchuk, uva9090@mail.ru
Veniamin Sergeevich Koz’min, Veniamin.Kozmin@m.ursmu.ru
Evgeniy Aleksandrovich Zhuklin, Zhuklin7@gmail.com
Artem Konstantinovich Trutnev, tema.trutnev@yandex.ru

Ural State Mining University
Ekaterinburg, Russia

Relevance of the work is in the fact that the studies of the last decade confirm good prospects of the Mankhambovsky block in relation to mineral resources. These include the research in connection with the work of the Northern Scientific-Research Geological Expedition (SNGEE) under the State Program “Reproduction and Use of Mineral Resources for 2012–2020”. The territory considered in the paper is related to the mountainous, exposed part of the Northern and Nether-Polar Urals from the waterhead of the Pechora river in the south to the Manyi river-basin in the north and stretches in the meridional direction by almost 300 km including the Khanty-Mansiysk Autonomous Region – Yugra and partly – the Republic of Komi. The prospects of the Mankhambovsky block in relation to ore minerals are confirmed by studies of the last decade including some works of the Northern Scientific-Research Geological Expedition (SNGEE). More than 50 ore occurrences and about 200 mineralization points for ferrous, nonferrous, noble, radioactive and rare metal ores have been identified within the area under consideration. Iron-ore features are developed limitedly and accomplished by two ore formations – banded iron formations and skarn iron-ore one. Only copper is widely used among nonferrous metals although no significant concentrations are found, and other metals are practically not shown, with the exception of poor polymetallc mineralization in the berylized sediments of the Laptopayskskaya suite. A number of rare metals, including niobium, tantalum, beryllium, zirconium, and also rare-earth elements in complex with uranium and thorium are widely developed within the Mankhambovskaya structure, with uranium and thorium leading in the ores. Radioactive elements in association with thorium, rare and rare earth metals are the leading minerals of the Mankhambovsky block. To date, there are about 20 objects of various sizes.

Purpose of this work is to determine the prospects of the Mankhambovsky block for rare-metal-uranium-thorium mineralization.

Results of the work. According to the conditions of formation and peculiarities of the placement of uranium-rare metal mineralization, three ore formations are distinguished: 1) uranium polygenic formation in unconformity zones localized in the frame of the Mankhambo block in terrigenous rocks of the base of the Hobeinskaya suite (RF); 2) uranium berezitic formation – hydrothermal volcanogenic in the rhyolites of the Sablegorskaya and Riphean–Vendian Laptopayskskaya suites; 3) formation of uranium-bearing peatlands – modern exogenous infiltration formation in mosses, peatlands and covering loams. The data obtained make it possible to assert that within the Mankhambovskaya block it is possible to expect the discovery of medium-scale deposits of multimetal ores.

Keywords: geology, black, non-ferrous, rare metals, uranium, thorium, Subpolar Urals, structural-formational zone, Mankhambovsky block, ore occurrences, isotopic age.

Introduction


The Mankhambovsky block is a large segment of the southern part of the Lyapinskaya structural-formational zone (mega-block) of the Subpolar Urals (Fig. 1). It was proposed in previous works as an independent pre-Paleozoic Tagilskaya transverse uplift [1], and then finally verified on the basis of geological and geophysical materials [2].

The Lyapinskaya megablock is a complex heterogeneous rock structure of various geodynamic environment [3, 4] realized in definite tectonic elements where the Paleocontinental, Paleoeocanic, and Plate sectors are distinguished from the west to the east (Fig. 1). The first one includes some accretional constructive-destructive complexes of Pre-Uralide (Mankhambovsky, Malopatoksky, Nyartinsky, Nerkayusky blocks) and rift slope formations of the Paleozoic (Eletskaya and Lemvinskaya structural-formational zones), at the base of which fragments of the ancient Archaean-Proterozoic crust (with Sm–Nd age of 1.4–2.9 billion years), usually continental one (Nyartinsky, Nerkayusky, etc.). The second one documentarily known as the Tagilskaya synform (Tagilskaya structural-formational zone) includes structural and compositional complexes of the melanocratic base (Dzelyausky block) of the Subpolar Urals (Fig. 1).

The oldest deposits, the basement of the Mankhambovskaya antiform (the Ukyu river, Pad–EL) are represented by a variety of amphibolite, gneisses, migmatites, quartzites and crystalline schists. They are distinguished as part of the Nyartinskaya poorly defined formation, which has a visible thickness of more than 1500 m. By analogy with the Nyartinsky complex, the age of garnet-biotite gneisses is determined on the basis of zircons isotope dating methods U–Pb (SHRIMP-II). It showed values of 2125 ± 25 million years; 2210 ± 25 million years; muscovite-biotite gneiss with a garnet of 1950 ± 35 million years [6, 7]. The age of strata is difficult to be determined. However, the presence of Early Proterozoic isotopic clusters in younger complexes of this region, along with intense metamorphism of the garnet-amphibolite facies and the discordance of structures, allows them to be classified.
with the early Proterozoic with a certain degree of conditionality [1, 3, 8]. The Riphean-Cambrian deposits, which comprise 90 %
of the Mankhambovsky block, differ significantly from the other structures by composition of components, volume, and ratio of
sedimentary and magmatic rocks (Fig. 2). They are metamorphosed under conditions of greenschist and less often amphibolite
facies and are divided into a series of suites from the Early Riphean Mankhobeinskaya (RF1), Shchokurinskaya (RF2) to Vendian
Laptopayskaya (V – E), which are more or less characterized by paleontology. The total thickness of the sections is usually 4-8
thousand meters [5, 6].

The intrusive magmatism of this period is represented by the Mankhambovsky (RF2) granite, sysinsky gabbro-diorite-granite
(RF3), Parnuksky diorite-gabbro (RF3–V1), and Salnersky (Potemyusky) granite-leucogranite (V – E) complexes [6].

Paleozoic deposits are considered in two structural-formation zones of the Belsko-Eletskaya and Zilairo-Lemvinskaya zones
characterized by facies-formation features of deposition of sediments with a characteristic complex of species composition of
the fossil fauna. The sediments of the first zone are precipitates of the shelf type of Telpskaya (O1 telp), Khydeiskaya (O1 hdi), Shchugorskaya (O1 sgh) suites and Tabarotinskaya (O2–3 tbr) series in the Telpos-Iz-Mankhambo region. The Zilaro-Lemvinskaya zone
is formed of deeper-water slope sediments of Saranhapnerskaya (E3–O1), Khomassinskaya (O2) and Pol’inskaya (O3) suites within
the Salatimskiy allochthon, which contacts with the complexes of the Tagilskaya megazone. The total thickness of sediments is
more than 4 thousand meters in the Belsko-Eletskaya zone and 2 thousand meters in the Zilaro-Lemvinskaya zone. The intrusive
magmatism of the Paleozoic is manifested both in the Riphean-Vendian basement of the Lyapinskaya structural-formational
zone (SFZ) – (Khartessky* kimberlite (E1), Siv'yaginsky* picrite (E1), Malopatoksky doleritic (E1), Paypudynsky* trachyrhyo-
The map does not show them (rocks” contain impregnation and thin layers of magnetite. The distribution of magnetite aggregates is concordant or bedded, and largely determine ore saturation of the territory. Branching structures, or traced the largest seams – Sobsko-Salatimskaya and Kulemshorsko-Mankhambovskaya zones, which structural-formational zones.

Figure 2. The geological map of the Mankhambovsky block (prepared by V. A. Dushin).

Belsko-Eletska structural-formational zone
Zilairo-Lemvinskaya structural-formational zone
Tagilskaya structural-formational megazone
Lyapinskaia structural-formational zone
Laptoypskaya suite Polymeric conglomerates
gravestones, sandstones, rhyolites, trachybasalts
Sablegorskaya suite undifferentiated. Lava, clastolava, tufts of myrioclastes and rhyolites, basalts, andesidolastics and their tufts
Moriinskaya suite. Shale roks, silstone, sandstones rarely, mafic effusive bodies and their tufts
Kr obkeimsky suite, white quartzites, sandstones, rare lenses of conglomerates
Manktobinskaya suite, micaeous quartzites, crystalline schist, gneisses, metaconglomerates
Tuyakhlan’insky, Pori’izsky complexes monocylic - syenetic small bodies
Orangygansko-Lemvinsky complex gabbro-dolentic
Pozhemsy rhyolitic complex
Malopatoksky doleritic complex
Salnersky (Potemusky) complex granite-leuconorite
Pamulsky complex gabbro-dioritic
Sablegorskaya subvolcanic formations. Rhyolites
Sylinsky gabbro-dioritic - granite complex
Mankhambovsky granite complex

Geological boundaries
Concordant bedding
Unconcordant bedding
Tectonic disturbance
Main thrusts (Glavny Uralsky)
Thrusts
Fails
a – proved, b – potential
Activated suture zones
Kulemshorsko-Mankhambovskaya
Sobsko (Salatimsko)-Nunderminskaya
Volcanic-tectonic structure (VTS)
Deposit
Ore occurrence
Mineralization occurrence

The map does not show them (Fig. 2) because of small dimensions.

