VOLODARSK APATITE DEPOSIT IN THE EAST PRYAZOVIA REGION

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ABSTRACT

Volodarsk deposit of complex ilmenite-magnetite-apatite ores is located within the ore field of the Kalchytsk ore district of the same name. Found in the process of GSM-200, studied in the process of search and evaluation work. It is dated to the Gabro-sienite phase of the South Kalchytsk complex, the rocks of which constitute a stratified intrusion of the main composition with an area of about 103.8 sq km in the southeastern part of the Volodarsk massif. In the process of formation of intrusion as a result of fractionation (separation from the melt of the greater part of it due to crystallization at the initial stage of dark-colored minerals and plagioclase), the magma was divided into two parts that did not mix: the main ultra-basic and middle composition. As a result of this process, most of the intrusion (60-70% of the area on the modern erosion slice) is composed of fairly homogeneous rocks - sienites, to a lesser extent quartz sienites (with amphibole, biotite, pyroxene and olivine). Among them are developed consistent lens-shaped, lamellar bodies of varied composition. The main rock-forming minerals that make up these bodies are plagioclase (oligoclase-andesine), microcline-pertite, rhombic and monoclinic pyroxenes, and olivine (fayalite). In the process of crystallization differentiation only their ratio was changing - on the core of wells there is a stratification of monzonites, gabbro-monzonites, gabbro (normal and subluxate), peridotites, pyroxenites and plagioclasites with the power of "layers" from the first meters to hundred meters. Actually, the ores include the bodies of peridotites and gabbro with dense inclusions of ilmenite, titanomagnetite and apatite. The genesis of the deposit is magmatic.

Three ore bodies with a capacity from 30 to 340 m are estimated, traced over a range of up to 6.0 km. The ores are massive, rarely spotted. The content of useful components is P_2O_5 – 2,0-5,5%, TiO_2 – 2,5-11,4%, FeO – 5,6-2,6%, Fe_2O_3 – 7,6-46,2 %. Profitable development of the deposit is possible either on condition of sale of all received production or at the change of market conjuncture on separate types of raw materials.

The complex types of apatite ores of the Eastern Pryazovia gabro-sienite formation have been published for the first time. It was found that the ores have significant differences from this type of ore extracted at other deposits of Eurasia, South America. The mineralogical-petrographic diversity of the apatite-bearing rocks, the uneven redistribution of mineralization along the section and also on the area provide the basis for enrichment of apatite ores. Geological structure, field stratigraphy are provided.

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Apatite ores of the Volodarsk deposit are of industrial importance and can be used for the production of phosphorus fertilizers. It is advisable to continue complex geological studies in connection with the needs of Ukraine in providing the existing mountain-concentrating plants with apatites and phosphorites.

Keywords: apatites, Volodarsk site, archaea, proterozoic, Demyanivsk (Sachkinsk) world.

INTRODUCTION

TOPICALITY

World agricultural practice shows that the introduction of tons of phosphate fertilizers provides a yield increase of 2 - 3 tons of cereals per hectare of arable land [15]. The development of new apatite deposits, especially located near resource sites, is of great importance for agricultural production (production of phosphate fertilizers). In this sense, the discovery in 1985 of apatite-ilmenite-titanomagnetite ores in the Volodarsk site in the East Pryazovia region [10] should have led to a reduction in the cost of production of phosphate fertilizers. But in the late 1980s and early 1990s, the economic and political situation in the Soviet Union at that time did not contribute into the development and exploration of ore deposits in the south of Ukraine (Northwestern, Eastern Pryazovia). The south of Ukraine was planned to be used solely for recreational purposes that could lead Ukraine to economic dependence. After Ukraine gained independence (1991) in the 1990s, the government did not pay sufficient attention to the development of Ukraine's raw materials base, especially in the south. Geological prospecting expeditions (Belozersk geological party (Mykhailivka, Zaporizhzhya oblast), Pryazovsk GRE (Volnovakha, Donetsk region)) carried out explorations of the Pryazovia region, ore bodies of iron ore deposits, and identified related fields, etc. The authors of the article [4,6] participated in the work of these institutions for the purpose of stratigraphic studies of the meso-cenozoic cover in connection with the work on GSM - 200, the implementation of scientific projects at the expense of the state budget from the early 2000s to 2014. We believe that the data on the Pryazovia minerals are not only of scientific importance but also economical, especially at the current stage of Ukraine's development.