V. A. Dushin et al. / News of the Ural State Mining University 3 (2018) 19-33
EARTH SCIENCES

late (Е–О), Tuyakhlan’insky monzonite-syenitic (D1–D2) complexes, as well as in the Paleozoic Belsko-Eletska (Lekvozhsky* dolerite (О1) complex) and Zilairo-Lemvinskaya (Pozhemsy rhyolitic (Є2–О1), Orangygansko-Lemvinsky (О1, Є2) complexes structural-formational zones.

Mesozoic, more precisely Late Permian-Triassic magmatism is represented by small bodies and dykes of dolerites, trachy-dolerites, monzogabbros, monzosyenites and ultrapotassic rhyolites related to Tatyinsky*, Pori’izsky* and Bolshepatoksky* complexes of plume nature activation type. As a rule, they are related to the northwestern structures of deep-level deposits and their branching structures, or traced the largest seams – Sobsko-Salatimskaya and Kulemshorsko-Mankhambovskaya zones, which largely determine ore saturation of the territory [2, 6, 8].

More than 50 ore occurrences (manifestations) and about 200 mineralization points for ferrous, nonferrous, noble, radioactive and rare metal ores have been identified within the area under consideration.

Ferrous metallic
Iron. In the Mankhambovsky block, iron ore objects are developed in a limited way and caused by the manifestations of two ore formations – branded iron formations (BIF) and skarn iron ore formation.

The formation of BIF is presented by a fairly large ore occurrence MAN-9, which is located in the upstream of the Mannjays river. It was opened in 1962 while carrying out of the airborne geophysical survey (Fig. 2).

It is associated with the zone of distant exocontact of the Mankhambovsky intrusion and is composed of metamorphic rocks of Nyartinsky complex PR. The most common rocks are quartzites, quartzite sandstones, para- and ortho-amphibolites, crystalline (garnet) schists, gneisses (often diaphormized ones), among which there are dykes of acidic and basic composition. “Shale rocks” contain impregnation and thin layers of magnetite. The distribution of magnetite aggregates is concordant or bedded, and their thickness varies from a few millimeters to 20–40 cm. In some workings, subconcordant magnetite bodies with a thickness of

1 The map does not show them (Fig. 2) because of small dimensions.
The Quaternary Nyartinsky complex
Khobeinskaya suite PFpb
Granites of Mankhambovsky (a) and Salnersky complexes
Kulemshorsko-Mankhambovskaya suture zone PRnt
Tectonic disturbances
Faults and strike-slip faults

Figure 3. The essential structure (plan) of the productive horizon of Fe-quartzites (MAN-9).
Рисунок 3. Принципиальное строение (план) продуктивного горизонта Fe-кварцитов (МАН-9).

up to 4–5 m are found. The width of mineralized zones (ore bodies) in the ore manifestation reaches 30–40 m. The size of grains
of magnetite is from 0.007 to 0.2 mm, and its content in ores varies from 15 to 70 %, whereas it does not exceed 10% in enclosing
rocks. As a rule, ore bodies are localized in the hinge parts of folds of different order with faulting. They are medium and small
in size lenticular deposits with uneven ore quality. The mineralized zones do not have clear geological boundaries; they are traced
by positive magnetic anomalies stretching in the north-west direction with an intensity of 1000 nT and higher. There are three of
them most promising connected ore zones which are delineated. They have a length of 860 to 1160 m and a width of 24 to 620
m. Zones were studied to the depth and to the area with the help of wildcat wells and gutters, according to which ore intervals
of the average thickness of 2.43 m with a total iron content of 36.12 % and a magnetite thickness of 23.09 % were identified. The
structural-lithological analysis of the yield of a productive bundle of ore-bearing quartzites allowed us to propose the existence
of a single complex stratified ore horizon with a total length of more than 3 km (Fig. 3).

Magnetite ores and their enclosing rocks are characterized by the presence of impurities of non-ferrous, rare and noble me-
tals. When carrying out the GDP-200/2 spectral analysis, an increased content (%) is identified in most samples: W is 0.00007–
0.007, Mo is 0.0005–0.01, Sn is 0.001–0.02, Bi is up to 0.005, less often Co is 0.01–0.05, Cu is 0.05–0.18 (in some cases more than
1 %), Ce – 0.01–0.1; Ag – up to 1–2 ppm. Au content is determined to be 0.01–0.5 ppm by atomic-absorption material analysis in
some of samples scheelite (up to 22 % of the weight of the heavy non-magnetic fraction), molybdenite, fluorite (up to 40% of the
weight of the heavy non-magnetic fraction) were established by mineralogical analysis of protoplasm samples, along with pyrite
and chalcopyrite that have already known. The mass-spectrometer analysis (ICP MS) of a sample from massive iron ores showed
that the number of rare earths in the ore that mainly associated with orthite is 0.668 % (Table 1). Some occasional fine (up to 0.1
mm) grains of xenotime and monazite were also determined. In addition to pyrite and chalcopyrite, molybdenite and tetradyime
have been also established. In two samples taken close the manifestation, Au was found in an amount of 0.2 and 0.5 ppm.

Points of iron mineralization of metamorphogenic type are recorded in the Riphean deposits along Podcherem, Ponya
and Sale rivers, on the western slope of the Uitym-Niyer Ridge, along the eastern slope of the city of Miron-Vany-Nier and others.

22 Душин В. А. и др. Геология и полезные ископаемые Маньхамбовского блока (Приполярный Урал) // Известия УГГУ. 2018.
Вып. 3(51). С. 19–33. DOI10.21440/2307-2091-2018-3-19-33
Iron ore-skarn formation is represented by small objects in the rank of manifestations and points of mineralization. The largest of these is the manifestation of Ponizskoye located in the interfluve of Ponja, Shchugor rivers near Pon'iz mountain. In the northern flank of the Ponizskaya paleovolcanic structure within the intense aeromagnetic anomaly, we determined some outbreaks and sedentary debris of skarn-magnetite mineralization. From the surface, the dimensions of the outcrops of andradite skarns are the first tens of meters with the thickness of first meters. Mineral assemblage: magnetite, hematite; pyrite, galena, chalcopyrite are rarely observed. The iron content in the ores reaches 33%; gold was identified up to 0.2 ppm by assay test [3, 5].

The skarn-magnetite mineralization is widely used within the block; its traces are noted in relation to the Sivyaginsky, Sablegorsk-Laptoyskiy and Moroinsky magmatism.

**Manganese.** Manganese ore occurrences in the Mankhambovsky block have not yet been identified, although it contains the Early Vendian manganese-bearing level among the deposits of the Ar'yanshorskaya (Laptopaiskaya) suite, which contains carbonate-silicate ore deposits of the pebbled-aleurite-sand ore formation in the north of the Malopatoksky block (Nadezhdinsky ore deposit). In the described territory of the region of the Yany-Yankech Ridge, a submeridional band of 13 secondary local geochemical anomalies of manganese was identified with a content of 1–2% and a background of 0.05-0.1% within the productive Vendian level.

**Non-ferrous metals**

Only copper is widely used among nonferrous metals although no significant concentrations are found, and other metals are practically not shown, with the exception of poor polymetallic mineralization in the beresitized sediments of the Laptopaiskaya suite (Podgornoye).

**Copper.** Within the Mankhambovsky block, copper ore objects lie mostly in the rocks of the Sablegorskaya suite saturated with subvolcanic comagmatic rocks of basic and acidic composition. Mineralization of vein and stringer-porphyry mineralization, as a rule, are localized in metabasalts and controlled by small bodies and rhyolite dykes.

The most studied are the Talminskoye and Rechnoye ore occurrences. Previous researchers considered them as copper-sulfide ore occurrences. When performing GDP-200/2, we have not established tympomorphic signs of sulfide ore mineralization and, with a certain degree of conventionality, copper objects of the south of Lyapinskaya structural-formational zone can be referred to a copper-quartz-sulfide ore formation [6].