LITERATURE REVIEW

In the second half of the twentieth century, a large amount of geological survey, hydrogeological, prospecting, geophysical, ecological and geochemical work was carried out in the East Pryazovia region. They have been implemented for a long time by various organizations that have used various research methods. The geological structure of the area of work (in relation to stratigraphy, magmatism, tectonics and metallogeny) is covered in a large number of published literature: scientific articles, monographs, dissertations, abstracts, etc.

In 1961 G.L. Kravchenko (Artemgeology Trust) [8] completed geological surveys (GZ-200) on the area of leaf L-37-VIII (sets of maps of 1-50000 scale L -37-27, А, Б, В, Г та L -37-38, А, Б). Within a short period of time, field work was carried out over a large area and sets of maps of 1: 200000 scale on the territory of 1.5 sheets were assembled, which of course caused insufficient processing of the actual geological material.

In 1966, the first edition of the geological map of scale 1: 200000 of sheet L-37-VIII (Mariupol) was made on the basis of the report of the state geological and hydrogeological survey. To date, the map has not lost its significance and is a reference. On the geological map the boundaries of distribution of the rocks of the South Kalchytsk (now Volodarsk and Kremenivsk) and Kamianomogylsk massifs were mapped. An attempt was made to use thicker amphibole and pyroxene-amphibole crystallines as marking the Precambrian horizons. The tectonic scheme shows: the main folded structure is the Mangusk (now Central Pryazovia region) synclinorium, Kalmiusk tectonic zone, Berdiansk rift. However, like other researchers of the time, gneisses are shown by migmatites.

Simultaneously with the completion of the 1: 200000 mapping of the Eastern Pryazovia territory, geological survey work of the scale 1: 50000 began. They were performed mainly in 1958-1970 by Artemivsk GRE Trust "Artemgeology". Only on the area of the sheet L-37-29-A, where the crystalline foundation lies at a considerable depth (300-500 m), mapping was carried out in the late seventies of the last century.

In 1961 Kon'kov and R.M. Polunovskyi completed the mapping of the area of sheets L-37-27-A, Б [12]. In 1965 a report on the territory of sheet L -37-27- B was prepared. In 1967, a large area report covering tablets was compiled - L -37-16-Г; 17-B; -28-A, Б; -27-B-Б, м і -27-A, B, Г [7]. As a result, the fields of granite distribution of the Anatolian massif are mapped. Among the discontinuous structures are the Kalmiusk tectonic zone and the fragments of the Maloyanisolsk zone.

In 1972, R.M. Dovgan completed work on complex hydrogeological and engineering-geological surveying in the territory of sheets L-37-27-G; 39-A, B [5]. The geological structure of the square is deciphered correctly. However, the authors were unable to identify the subluxine gabroids of the Volodarsk massif defining them in one case as magnetite-enriched sienites and in the other as diorites. The Volodarsk massif granites were mapped as granosienites.

The most important studies of the end of the last century include the large-scale deep geological mapping of the Eastern Pryazovia. In 1985, V.F. Rozdorozhnyi, O.G. Neliubin and others finished the work on the GSM-200 of the Eastern Pryazovia region [13].

All geological materials of the precursors were summarized. As a result, data were obtained on stratigraphy, magmatism, tectonics and metallogeny, which made it possible to substantially clarify the geological structure of the region. For the first time, stratigraphic units dating back to the Lower Archean, new intrusive arrays, and tectonic structures were discovered. Particularly effective GSM-200 was in the relation to the detection of minerals. The Azov site of rare-earth-rare-metal ores, the Volodarsk site of complex apatite-ilmenite-magnetite ores and numerous ores and mineralization points were opened.

The Pryazovia stratigraphy has undergone significant changes: the Karatish series was eliminated in the Central Pryazovia region series. On the area of its distribution, the authors identified the West-Pryazovia series of rocks that form the anticlinal structure of the Lower Archean age.

For the first time the Middle Archean Shevchenkivsyi complex represented with plagiogranites was mapped on the East Pryazovia area. Among the Lower Proterozoic

formations in the Pryazovia complex are distinguished: autochthonous birefringent leucocratic and biotite granites, granodiorites and allochthonous - aplites, pegmatites, migmatites, granites, granodiorites. A series of rocks were distinguished in the East Pryazovsk intrusive complex: granosienite-granite (quartz sienites, granosienites, granites) and gabbro-syenite (gabbro, pyroxenites, peridotites, sublux gabbro, anorthosites, alkaline and nefelinites).

The works that have been carried out have ensured a justified division of the South Kalchytsk massif into Kremenovsk and Volodarsk intrusions; Kalmiusk massif, respectively, in the Dubovsk and Talakovsk intrusions; Yelanchytsk massif - on Grekovo-Olexandrivsk and Kumachivsk intrusions.

In the late 80's - early 90's the GSM-50 of the Volodarsk and Kalmiusk areas were completed. The result of the works performed on the GSM-50 of Volodarsk area, sheets L-37-27-A-g, B, B-b, g, D [13] is the attribution of the Central Pryazovia region series to the upper archaea according to age determination, the isolation of the Lower Archean Age Trondemite complex and the Star Subvolcanic complex.

Thematic work "Critical analysis of geological-geochemical data for the purpose of estimation of prospects of the Pryazovia region" which was carried out in 1989-1991 made it possible to summarize geological, geochemical, metallogenic data in the territory of the East and West Pryazovia and to develop general search criteria for different groups of minerals with a clear geochemical specialization.

Completing the analysis of the geological studies of the Eastern Pryazovia region, we note that in this area the precursors obtained interesting and valid data on stratigraphy, magmatism, and metallogeny that allowed to make significant changes in the geological structure of the region.

Study of the scientific works of the world geological community regarding apatite deposits [1,2,11,14] led us to conclude that the volatile ores of the Volodarsky deposit have higher geological and economic indicators the study of which is a further goal for the authors.

MATERIALS AND METHODS OF STUDY

Until 2014, a number of geological works were carried out at the Volodarsk area: search routes, topographic and geodetic works, well drilling, geophysical studies, prospecting and prospecting works, stratigraphic studies, core work and laboratory tests. The authors of the article worked with the cores, made stratigraphic conclusions, took part in laboratory work on the basis of the Pryazovia exploration expedition in a test shop. Until 2014, chemical and mineralogical analyzes were carried out in the laboratory of the Pryazovia Geological Exploration Expedition (GEE), and since 2015 in the chemical laboratory and the geotechnical research laboratory of Dmytro Motornyi Tavria State Agrotechnological University (Melitopol). The authors had the opportunity to work with the stock materials of the expedition, geological reports, for what we are sincerely thankful to the employees of the Pryazovia GEE. Scientific materials on tectonics and field stratigraphy were kindly provided by the employees of the Pryazovia GEE including the leading geologist I.L. Kniazkova.

RESULTS AND DISCUSSION

The Volodarsk field of complex ilmenite-magnetite-apatite ores located within the ore field of the Kalchitsk ore district, discovered during GSM-200 [13], studied during the process of prospecting and evaluation works [9]. The deposit is dated to the Gabro-Sienite phase of the South Kalchitsk complex, whose rocks constitute a stratified intrusion of the main composition of about 103.8 sq km in the southeastern part of the Volodarsk massif. Administratively, the Volodarsk plot is located on the territory of Nikolsk and Mangushsk districts of Donetsk region. Geographic coordinates of the area 47° 04'-47° 11' N and 37° 20'-37° 25' N. (Fig. 1). According to geomorphology, it is a slightly hilly, hollow, sloping south plain, rising above sea level and cut by beams, ravines and valleys a year, absolute markings vary from +35 to 153 meters.

Tectonics. Geologically and structurally, the Volodarsk plot is located on the southeastern part of the Pryazovia crystalline massif. Several major cycles of tectonogenesis were involved in the formation of the Pryazovia massif: the Precambrian and Meso-Cenozoic are significant.

In the Lower Precambrian structural floor stands out a large Central-Pryazovia tectonic block, almost entirely composed of supercrystalline formations of the Archean and Early Proterozoic ages, containing small bodies of granitoids (Volodarsk, Kamenomogylnyi, Katerynivsk, Starodubovsk, and others). It is separated from the East-Pryazovia block by Maloyanisolsk tectonic zone. The super-crystalline formations of the Central-Pryazovia block form a large folded structure - the Central-Pryazovia syncline complicated by folds of higher orders. The wings of the synclinorium are extended in a northwest direction, the maximum length of which is 130-140 km with a width of 15 to 40 km.