**Talminskoye** ore occurrence is located on the right bank of the Taltma river, 2.5 km below the outflow of the Tiltima river. Sulphide mineralization was found during geological and geophysical works in 1967–1969. The ore occurrence is composed of metavolcanogenic–terrigenous sediments of the Sablegorskaya suite, in which sericite-chlorite-albite-quartz schists participate in slatstone, less often in sandstones and in volcanics of acidic and basic composition. In shale rocks, carbonaceous material is often present in quantities of up to 5% or more. The shale rocks are intruded by small bodies of monzonites, diorites and alkali granosyenites (μξ) of the Manaragsko-Sivyaginsky complex (ν–μ–δV ms). Wells intersected a stringer-porphyry fine-grained ore mineralization in apoteric shales of chlorite-carbonate-sericite (muscovite)-albite-quartz, quartz-albite-chlorite-sericite, carbon-quartz-carbonate-albite-sericite composition. The ore-bearing zone is traced by boreholes and mine workings at 3000 m in the sub-meridional direction. Its width is up to 350 m. The main ore minerals are chalcopyrite and pyrite. There is pyrrhotite sporadically. Sphalerite, galena, arsenopyrite are observed in occasional particles. In addition to sulphides, sphen is present in the ore, and rutile is less common. The carbonic matter is evenly distributed over the rock in the form of small flakes. The content of Cu up to 0.73 %, Zn up to 0.15 %, Ag up to 9.75 ppm. In secondary dispersion outbreaks and sedentary debris of skarn-magnetite mineralization. From the surface, the dimensions of the outcrops of andradite skarns are the first tens of meters with the thickness of first meters. Mineral assemblage: magnetite, hematite; pyrite, galena, chalcopyrite are rarely observed. The iron content in the ores reaches 33%; gold was identified up to 0.2 ppm by assay test [3, 5].

The scarn-magnetite mineralization is widely used within the block; its traces are noted in relation to the Sivyaginsky, Sablegorsk-Laptoyskiy and Moroinsky magmatism.

**Chromium.** A large object is the Rechnoye ore occurrence on the left bank of the Talma river. Its ore deposit is located on the right bank of the Taltma river, 2.5 km below the outflow of the Tiltima river. Sulphide mineralization was found during geological and geophysical works in 1967–1969. The ore occurrence is composed of metavolcanogenic–terrigenous sediments of the Sablegorskaya suite, in which sericite-chlorite-albite-quartz schists participate in slatstone, less often in sandstones and in volcanics of acidic and basic composition. In shale rocks, carbonaceous material is often present in quantities of up to 5% or more. The shale rocks are intruded by small bodies of monzonites, diorites and alkali granosyenites (μξ) of the Manaragsko-Sivyaginsky complex (ν–μ–δV ms). Wells intersected a stringer-porphyry fine-grained ore mineralization in apoteric shales of chlorite-carbonate-sericite (muscovite)-albite-quartz, quartz-albite-chlorite-sericite, carbon-quartz-carbonate-albite-sericite composition. The ore-bearing zone is traced by boreholes and mine workings at 3000 m in the sub-meridional direction. Its width is up to 350 m. The main ore minerals are chalcopyrite and pyrite. There is pyrrhotite sporadically. Sphalerite, galena, arsenopyrite are observed in occasional particles. In addition to sulphides, sphen is present in the ore, and rutile is less common. The carbonic matter is evenly distributed over the rock in the form of small flakes. The content of Cu up to 0.73 %, Zn up to 0.15 %, Ag up to 9.75 ppm. In secondary dispersion outbreaks and sedentary debris of skarn-magnetite mineralization. From the surface, the dimensions of the outcrops of andradite skarns are the first tens of meters with the thickness of first meters. Mineral assemblage: magnetite, hematite; pyrite, galena, chalcopyrite are rarely observed. The iron content in the ores reaches 33%; gold was identified up to 0.2 ppm by assay test [3, 5].

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**Copper.** Within the Mankhambovsky block, copper ore objects lie mostly in the rocks of the Sablegorskaya suite saturated with subvolcanic comagmatic rocks of basic and acidic composition. Mineralization of vein and stringer-porphyry mineralization, as a rule, are localized in metabasalts and controlled by small bodies and rhyolite dykes.

The most studied are the Talminskoye and Rechnoye ore occurrences. Previous researchers considered them as copper-sulfide ore occurrences. When performing GDP-200/2, we have not established tympomorphic signs of sulfide ore mineralization and, with a certain degree of conventionality, copper objects of the south of Lyapinskaya structural-formational zone can be referred to a copper-quartz-sulfide ore formation [6].

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**Rechnoye** mineralization is located in the middle reaches of the Yany-Manya river, 1 km east of the outflow of the Huntynya river. Sulphide mineralization here was found during the core drilling in 1967. Mineralization is located in the meta-terrigenous rocks of the Moroinsky suite of the upper Riphean intruded by the Sablegorskaya subvolcanic formations of acidic and basic compositions. When carrying out the prognostic and exploration works in 2007–2009, several mineralized zones have been identified that are controlled by faults and localized at the contact of meta-terrigenous and meta-volcanic rocks. The length of the western zone is 2 km, the eastern zone is 4 km, the central zone is 1250 m, the width of the zones is from 150 to 400 m. The wells and ditches have revealed pyrite-carbonate-chlorite-micaceous metasomatites of the beresite formation with impregnation...
of sulfides. Together with pyrite, chalcopyrite, galena, sphalerite, and rarely chalcolite, bornite and barite in occasional particles are constantly present. Mineralization can be traced to a depth of 200 m or more. The content of Cu up to 0.9 %, Zn – up to 0.9 %, Ag – up to 6.5 ppm, Au – up to 0.14 ppm. The spectral analysis of channel sampling from metasomatites showed the content (%): Pb up to 0.18, Zn up to 0.04, Mo up to 0.001, Ag up to 2 ppm; In addition, increased concentrations of Ce (up to 0.1 %) peculiar to acid effusives of the Sablegorskaya suite have been determined. Hematite, pyrite, ilmenite, chromespinelides, rutile, sphene, zircon, occasional particles of sphalerite, galena and gold are noted in the black sand taken from the areas of beresite oxidation. Against the background of the polymetallic assemblage of minerals, a group of rare earth and rare metal minerals, orrite and tantalum niobates, is manifested. According to the results of the atomic-absorption material analysis, the content of gold in the samples taken from the outcrops of beresites manifestation was from 0.02 to 0.37 ppm.

**Noble metals**

**Gold.** A significant number of small gold ore objects (points of mineralization) is concentrated in the region of the fall of the Yangtump and Matum-Tahamtamya rivers to the Ioutynyu river. The largest of which is the manifestation of vein gold Yangtumpskoye. The loutyninsky gold-bearing placer is located in the valley of the loutynya river – the largest one in the considered territory as a placer production.

**The Yangtumpskoye** manifestation is located in the left side of the valley of the Matum-Tahamtamya river, 1.5 km above its outflow. It is associated with the formation of the Sableygorskaya formation, represented by the apobasal shale rocks of chlorite-epidote, chlorite-feldspar-epidote, mica-chlorite-feldspar composition. Strike of the rocks is submeridional, strata inclination is eastern and heavy. The rocks are largely quartz bearing, carbonatized and epidotized. Some small sub-concordant dykes of gabbrodolerites are developed. The ore zone is represented by three stockwork-like bands, composed of quartz, carbonate-quartz veins, and stringers. The veins are associated with phyllices and phyllitic shale rocks occurring accordant to foliation and bearing a slight impregnation of bornite. The most interesting is the eastern belt, where a quartz vein with a thickness of up to 9 m, traced at 50 m, is opened with ditches. Strike of the vein is submeridional, strata inclination is eastern and heavy. The vein is associated with the contact of porphyritic andesibasalts and chlorite-feldspar-epidote shale rocks and oriented at 20–30° to the schistose. There is a dispersed impregnation of chalcopyrite and pyrite (up to 1%); sometimes there are some runs up to 10 cm with a sulfide content of up to 40–50 %. Copper greens, malachite and azurite develop on the fissures and voids of rocks. According to the results of the chemical analysis of channel samples, the Au content is up to 0.2 ppm, Cu – up to 0.48 %. Sericite-albite-quartz, sericite-chlorite-albite-quartz schistose metasomatites of silver-light gray color, with a thickness of 5 to 35 m, penetrated by thin (10–20 cm) quartz veins, both concordant and counter ones. The gold content of one of the channel samples from the albic shale rocks according to the gold spectrometric analysis is 1 ppm, to the assay test – 0.4 ppm. Shale rocks differ somewhat increased radioactivity (9–11 µR/hr) from the surrounding rocks (3–4 µR/hr). The system of convergent counter feldspar-carbonate-quartz veins with a total thickness of about 1 m contains impregnation and schliers of chalcopyrite and pyrite. The gold content in the channel samples is 0.25–0.6 ppm [3].

When verifying the points of mineralization of gold and copper in the middle reaches of the Matum-Tahamtamya river the metasomatic zoning of the enclosing rocks was studied. It shows that mineralization is connected with rocks of the formation of quartz-sericite metasomatites formed from propylitized metabasalts. Some mineragraphic studies have established the presence of hematite, chalcolite, chalcopyrite in ore-bearing metasomatites; covellite, bornite, pyrite, native copper have been established by mineralogical analysis of the crushed sample. There is also one grain of gold.

The increased gold content is characteristic not only of the metabasalts but the metabulyrites of the Sableygorskaya formation as well. In the drill-hole cores drilled by the Berezovskoye exploring-and-producing enterprise in the area of Yatyra, there are some thin quartz, quartz-carbonate veins, and stringers with bornite and chalcopyrite in the metarhylites, as well as feldspar-quartz veins with galena. An increased gold content in veins was established by atomic-absorption material analysis – 0.13, 0.17 and 0.086 ppm [6].