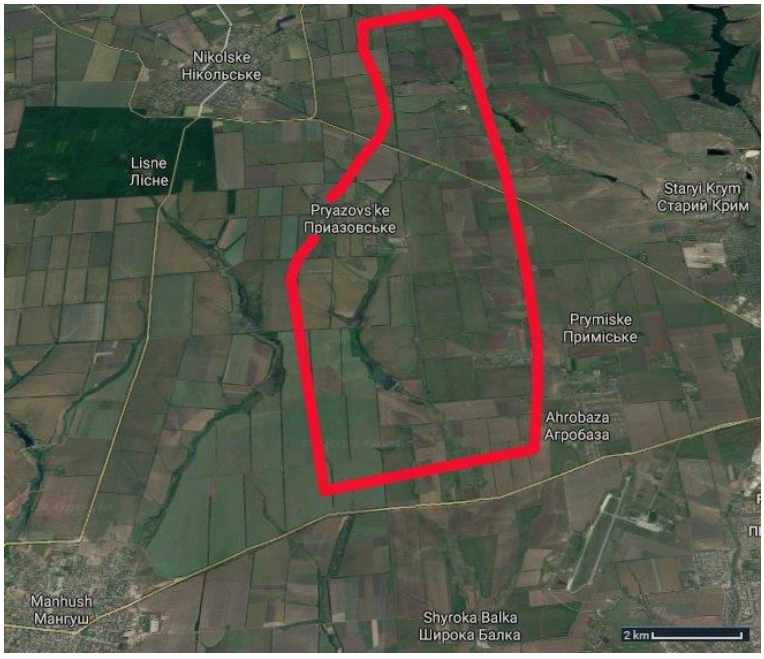

Fig. 1. Location of the Volodarskyi plot

The Pryazovia region is characterized by the widespread development of diverse and age-old in nature and scale manifestations of disjunctive tectonics which complicates the structure of large and small plicate structures of the Precambrian foundation. Within the Volodarsk region, in addition to the deep mantle fault, there are rifts of crustal bedding. Breeds of magmatic genesis are universally developed at the intersections of disturbances. The upper structural floor is represented by horizontal-sedimentary deposits of Meso-Cenozoic age, which cover the blurred surface of Precambrian rocks.

Stratigraphy. The stratified formations are represented by rocks of the Archean, Proterozoic age which make up the lower structural floor, and the Meso-Cenozoic age, the upper structural floor.

Archean formations form the nucleus of the second-order structure - the Central Pryazovia Synclinarium, represented by gneisses plagioclase, biotite, amphibole-biotite, crystal-shale biotite-amphibole, biotite-pyroxene-amphibolite (Ar_2 Pr). The Proterozoic rocks are united into the Central-Pryazovia series, that consists of two series, the lower Temriuksk (Pr1 tm) and the upper Sachkinsk (Pr1 sč) which now belongs to the Demyanivsk series (Fig. 2 a,b).

Formation of the Temriuksk series, which is dominated by biotite and amphibole-pyroxene gneiss with horizons of magnetite-pyroxene shale and pyroxene-magnesium, and garnet-pyroxene amphibolites, high alumina and graphite-containing gneisses and shales, as well as feldspar quartzites are widespread within the Volodarsk area of apatite in the Pryazovia; lie on the blurred surface of Archean rocks.

The Temriuksk series is divided into three parts. The lower third of the Temriuksk series is composed mainly of thick strata of amphibole and pyroxene-amphibole plagiogneisses, which contain scattered magnetite, stratified by low-power (5-10 m) layers of amphibole-pyroxene, often with shale pomegranate. The total capacity of this part of the section is estimated at 1000 m.