Another group of congrever gold ore and copper-polymetallic features is in the wellhead part of the Pazyptaymskoye stream, the left-bank tributary of the lotynya river. Detailed works in this area called Pazyptaymskoye were also conducted in 1976–1981. We established the point of mineralization of gold within the boundaries of the section of ore occurrence of banded iron formations MAN-9. In the drill-hole cores C-68 drilled by the Berezovskoye exploring-and-producing enterprise, thin conformable counter sulfidized quartz veins and stringers have been established in magnetite mineralization of muscovite-quartz crystalline schists. Sulphides are represented by pyrite, chalcopyrite; molybdenite and tetrahedrite are noted in a subordinate quantity. We have established by spectral analysis the following: Cu – 1 %; Zn – 0.04 %; Mo – 0.001 %; Bi – 0.005 %; W – 0.003 %; Ag – 0.0002 %. The gold content, according to the results of the atomic-absorption material analysis, is 0.5 ppm; according to the assay test – 0.2 ppm. Apparently, the considered features of gold ore and copper-polymetallic mineralization belong to a single gold-sulphide-quartz vein formation.

The complex uranium mineralization of the eastern structure of the Mankhambo complex is characterized by a fairly high gold content, which confirms the point of view of S. S. Shcherbin about the prospects of conglomerates in relation to gold [9]. Thus, according to our data, in the sample of cement from conglomerates of Neivyestnaye ore occurrences, the content of noble metals is: Au – 6.06 ppm; Ag – 20.04 ppm with a content of U – 0.12 %; Th – 1.30 %; Bi – 180 ppm; Nb – 0.26 %; Ta – 0.018 %; Zr – 0.7 %; Ce – 0.187 %; Y – 0.059 %; La – 0.18 %; ZTR – 0.8 %. In the course of works on studying the manifestations of uranium mineralization, some employees of OAO “UGSE” also established gold in the amount of up to 4.9 ppm in individual samples from uranium-bearing conglomerates and gravels of the areas of Turman, Paryaur, and Neizvestny.

**Silver.** Elevated concentrations of silver (up to 10 ppm) are noted in quartz veins in the Yangtump area and in the zones of sulfide mineralization of the loutynya copper occurrence, as well as in a number of mineralization points of gold in the upstream of the Matum-Tahamtamya river. According to the results of the mineralogical analysis of the crushed sample from the quartz vein, there are some iron-silver-copper formations – isometric grains or close to them with pseudoaxagonal outlines resembling the shape of pyrite crystals (pentagonal dodecahedron with a cube). Their size is 0.2–0.6 mm. We have established by spectral analysis the following elements: basic – Cu, Ag, Fe; impurities – Zn, Mn, Cd, Al, Ba, Ca, Mg, Si.

A high content of silver was established in complex uranium ore of the ore occurrence of Turman and the Paleodolinny area (manifestations of Paryaur and Neizvestnaya). Thus, in the trough-like structures of the first area and in the shallow-dipping ore zones of the second one, there is the presence of silver in the amount of 0.5 to 190 ppm according to X-ray spectroscopic analysis of core samples. The mineralogical analysis of ores includes argenteite and proustite.

**Platinum.** Platinum together with gold is found in alluvial placers of the main rivers and their tributaries. The average gradient factor is 0.365 mm. In the loutyninskaya placer of the Pazyptynmskoy area, platinum is contained in an amount of 1.4 % of the total amount with gold. Its color is usually steel-gray with thin flaky and lumpy form; rounding is mostly good. It is represented by palladic platinum and osmiridium, as far as the content of impurities is concerned (according to the spectral analysis).

The high content of platinoinds in uranium ores was first established by our investigations. According to the results of the quantitative analysis (ICP MS), using the cement of ore conglomerates (radioactivity is 800 μR/h) of Neizvestnaya manifestations with a content of U – 0.12 % and Th – 1.30 %, the content of platinum group metal (PGM) was: Pt – 8.44 ppm, Ir – 5.11 ppm [6]. Close concentrations of platinum group metals were established during the prognostic and exploration works of OAO "UGSE" in the Verkhnelenskaya area. In complex uranium ores of the Turman and the Paleodolinny area (manifestations of Paryaur, Neizvestnaya), the content of platinum group metals was: Ir – from 4.6 to 40, Os – from 1.5 to 29 ppm, Ru – from 1–2 to 50–123 ppm, Ro – from 1.3 to 2.5–10 g/ t. Pt – up to 13 ppm is rarer in the ores [2, 6, 10].

**Rare metals, traced and rare-earth elements.**

Rare metals including niobium, tantalum, beryllium, zirconium, and rare-earth elements in complex with uranium and thorium are widely developed within the Mankhambovskaya structure and are represented by ore occurrences Neizvestnaya, Paryaur, Yuzhnoe, Ukyu, Bolshaya Turupya, and others.

**Tantalum, niobium.** The largest feature of these metals is the ore occurrence Bolshaya Turupya located in the interstream area of the Turupya and Tujahlanty rivers. The pay streak is about 650 m wide extends in the meridional direction by more than 6 km. It was revealed by the polar airplane of the Shabrovskaya expedition in 1955 based on the results of the radiometric survey. It consists of three anomalies associated with the Sobsko-Salatimskaya activated suture zone (Fig. 2), along which narrow tectonic plates of Paleozoic rocks were formed. Radioactive anomalies and secondary dispersion halos (Be, Sn, Nb – 0.01 %, Y – 0.02 %, Z – 0.1 %) trace the zones of alkaline metasomatites with columbite, pyrochlore, bastnashite, orthite, zircon, genthelvite, eucalise, phencatie, and fluoride (grain size is 0.07–1.2 mm), and alkaline-carbonate metasomatites with apatite and fluorite. The age of muscovite from rare-metal micaceous metasomatites was determined from the K–Ar isochronopach at 330–320 Ma, which corresponds to the Middle Carboniferous period, and the age of the carbonate metasomatism – Medium-Late Triassic epoch [11]. The manifestation revealed seven sheet-like bodies localized in the cores of anticlinal folds of high orders. Mineralization is bedded on intensely altered mica-feldspar-quartz schists (metataniates). When carrying out GDP-200/2, some mineralogical-geochemical features were studied in detail (P. L. Burmako, A. A. Baki-lina). These are the features of manifestations of the Bolshaya Turupya, the wallrock metasomatites of which correspond to the eisite and qualmite formations [2].

The former is characterized by the formation at late stages of development of the areas in the zones of deep faults, in felsic rocks and intermediate acidity rocks. Their formation is expressed by the wide development of processes of albitization, carbonatization, and chloritization. Ore minerals occur in the form of fine impregnations and micro-stringers. A characteristic sign of eisitization is the appearance of brownish-red coloration of rocks, due to the presence of finely dispersed hematite and uranium mineralization, and in the intermediate zones – apple-green, associated with hydromica formation. The development of processes of apatite mineralization and fluorsparization is typical for intermediate zones.

At the same time, crystallization of tantalum-niobiumates requires higher temperatures. The occurrence of higher-temperature processes preceding the eisitization is indicated by the presence of a long-prismatic zircon predominated in the rocks of the inner zone. Due to a combination of all mineralogical and geochemical data, the early metasomatites preceding the eisites are referred to the quartz-albite-microcline (qualmite) metasomatic formation. It is with this formation that rare metal ore mineralization is associated. The following facts serve as signs of quarmites. In all metasomatic zones, the presence of relics of microcline, which is replaced by albite, was established. Sericitization of sodium-calcium feldspar is widely developed with the formation of deutericgenic soda feldspar. Impregnation of calcite is associated with chlorite-sericite and quartz-albite packs and is located evenly in them. For the rocks of the intermediate zone, a characteristic addition of K, Mg, Ca, Al and H atoms is established, for the inner zone, Mn, Na, Fe and Ca are introduced. The geochemical specialization focused on rare metals (Ta, Nb, Zr, Sn, Be), as well as typical high-temperature minerals indicate the presence of qualmite formation. In determining the correlation dependence, a significant relation was established between the main ore elements – Nb, Zr, Sn, Be, with a content of U – 0.12 % and Th – 1.30 % trace the zones of alkaline metasomatites with columbite, pyrochlore, bastnashite, orthite, zircon, genthelvite, eucalise, phenacie and euclase [2, 12].
Regarding the mineragenic type of tantalum-niobium mineralization, there is no single point of view. S. G. Karachentsev and E. G. Negurica considered the Turupynsky metasomatites as rare metal albitites comparing them with the Polar Urals ones (Taikeuskoye). A. V. Kalinovsky identifies alkaline metasomatites – albitites and alkaline-carbonate –carbonatites? and, taking into account their connection with the Turupynsky ring structure, considers the mineralization to be closer to carbonatites with the features of both groups of formations. According to the latest published data [12–14], isotopic-sedimentary (Rb–Sr, Sm–Nd) and geochemical (REE, Ba, Sr, etc.) studies of rocks as well as microprobe analyzes of ores unambiguously reject the carbonatite nature of metasomatites and indicate on the connection of the mineralized zones of the Turupynsky manifestation with albitized and sericitic schists (metariolites), and not with carbonate rocks. On the basis of these materials, as well as the results of our own research given above in the description of ore manifestation, rare metal mineralization refers to a rare-earth–rare metal uranium–carbonate formation in alkaline metasomatites [2]. They are close to the rare metal object described above but smaller in importance (not studied); they are established in several places within the Mankhambovsky block and are mainly associated with dykes and small bodies of trachyriolites and granosyenites. The latter intrude the Riphean–Vendian section and are accompanied by metasomatites of the qualmite and sodic alteration formations. In the region of outflows of the Watla, Taltma, Tol'ya, Yatya rivers, the tributaries of the Ponya, Huntynya, Nyartsyuyu rivers and others (Table 2). The rare-metal–rare-earth mineralization in connection with the apogranities is manifested only within Mankhambovsky and Ilyaizsky massifs, the ore-bearing magma complex of which is the Salnersky granite-leucogranite complex of the Vendian–Early Cambrian. The characteristics of the objects are given in Table 3.

**Radioactive elements**

Uranium, thorium. Uranium, in association with thorium, rare and rare-earth metals, is the leading mineral in the Mankhambovsky block; about 20 its objects of different sizes are established here (Fig. 2).

### Table 2. Characteristics of ore objects in connection with small bodies of trachyriolites.

<table>
<thead>
<tr>
<th>Name of the object</th>
<th>Ore-hosting rocks, complex, metasomatites</th>
<th>The content of ore elements, %; radioactivity, µR/hr</th>
<th>The main minerals of ores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Nyatsyuyu (western, eastern)</td>
<td>Quartz porphyry; Laptopaysky</td>
<td>STEX – 0.01 – 0.06 to 0.1 – 0.25; ( Ta_2O_5 ) – 0.005</td>
<td>Scheelite, chernovite, orthite, zircon, rutile, sphen</td>
</tr>
<tr>
<td>Nyatsyuyu II</td>
<td>Riolites, trachyriolites, (qualmites?); Sabegorsky</td>
<td>Nb, O, – 0.001 to 0.018; STEX – 0.002–0.007 to 0.02 chemical analysis 0.002–0.006 to 0.2; U – 0.001</td>
<td>Monazite, thorites, chalcopyrite, chalcosine</td>
</tr>
<tr>
<td>Verkhnetaltminkoe</td>
<td>Riolites, trachyriolites (qualmites); Laptopaysky</td>
<td>Nb – 0.1; Ta v 0.0014; Zr – 0.03; U – 8 ppm; Th-30 ppm</td>
<td>Fluorite, wolframite, fergusonite, zircon, orthite, titanic iron ore, aikinite, chalcopyrite</td>
</tr>
<tr>
<td>Huntynya</td>
<td>Trachyriolites; Ponyizsky</td>
<td>Nb – 0.05; Ce – 0.02; Y – 0.006; Zr – 0.1; Ba – 0.9; Au – 0.16–0.33 ppm</td>
<td>Xenotime, tantalito-niobates, euxenite, polycrase, hematite, zircon, pyrochlore, monazite, chalcopyrite</td>
</tr>
<tr>
<td>The source of the Bol. Turupya</td>
<td>Granosyenites, rhyolites (qualmites); Ponyizsky</td>
<td>Ta – 0.001; Ce – 0.01; Sn – 0.002; Pb – 0.01; Au – 8 ppm;</td>
<td>Pyrochlore, zircon, fersmite, chevkinite</td>
</tr>
<tr>
<td>Vatkinskoe</td>
<td>Rhyolites, qualmites; Ponyizsky</td>
<td>Nb2O5 – 0.01; Y – 0.024; Ta2O5 – 0.003</td>
<td>Tantalito-niobates, fluorite</td>
</tr>
</tbody>
</table>

### Table 3. Characteristics of ore objects of the endo-exocontact part of the Mankhambo massif.

<table>
<thead>
<tr>
<th>Name of the object</th>
<th>Ore-hosting rocks, formation, complex</th>
<th>The content of ore elements, %; radioactivity, µR/hr</th>
<th>The main minerals of ores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shchugorskoye</td>
<td>Granites (albitites), Salnersky</td>
<td>( Ta_2O_5 ) – 0.005, ( Nb_2O_5 ) – 0.01–0.12; 60 µR/hr</td>
<td>Orthite, zircon, fluorite, apatite, hematite</td>
</tr>
<tr>
<td>Tol'ya</td>
<td>Cataclasped granites, greisenization, Salnersky</td>
<td>( Ta_2O_5 ) – 0.005–0.01; ( Nb_2O_5 ) – 0.005–0.02, STEX 0.005–0.03; ( 60 µR/hr</td>
<td>Orthite, zircon, fluorite, apatite, hematite</td>
</tr>
<tr>
<td>Zapadnoye</td>
<td>Cataclasped granites, greisenization, Salnersky</td>
<td>( Ta_2O_5 ) – 0.003, ( Nb_2O_5 ) – 0.009, ( 50 µR/hr</td>
<td>Orthite, zircon, fluorite</td>
</tr>
<tr>
<td>Shchugorskoye II</td>
<td>Leucocratic cataclasped granites, albitization, greysenization, Salnersky</td>
<td>U = 0.019–0.076, Th = 0.376–1.5, Th / U–20; 760–1530 µR/hr</td>
<td>Fluorite, thorite, orthite, monazite, zircon, hematite, U-containing magnetite, molybdenite, fergusonite, sphen</td>
</tr>
<tr>
<td>Otverzhennoye (Turinskoye)</td>
<td>Granite-porphry cataclasped, beresitization, Salnersky</td>
<td>U = 0.082–0.129, Ti to 1.0, Pb to 0.01, Zn to 0.02, Mn to 0.18, Hf to 0.02; 200–1000 µR/hr</td>
<td>Uranotorite, fluorite, galena, monazite, sphen</td>
</tr>
<tr>
<td>Pon'izskoe I</td>
<td>Leucogranites, albitites, beresites</td>
<td>Y – 0.05; Zr – 0.08; Ce – 0.01; Au – 0.05 ppm</td>
<td>Xenotime, orthite, zircon, fluorite, sphen, octahedrite, tourmaline</td>
</tr>
</tbody>
</table>
According to the conditions of formation and peculiarities of uranium-rare metal mineralization, three ore formations are distinguished: 1) uranium polygenic formation in unconformity zones localized in the frame of the Mankhambo block in terrigenous rocks of the base of the Hobeinskaya suite (RF.), 2) uranium beryozit magnatic – hydrothermal volcanogenic in the rhyolites of the Sablegorskaya and Riphean-Vendian Laptopayskaya suites; 3) formation of uranium-bearing peatlands – modern exogenous infiltration formation in mosses, peatlands and covering loams [2].

Uranium-rare metal objects are distributed unevenly across the territory. Most of them (Neizvestnoye, Paryaur, Severnoye, Turman, Uzohnoye) are associated with the eastern exocotact of the Mankhambovsky granite massif. The other group is located in the southern near-contact zone (Khapkhkartuittump, Ukyu, Zapadnoye, Uzhnoye II). The uranium group (Perchuk I, II, Mokhovoye I, II, Maldizskoye) was found in the remote endocotact and inside the massif (surface type). The uranium beryozit group is located in the north (Redka I, II) and in the south (Matumskoye) from the Mankhambovsky pluton within the unified Kulemskorsk-Mankhambovskaya suture zone, which is an activated area of structural-stratigraphic unconformity (SSU) identified by us [2, 6], as well as tracing uranium, uranium-rare metal, uranium-rare earth-rare metal mineralization within the Lyapinsky megablock.

The northern part of the ore zone is located in the upstream of the Shchugor and Tol’ya rivers and includes ore occurrences and mineralization points of the Neizvestnoye, Paryaur and Severny. Neizvestnoye and Paryaur occurrences have been studied in the process of prognostic and exploration works for uranium in 2007–2009 within the boundaries of the detailed Paleodolinn section.

Neizvestnoye occurrence is in the sources of the Parya river on the eastern slope of Tol’ya-Atol’yassahal (Fig. 4). The horizon of conglomerates, breccia-conglomerate and quartzite sandstones of the Hobeinskaya suite (RF.) lies at the base of the section of the ore-bearing stratum with a thickness of 3–10 m, in the section of which there are concordant mylonitization zone and cataclas with a thickness of 5–15 m and bedded. According to gamma ray logging data, the zone of anomalous radioactivity (100–2800 µR/hr) is fixed at the contact of the unconformity of rocks and at the base of the section from brecciated conglomerates, conglomerate breccias and quartzite sandstones. The thickness of the zone is from 1 to 6 m. Silica-alumina rock alterations are spatially associated with the ore zone including silification, carbonatization, pyritization, chloritization and epigenetic oxidation. At depths of 40–90 m, from one to three converged ore intervals are established into the ore deposit Severnaya II with a content of U 0.014–0.069 % for thickness from 0.5 to 1.6 m, Th – 0.13–0.41 % at Th/U 3.5–10.3. There are uranium-containing thorite-orange, zinc, andrite, rutile, sphen, etc. in the ores composition. The dip of the ore zones to the northeast at 30°–40°.