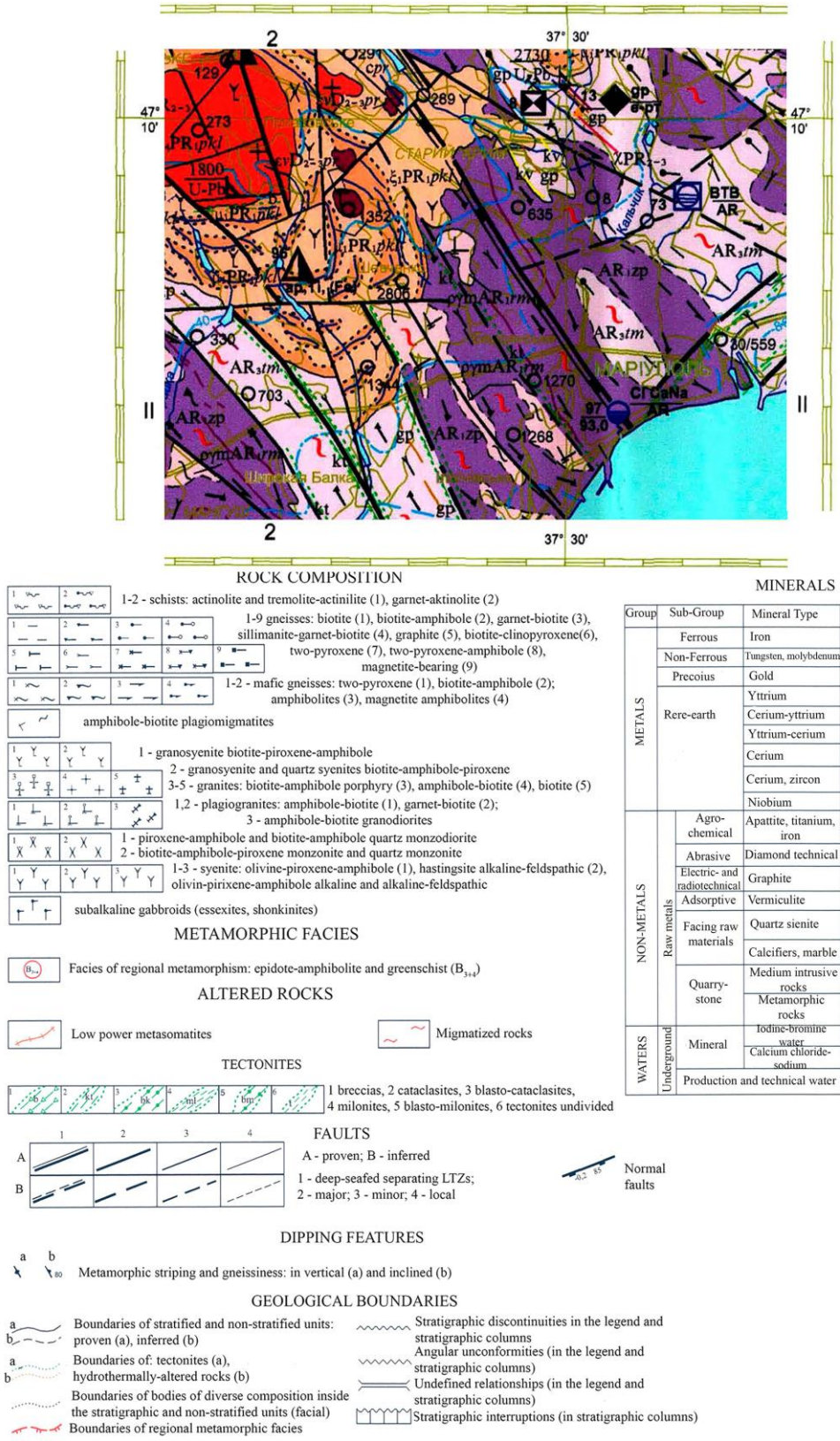

Fig. 2a. Geological and mineral map of the crystalline foundation of the Volodarsk apatite deposit area [3]