The potential width of the ore deposit of Severnaya II to a depth of 300 m is about 500 m, the length is more than 2.5 km [2, 10].
Paryaur manifestation is located in the upstream of the left tributary of the Parya river at the S86 2 m elevation. An anomalous band of 1.4 km in length is established in exocotact of the granite massif of Mankhambo and is outlined by pits, ditches and verified by the profiles of wildcat wells. Two narrower (with a width of 50–50 m) anomalous zones are outlined by ditches to the south in endocotact of granites. The thickness of the deposits is 1–50 m, the radioactivity is 50–300 µR/hr. The content of ores: magnetite, uranium-containing zircon, thorite, sphen, fluorite, titanite, iron ore, rutile, tourmaline. The content of U is 0.01–0.02 %, Th is 0.06–1.2 %, Th/U is 3–6 [10]. Three sheet-like ore bodies are distinguished in the section. The first (lower) is outlined by a dip of 300 m to a depth of 160 m and is associated with the horizon of brecciated gravelite quartzite sandstones with a thickness of 2–4 m. The content of U 0.01–0.032 % (mean 0.024 %), Th – 0.04–0.19 % (mean 0.139 %) for thickness from 0.5 to 6.9 m (average 2.5 m) at Th/U about 6. The other two (middle and upper ones) are associated with the horizons of brecciated gravelly quartzite sandstones in the depth intervals of 56–78 and 125–145 m. The average content of uranium in them is 0.018–0.017 %, Th is 0.1–0.14 % for thickness of 1.1–0.3 m, respectively. The occurrence of ore bodies is shallow (25–35°). Both bodies united in the ore deposit Severnaya I, are accompanied by the manifestation of high-temperature siliciclastic-alumina metasomatic changes (silification, K-feldsparization, albitization, fluoritization, hematitization, etc.) developing from the granite basement to the lower part of the ore-bearing pack of gravelly quartzite sandstones. The processes of low-temperature hydrothermal changes (silification, carbonatization, chloritization with boronite, calcopyrite, molybdenite) are manifested in the upper part of the section of the ore-bearing strata and along the overlying shale rocks. These processes are also noted in the lower part of the section of the ore-bearing strata near the contacts of the bedded dolerite dyke, where large (up to 2–3 cm) pocket segregations of molybdenite, calcopyrite, platy hematite are fixed.

The western part of the lateral ore reserves is represented by a series of converged ore bodies shallow dipping (20°) at a depth of 15 to 50 m. They are localized in the fault zone at the base of section of the gravelly quartzite sandstones and are accompanied by siliciclastic-alumina rock alterations with the addition of potassium. The content of U is 0.01–0.032% for thickness of 0.5–3.4 m with a content of Th 0.03–0.11 % and Th/U of 3–3.4. To the west, near the large sub-meridional fault, the thickness of the ore deposit increases to 22–30 m, the content of U, according to the data of channel sampling, is 0.015–0.02 % at thickness of 0.5 m and concentration of Th 0.07–0.12 % and Th/U ~ 6. On the western pinch, the ore deposit is outlined on the strike along a high-dipping tectonic disturbance to the north at 1.100 m. It is associated with the brecciation zone developed at the base of the horizon of gravelly quartzite sandstones. The thickness of ore deposit is 5–10 m, the content of U is 0.02 %, Th is 0.12 %, Th/U ~ 6. The total length of Severnaya I ore deposit is more than 5 km [10].

The Severnaya mineralization was discovered in 1962 by N’yaskaya PSP and was considered as a detailed area Turman Severn [6]. The ore deposit Tsentralnaya I was established in this area and studied to a depth of 350 m by exploratory wells drilled at a pitch of 50–100 m. The deposit is associated with a trough-like structure formed at the intersection of deep faults of the sublatitudinal, northern submeridional orientations at the place of sharp rotation of the structural and stratigraphic unconformity zone from the northwest to the sublatitudinal direction.

The size of this structure is 500 m in width, about 2 km in length north to its intersection by a deep fault of the northwest orientation and subvolcanic intrusion of gabbrodolerites. The deposit is outlined and localized at the base of thick (up to 120 m) terrigenous stratum of the Hobeinskaya suite. Its dip is at angles of 40°–50° to the northeast, according to the tectonically rejuvenated contact of granites and the surface of the structural and stratigraphic unconformity. The thickness of the ore deposit varies from 22.7 to 18.7 m with an average content of U – 0.013–0.044 %, Th – 0.068–0.14 % with a thickness of ore intervals of 2.2 to...
7.7 m. Separate ore intervals and ore deposits are generally associated with numerous bedded zones of cataclasis, brecciation, and fracturing in gravelly quartzite sandstones. These intervals, as a rule, are enriched with cataclasized crushed debris of bluish-gray quartz. Some thin veins of potassium feldspar, green muscovite, fluorite, and ore (ilmenite, hematite, titanomagnetite) are localized on the fissures in the zones of the cataclasis and around the crushed debris. The ore deposit is outlined by a dip of 400 m (to a depth of 300 m) and is not delineated. The mineralization productivity with depth significantly increases including U from 0.0295 to 0.0823 m.

The central part of the Mankhambovskaya ore zone is the mineralizations of Turman, Yuzhnoe and Yuzhnoe I (Fig. 4).

Figure 4. Geological map of the eastern frame of the Mankhambo massif (prepared by V. A. Dushin).

Рисунок 4. Геологическая карта восточного обрамления массива Маньхамбо (составил В. А. Душин).
The ore deposit Tsentralknaya II is associated with the series of converged trough-like structures separated into some isolated blocks by a series of tectonic disturbances of the submeridional orientation. The deposit is localized in the lower part of the section of the ore-bearing strata, in conglomerate-breccia, gravels, and gravelly quartzite sandstones. It has a medium pitch of 30°–50° to the northeast, concurrent with the tectonically rejuvenated contact of granites and unconformity surface. The thickness varies from 3 to 15.9 m, the average uranium content is 0.012–0.026 %, Th is 0.18–0.089 % (at Th/U 3.4–15). In general, the Tsentralknaya-II ore deposit can be outlined for a distance of 4.5 km. Distribution of mineralization along the vertical is about 200 m.

The ore deposits Yuzhnaya is outlined by ditches and pits. The intensity of radioactivity in them varies from 50 to 2800 µR/hr. The width of the ore intervals is from 1 to 30 m. The deposit includes three uranium-thorium-ore bodies. Mineralization is usually located at the contact of gravels and quartzite sandstones with granites and shale rocks, but is also noted in the middle and upper part of the section of the ore-hosting strata. Ores are bedded with thorite, uranium and thorium-containing ilmenorutil, zircon, tantaloniobates. The character of radioactivity is predominantly mixed, although lower values of Th/U are noted (up to 1 or less).

The Yuzhnaya and Yuzhnaya I mineralizations are located in the upstreams of the Nyays and Mannyays rivers. The Yuzhnaya mineralization is located in the north of the section, in the valley of the left nameless tributary of the Nyays river, Yuzhnaya I – in the south, in the valley of the Mannyays river (Figure 4). When estimating the section in a 8.2 km long and a width of 2 to 9 m, a series of thin lenses (from several centimeters to several meters) and vein-like bodies with rare metal mineralization are established. They have length from 100 m to several kilometers separated by ore-free intervals. In the conglomerates (pseudoconglomerates), gravels, and less frequently in quartzite sandstone, there is an impregnation of thorite, orthite, uranorotite, hauetteite, uranium-containing zircon, titanite iron ore, ilmenorutil, magnetite, titanomagnetite and secondary minerals: otenite, uranocircite, limonite, associated with the base of the section. In this case, the tectonized contact with elements of weathering crust is fixed here. Quartz-feldspar rocks contain sercite, muscovite, biotite, chlorite, apatite, sphen, touralmine, epidote. According to the composition of elements, two types of mineralization are distinguished: uranium-thorium-zirconium and uranium-tantalium-niobium-rare earth. In the quartz-bearing, faulted and folded schists, there is a rich vein orthite mineralization. The U content is 0.03–0.32 %, Th is 0.11–4.4 % (chemical analysis). The secular equilibrium coefficient is from 75 to 131 %. In the technological sample, the content: %: U – 0.36, Th – 4.9, Ta₂O₅ – 0.03, Nb₂O₅ – 0.3, ZrO₂ – 0.96, ΣTR₂O₅ – 3.95. Two midge wells were drilled in the north of the Yuzhnaya mineralization, which blocked out the ore zone up to 5 m in thickness at a depth of 50 m. It is represented by a series of ore veins up to 5–8 mm in thickness and veinlet-impregnated ore in a cement of conglomerates with gamma logging up to 6,000 µR/hr. The exploring shaft of a large section laid here, has been passed to a depth of 7 m. Quartzites with thin beddings of quartz gravel characterized by radioactivity up to several thousand µR/hr, have been opened in the broken ground interval with the exploring shaft. Three samples from an interval of 1 to 5 m, mainly in gravellite quartzites, are characterized by the following content of useful components: %: U = 0.01–0.04, Th = 0.08–0.46, ΣTR₂O₅ – 3.95.

### Table 4. Geochemical spectrum of ore occurrences of Neizvestnoye, Yuzhnoye (ICP MS, ppm).

<table>
<thead>
<tr>
<th>Element</th>
<th>Neizvestnoye</th>
<th>Yuzhnoye</th>
<th>Ukyu</th>
<th>Element</th>
<th>Neizvestnoye</th>
<th>Yuzhnoye</th>
<th>Ukyu</th>
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<tr>
<td>Li</td>
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<td>6315.1</td>
<td>1797.0</td>
<td>Ba</td>
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<td>Mn</td>
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<td>1116.6</td>
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<tr>
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<td>Tb</td>
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<td>19.8</td>
<td>1.6</td>
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<td>0.2</td>
<td>Dy</td>
<td>70.6</td>
<td>109.2</td>
<td>11.7</td>
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<td>Th</td>
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<td>9334.6</td>
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<td>Ho</td>
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<td>3.6</td>
<td>Er</td>
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</table>
The correlation analysis showed a strong connection between radioactive and rare elements in ores, as well as a weak but significant dependence of titanium oxide and rare earths. Obviously, the genetic relationship with titanium is poorly expressed in the rare earths of the yttrium group

\[ \text{La/Yb} = 8.65 \text{–} 8.96 \]

and rare earths. Concentration, %: U is up to 0.019, Th is up to 0.18, Ta,O₅ is 0.002–0.01, Nb₂O₅ is 0.017–0.11, ZrO₂ is 0.05–0.3, by 7.3 km with a width of 100 m in the north and to 50 m in the south. The ores are characterized by a high content of Ta, Nb, and Nb₂O₅ is 0.005–0.1, ZrO₂ is up to 0.24. The content of silver in conglomerates is up to 6.1 ppm. The main minerals-carriers of tantalum and niobium are ilmenite and rutile; rare earths are found mainly in the orphite, which has intergrowth with titanite iron ore, zircon, muscovite and sometimes quartz. Uranium and thorium, most likely, are present in the form of isomorphic impurities in ilmenorutilis, titanite iron ore, and zirconas.

The mineralization of Khapharthuytum was found in 1963 and is located 2.5 km to the north-west of Yana-Khaphartuytum (Fig. 2). The section of mineralization is located in the southeastern exocontact of the Mankhambo granite massif and is stroked by a narrow band in the meridional direction for 4.5 km. It has sedimentary-metamorphic rocks of the Hobeinskaya suite intruded by small-sized stock-like intrusions of microcline medium- and fine-grained granites of the Salmersky complex and dykes of the Moroinsky amphibolitized gabbrodroblertites. The rocks as a whole have a heavy eastern monoclinal dip and have folds complicated by disjunctive faults of the meridional and sublateral directions. In conglomerates and quartzites, poor mineralization is noted. Along the strike, the mineralization is outlined for 1.5 km, the thickness of the zone is 20–30 m. Radioactivity of mineralized rocks in the range of 40–70 µR/hr, at occasional points – 160 µR/hr. The character of the anomalies is uranium-thorium one. Content of useful components, %: U is up to 0.018, Th is 0.006–0.074, ΣTR₂O₅ is 0.005–0.19, Ta₂O₅ is 0.003–0.005, Nb₂O₅ is 0.005–0.1, ZrO₂ is up to 0.24. The content of silver in conglomerates is up to 6.1 ppm. The main minerals-carriers of tantalum and niobium are ilmenite and rutile; rare earths are found mainly in the orphite, which has intergrowth with titanite iron ore, zircon, muscovite and sometimes quartz. Uranium and thorium, most likely, are present in the form of isomorphic impurities in ilmenorutilis, titanite iron ore, and zirconas.

Uranium beresite formation in the volcanic rocks is represented by several objects in the ore mineralizations. This is a large mineralization of Redka I and a number of smaller ones Redka II, Leptaiiskoye, Podcheremskoye, Telpoyskoye, accompanied by a large number of mineralization points and radioactive anomalies that are developed both in the northern part of the Kulemshorsko-Mankhambovskaya zone and in the southern part. All of them are due to the occurrence of trachyriolites and rhyolites of the Sablegorskaya, Laptaybskaya and Bolshepatokskaya subvolcanic complexes (Fig. 2).

The Redka I mineralization is located in the southeastern slope of the mountain of the same name (the source of the Podcherem river) and was found during the wide-scale searches in 1964 by Ponyinskaya and Vorkutinskaya expedition [6]. It is associated with the Podcheremskaya Vendian–Early Cambrian paleo-volcanic structure of the central type injected with dolerite-trachyriolite magmatism of the Sablegorskaya, Laptaybskaya and Bolshepatokskaya complexes. The ore zone with a radioactivity of 45–125 µR/hr (with two maximum values of 700–2500 µR/hr) is connected with the endocontact of schistose and ferralugizined trachyriolites, which have a visible thickness of 350–400 m. The zone is outlined along the strike for 6.2 km in the north-west direction and dips to the south-west at 45°–70°. In the eastern endocontact of the intrusion a whole series of converged schistose zones with a thickness of 5 to 30 m is established, along which the rocks are metasomatically transformed including hematitized,
pyritized and carbonatized. The uranium content ranges from 0.03 % to 3.4 m; in the exposure of the Rudny stream to 0.075 % for thickness of 0.45 m, including 2.305 % for thickness of 0.15 m. There were found 14 uranium-bearing echelon-like veins with a length of 12 to 70 m at thickness of 0.5–5.5 m with uranium content of 0.03–0.05 % and higher. Mineralization is represented by uranite, secondary minerals – curite and kazolite. Titanite, iron ore, fluorapatite, titanite, manganooilmenite, zircon, orthite, monazite, magnetite, pyrite, hematite, chalcopryite, galena, molybdenite, sphalerite, and wulfenite are also found in the ores. The most widespread are bornite, covellite, malachite, cerussite, gummite among secondary minerals. Based on the results of the semi-quantitative analysis, the following contents are estimated in ores, %: Cu – 0.2, Pb – 0.2, Ag – 0.001, Mo – 0.01, Nb – 0.007, Zr – 0.03, U – 0.1, Y – 0.01. According to ICP MS, %: Cu – 0.3, Pb – 0.04, Ag – 0.001, Mo – 0.008, Nb – 0.005, Zr – 0.05, U – 0.04, ∑TR – 0.03. The metasomatice core corresponds to the bersite formation, the calculation of its substance budget shows that the formation of polymetalytic mineralization is associated with the stage of acid leaching in the outer zones, whereas the formation of uranium and rare metal mineralization occurred at the late alkaline stage in the interior zones of the core [2].

The southern part of the Kulemskorsko-Mankhambovskaya zone within the Matumskaia paleovolcanic structure is potentially promising for the uranium bersite ore formation, as evidenced by two radiometric anomalies, the concentrate stream of rare earth minerals, etc. Lithochemical anomalies of rare metals. Some radioactive anomalies are identified in the valley of the Matum-Takhamtamyia river. The rhyolites of the Laptapysky complex here are distinguished by increased radioactivity (up to 30 μR/hr) and more. Two anomalous zones with separate radioactivity points are established up to 224 μR/hr. Anomalies are associated with zones of schistose, kaolinization, fluorcarbonization, and barytization. The thickness of anomalous intervals along the ditches is 0.2–1.0 m, the length is the first meters. The content of U – 0.012 % in the crashed samples have been established barite, galena, pyrite, magnetite, ilmenite, hematite, rutile, zircon, leucoxene.

The development of modern infiltration concentrations of uranium in peat-mud deposits of surface watercourses (surface type according to the IAEA classification) is typical for the Mankhambovskaya area. These are the occurrences of Maldizskoye, Perchuk II, Perchuk I point of mineralization and a number of radioactive anomalies (Fig. 2, 4).