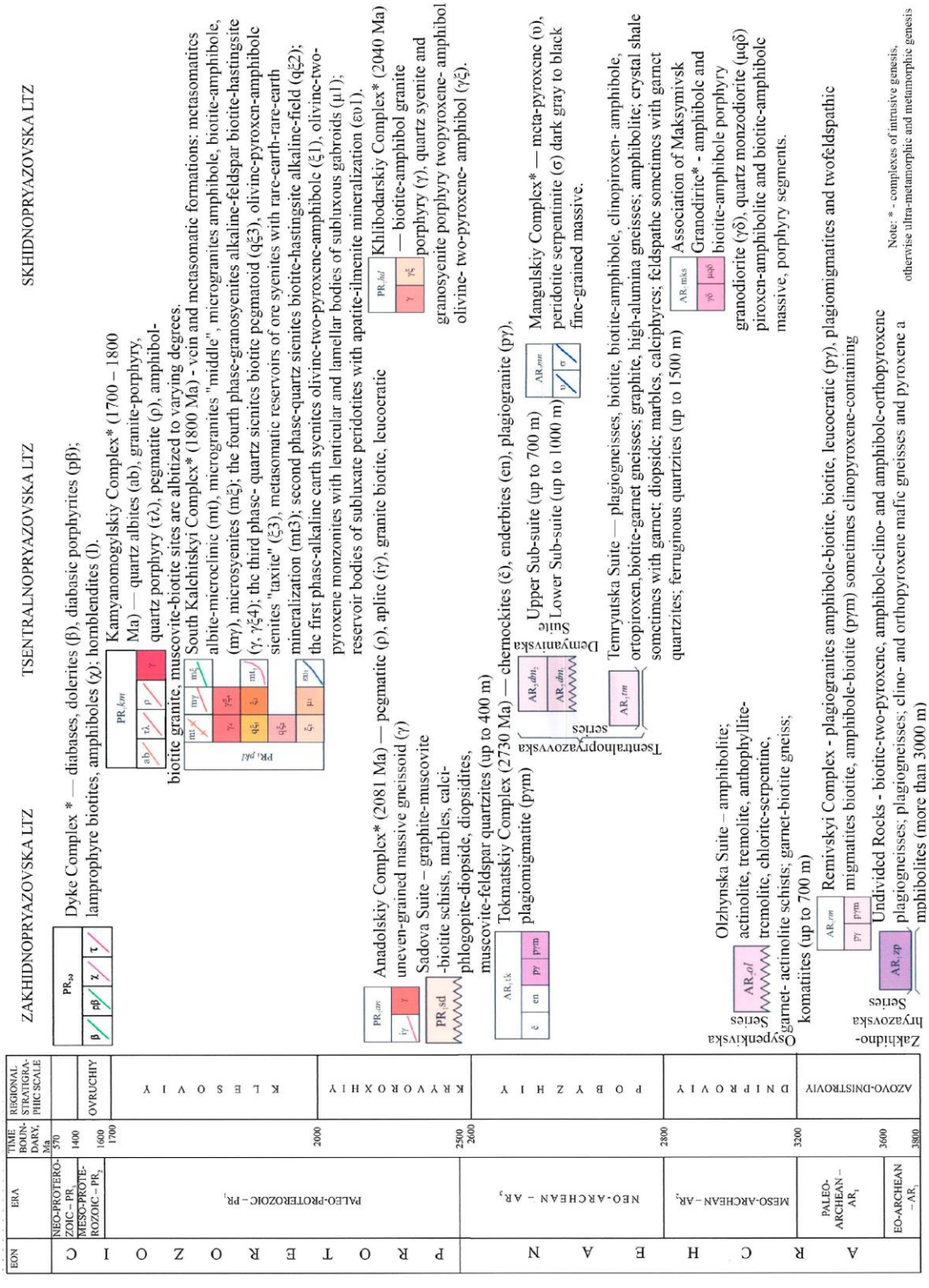

Fig. 2b. Stratigraphic columns of the Volodarsk apatite deposit area [3]

The middle third of the section of the Temriuksk series is characterized by the presence of an unbearable thickness of diopside calcifers whose capacity varies from units to 50 meters, and the exits to the surface are spread on the left side of the Kalets River and one kilometer north-east from the village Peremoga.

The upper part of the section of the Temriuksk series is characterized by the development of magnetite-pyroxene shales, pyroxene-magnetite and feldspar quartzites, high-alumina thicknesses (sillimanite-spinel-corundum-pomegranate), as well as graphite-containing gneiss-gougevils. Occasionally, interleaves of diopside calcifiers are noted among these rocks. The total power of the Temriuksk series reaches 2000 m.