The occurrence of Maldizskoye was discovered by the Khulinsky airborne geophysical expedition of the Tyumen State University in 1962. It is located in the upstreams of the Pyrsy river. The site of occurrence is near the zone of the northeastern fault with medium-grained, partially albitized granites, intruded by small bodies of leucocratic granites. The group of 12 point halos with a radioactivity of 100 to 1700 μR/hr associated with shallow watercourses was established in the occurrence. The width of the anomalous watercourses is 150–200 m at a width of up to 1.5 m, rarely up to 10–15 m. The highest radioactivity up to 880 μR/hr has a water-out layer of loam soil with vegetable earth at a depth of 25–30 cm. The content of U in the samples of weak material with vegetable earth is 0.03–0.092 % according to the chemical analysis and 0.026 % according to luminescent-pearl [2, 6].

The occurrence of Perchuk II is located in the valley of the Padei stream and represent a radioactive anomaly in groundwater similar to the Maldizskoye. The occurrence was open by the Ilychskaya airborne geophysical group of the Vorkutinskaya geologi survey expedition in 1964. The section of occurrence has coarse-grained cataclasized two-mica granites. Granites have a cover of soft quaternary sediments represented by loams with fragments of granites. In the central part of the section, there is a tectonic disturbance of the submeridional strike in the form of mylonitization with a width of 6 m. Peatlands are also developed here. Two radioactive halos with dimensions of 100 × 130 and 50 × 35 m with a radioactivity of up to 372 μR/h are established, which are associated with water from freshets in the area of their sources. The radon anomaly (no thoron) 300 × 300 m is installed in water in size with a maximum concentration of 1392 Em. The content of U in soft sediments is 0.005–0.16 %, according to the data of the radiation analysis, and 0.002–0.023 % according to the luminescent-pearl analysis. It is also established, %: Y – 0.005–1.0, Mo – 0.0005–0.003, Zr – 0.005–0.02, V – 0.001–0.01, Pb – 0.0003, Ga – 0.0005–0.005, Cu – 0.001 [6].

The Perchuk I point of mineralization is located in the south, in the sources of the Yidzhid-Parus-Yol stream and has similar characteristics.

S. S. Shcherbin described the anomaly called “Mokhovaya” located 2 km to the west of the Paryaur and Neizvestnye occurrences, in the sources of the Lagerny stream (left tributary of the Parya river). Here some radioactive anomalies in mosses are fixed. In the samples from radioactive mosses, the anomalous content of U, Th, Mo, TR, Be is determined. In terms of dry matter, the U content was, %: 0.01–0.61, Th – up to 0.03, ∑TR, O – 0.05–0.86 (Fig. 4). The analogous anomaly (No 14 G [2, 6]) associated with the contact of granites and sandstones was established in the Turman Tsentralsky section within the generalized contour [15]. The maximum width of the anomaly is 80 m, the activity is up to 450 μR/h. The gray-colored alluvial deposits with pebbles of various types – quartzite sandstones, slate rocks, and granites covered with peat-mud deposits up to 1 m thick. X-ray spectral analysis has shown the maximum content of U – 0.4913 % with an insignificant content of Th – up to 0.0019 % associated with peat-mud deposits. In gray-colored alluvial deposits, there is also a high content of U – 0.017 % with Th concentration of 0.0012 %. The average-weighted content of U is 0.2337 % for a thickness of 1.2 m. The type of the anomaly is essentially uranium one. A peculiar “mossy” anomaly of radioactivity was established by us in the upstream of the Shchugor river (Mokhovoye II). The anomaly is outlined along the contour at 50 μR/h and has dimensions of 15 × 30 m with an epicenter of 100 μR/h on the surface. The opening of the epicenter at a depth of 60 cm showed a radioactivity of about 1800 μR/h, which was outlined along the contour of 1000 μR/h to a depth of 1.2 m, to the permafrost level [6]. The black peat with a low-observable structure and characteristic odor has the highest radioactivity. It is placed of ordinary peats on the surface in the system of water-sick watersheds and river drains. Such a point-nodai anomaly is probably associated with deep emanations from an endogenous stockwork-type source in the zone of the fault in the southern exocontact of the Atyolaysiyahal stock, which indicates very significant prospects for the Neizvestny-Paleodolinny section with respect to complex U-Th-TR mineralization.

Conclusion
Thus, the Mankhambovskaya block is a structure close to formations of the middle massif or terrane type, the nuclear parts of which form the Doriphean?-Riphean conjugated in space, magmatogene-metamorphic crust-metasomatic ore systems, similar to the structural-material basement complexes of platforms for which the pre-Vendian metallogeny of the platform intraplate stage is typical (Fe-quartzites, pegmatites, skarns, coastal metamorphosed placers, (Fe, U, Th, TR, Au, Ag, Pb), as well as

the collision Vendian-Early Cambrian albite (greisen)-isite-beserite (U, Th Mo, Be, Au, TR, Cu), the Paleozoic rift-collisional qualmites-eisite-beserite (Ta–Nb, Be, U, Th) and Mesozoic-Cenozoic (Au, U) intraplate type of “hot spots” of metallogeny of infiltration-argillic nature. This circumstance determined the observed polygenicity (metamorphogenic-sedimentary, rare-metal-albite-greisen, hydrothermal qualitative-eust-beresite, argililitiz) and polychronism (RF–KZ) of the iron-ore (MAN-9) rare metal-rare earth (Great Turupya, Yuzhnoye), uranium-thorium with gold and platinoid mineralization (Thurman, Neizvestnoye, Mokhovoe, etc.). The obtained data make it possible to assert that within the Mankhambovsky block it is possible to expect the discovery of medium-scale deposits of complex ores where the main components are rare earths, uranium, thorium, tantalum, niobium, zirconium, and associated gold, platinum, beryllium, possibly apatite, fluorite, etc.

REFERENCES


The article was received on February 20, 2017
Геология и полезные ископаемые Маньхамбовского блока
(Приполярный Урал)

Владимир Александрович Душин,
Vladimir.Dushin@m.ursumru.ru
Денис Игоревич Прокопчук,
denis9080@mail.ru
Вениамин Сергеевич Козьмин,
Veniamin.Kozmin@m.ursumru.ru
Евгений Александрович Жуклин,
ZhuKlin7@gmail.com
Артем Константинович Трутnev
tema.trutnev@yandex.ru

Уральский государственный горный университет
Россия, Екатеринбург

Актуальность работы заключается в том, что исследованиями последнего десятилетия, в том числе в связи с работами Северной научно-исследовательской геологической экспедиции (СНИГЭ) в рамках Государственной программы «Воспроизводство и использование природных ресурсов» на 2012–2020 гг., подтверждается серьезная перспективность Маньхамбовского блока в отношении рудных полезных ископаемых. Рассматриваемая в статье территория охватывает горную, обнаженную часть Северного и Приполярного Урала от истоков р. Печоры на юге до бассейна р. Маньи на севере и протягивается в меридиональном направлении почти на 300 км, административно входит в Ханты-Мансийский автономный округ — Югру и отстоит от Республики Коми. Перспективность Маньхамбовского блока в отношении рудных полезных ископаемых подтверждается исследованием последнего десятилетия, в том числе в связи с работами Северной научно-исследовательской геологической экспедиции (СНИГЭ). В пределах рассматриваемого района установлено более 50 рудопроявлений (проявлений) и около 200 пунктов минерализации рудных, цветных, благородных, радиоактивных и редких металлов. Железорудные объекты развиты ограниченно и обусловлены проявлениями двух рудных формаций — железистых кварцитов и сыловой жилолезной. Из цветных металлов широким распространением пользуется только медь, хотя существенных концентраций ее не установлено, а другие металлы практически не проявлены, за исключением убогой полиметаллической минерализации в бере- житизированных отложениях хобеинской свиты. Ряд редких металлов, включая ниобий, тантал, бериллий, цирконий, также редкоземельных элементов в комплексе с ураном и торием, широко развит в пределах Маньхамбовской структуры, причем ведущее значение в рудах имеют уран и торий. Радиоактивные элементы в ассоциациях с топонимами выделяются рудами и рудообразующими металлами — это ведущие полезные ископаемые Маньхамбовского блока. На сегодняшний день здесь установлено около 20 объектов различного масштаба.

Цель работы — выяснение перспектив Маньхамбовского блока на редкометальное-уран-ториевое оруденение.

Результаты работы. По условиям образования и особенностям размещения уран-редкометаллической минерализации выделямы три рудные формации: 1) ураново-полигенная в зонах несогласия, локализованная в обрамлении массива Маньхамбо в терригенных породах основания хобеинской свиты (RF hb); 2) ураново-безеритовая — гидротермальная вулканогенная в риолитах саблегорской и лаптопайской свит рифея–венда; 3) ураноносные торфяники — современная экзогенная инфильтрационная в мхах, торфяниках и покровных суглинках. Полученные данные позволяют утверждать, что в пределах Маньхамбовского блока можно ожидать обнаружения редких металлов, в том числе редкометаллов, урана и тория.

Ключевые слова: геология, черные, цветные, редкие металлы, уран, торий, Приполярный Урал, структурно-формационная зона, Маньхамбовский блок, рудопроявления, изотопный возраст.

ЛИТЕРАТУРА

Статья поступила в редакцию 20 февраля 2017 г.