The formation of the Demyanivsk (Sachkinsk) series is widespread on the sides and in the axial part of the Central-Pryazovia syncline and within the Korsaksk syncline. The series lies with a stratigraphic break in the dark suite. In the lower part of the world biotite-amphibole-plagioclase gneisses with boulders of amphibolites and garnet-biotite gneisses are developed. Their capacity is about 100 m. Then there is the thickness of marbles and calcifers.

The carbonate thickness is heterogeneous in structure, composed of marbles, calcifers, which are interbedded with biotite, garnet-biotite gneisses and shales. The total capacity of carbonate layer is 150-300 m.

The terrigenous carbonaceous strata have a capacity of 230-500 m. At its base pomegranate-biotite shales, which pass up the incision into amphibole-biotite and biotite gneisses are developed, they are often graphite-containing.

Above the terrigenous thickness there is an iron ore layer with a capacity of 30-210 m. It is characterized by the development of two layers of ferruginous quartzites with a capacity of 0-30 to 120 m, which are in association with crystalline shales of the main composition (pyroxene-plagioclase and amphibole-pyroxene-plagioclase), as well as leadless quartzite.

This is followed by a powerful (60-360 m) thick, composed mainly of metal-morphic terrigenous rocks (biotite, graphite-containing gneisses, amphibole-pyroxene crystalline), among which are low-power (up to one meter) layers of calcifers, as well as fast exclamation points lenses of fayalite-pyroxene and magnetite-pyroxene quartzites.

The incision ends with the Sachkinsk thicker biotite and garnet-biotite gneiss (100-200 m capacity). Undivided formations of the Central-Pryazovia series include thicker rocks whose material composition and structural provisions do not allow them to be unequivocally attributed to the Temriuksk or Demianivsk series. The strata are established within the boundaries of the Cyrylivsk anticlines and the southeastern part of the Volodarsk intrusion, composed of biotite-plagioclase and biotite-amphibole shales and gneisses which are predominant in section.

Mesozoic sediments are represented by Triassic and Cretaceous systems.

Upper Triassic deposits are confined to the so-called Panovsk local depression. According to lithological features and color upper Triassic sediments are divided into three strata (top to bottom):

- the layer of gray and greenish-gray gravelites and sandstones;

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- the layer of greenish-gray, with splashes of red-brown sandstones and gravelites with frequent layers of clay;

- the layer of brightly colored cherry red and greenish brown gravelites with layers of conglomerates.

The deposits of the Cretaceous system are dated to the graben-like depressions of the crystalline base on the territory of the Konksko-Yalinsk depression in the northern part of the Belosaraisk sunken block. They are represented by marls, siltstones, siltstones, rarely - clays gray, greenish-gray, dark gray with impurities of glauconite, sands, sandstones glauconite-quartz from fine to coarse-grained, spongolites. The basis of sediments are quartz pebbles and gravel, veins of phosphorites are noted.

Cenozoic rocks are located universally, lithologically represented by sandstones, marls, sands, and rarely clays of the Neogene age and loam of the Quaternary system. The capacity of Cenozoic deposits ranges from 3-40 m in the central part of the Volodarsk region to 200-400 m in the south.

Magmatism. Magmatic Proterozoic formations are represented by ultramethagenic granitoids (central-Pryazovia series of Pryazovia complex (PR_1^2 pv)), intrusive sublux granitoids, syenites, gabroids of the East Pryazovia complex (PR_1^3 vp (Volnovakhsk) intrusive field. The Volodarsk intrusion forms the southern fragment of the Volnovakhsk intrusive field [3]. In the process of formation of intrusion as a result of fractionation (separation from the melt of the greater part of it due to crystallization at the initial stage of dark-colored minerals and plagioclase), the magma was divided into two parts that did not mix: the main-ultra-basic and middle composition. As a result of this process, most of the intrusion (60-70% of the area on the modern erosion slice) is composed of fairly homogeneous rocks - sienites, to a lesser extent quartz sienites (with amphibole, biotite, pyroxene and olivine). Among them consistent lens-shaped, lamellar bodies of varied composition are developed. The main rock-forming minerals that make up these bodies are the same - plagioclase (oligoclase-andesine), microcline-pertite, rhombic and monoclinic pyroxenes, and olivine (fayalite). In the process of crystallization differentiation only their ratio changed - on the core of wells there is a stratification of monzonites, gabbro-monzonites, gabbro (normal and subluxate), peridotites, pyroxenites and plagioclasites with the power of "layers" from meters to meters. Actually, the ores include the bodies of peridotites and gabbro with dense inclusions of ilmenite, titanomagnetite and apatite. The genesis of the deposit is magmatic.

Three ore bodies with a capacity of 30 to 340 m were isolated and traced up to 6.0 km. The ores are massive, rarely spotted. The content of useful components is P_2O_5 – 2,0 - 5,5 %, TiO_2 – 2,5 - 11,4 %, FeO – 5,6 - 2,6 %, Fe_2O_3 – 7,6 - 46,2 %.

Qualitative characteristics of ore. The apatite-ilmenite ores of the Volodarsk section belong to the apatite-ilmenite-titanomagnetite type of ores in the gabroids. They are represented by alkaline gabroids, rarely by gabbro in the form of low-power layers in layers. The deposit is dated to the formations of the main series of gabbro-syenite formation of the East-Pryazovia complex. Ores are fine-grained, gray, and have massive texture.

Mineral composition of apatite-containing ores is apatite - 4.5-20%, ilmenite - 5.5-10%, magnetite-titanomagnetite - 5.5-15%, pyroxene - 16.6-36.8%, olivine - 4.6 -39%, biotite

- 0.1-8%, feldspar - 1.7-14.5%, amphibole is present. Free apatite accounts for 88.3-90.8% of the total ore in P_2O_5. The rest of the phosphorus is associated with subtle inclusions of apatite in ilmenite, titanium magnetite and rock-forming minerals. 68.6-69.2% of TiO_3 and 19.2-22.8% of TiO_2 attributable to titanium magnetite are associated with ilmenite. The remaining TiO_2 is present in dark-colored silicates and feldspars in the form of fine inclusions and isomorphic impurity.

Characteristics of ore minerals are given by the results of petrographic, mineralographic studies, as well as the study of monofractions of apatite, ilmenite and titanomagnetite [3].

Apatite forms thin short-prismatic and needle inclusions in silicates and ore minerals, as well as independent large dipyramidal-prismatic, barrel-shaped and irregularly shaped crystals. Apatite is represented by fluoroapatite with small impurities of hydroxyapatite and apatite carbon. Spectral analysis revealed that copper, lead, cobalt, nickel, chromium, vanadium, titanium, tin, magnesium, manganese, lanthanum, cerium, yttrium, ytterbium, silver, bismuth, strontium are present in apatite. The presence of chalcophilic and siderophilic elements is due to the presence in the apatite of thin inclusions of silicate and ore minerals.

Ilmenite forms xenomorphic, lamellar and polygonal crystals. Thin plate and needle separations in pyroxene and titanomagnetite occur. Ilmenite contains subtle inclusions of silicates and apatite. Among the elements of impurities copper, lead, cobalt, nickel, scandium, vanadium, zirconium, niobium, tungsten, tin and others were found.

Titanomagnetite is developed within the site in close association with ilmenite. Sometimes it is observed in the form of wedge-shaped or rounded isolated in large grains of ilmenite, and on the contrary, around the xenomorphic grains of titanomagnetite, margins of ilmenite are noted. Along with the main components (Fe_2O_3 - 55.12%, FeO - 30.48%), the mineral contains titanium, magnesium, manganese, as well as a number of impurity elements: vanadium, molybdenum, zinc, chromium, nickel, cobalt and others. The high content of SiO_2 and Al_2O_3 is due to the small inclusions of silicates.

In general, the valuable minerals of the Volodarsk gabroids studied in chemical composition, content of impurity elements, in crystal-chemical composition correspond to reference samples and can serve as raw materials for the preparation of conditioning apatite and ilmenite concentrates.

The ore content of olivine, pyroxene is 45.6-55.7%. Talc-mica-chlorite aggregate is formed on cracks in olivine. From 10 to 30% of the total amount of dark-colored minerals contain a thin magnetite mesh and have high magnetic properties (Table 1).

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Table 1. Chemical and spectral characteristics of the apatite-containing ores of the Volodarsk section

The name of the oxidizer	Content of the mass shares, in%	Item name		Content of item
TiO_2	4,84	п. 10^{-2}	Ba	5
P_2O_5	2,40	п. 10^{-3}	Cu	2,8
FeO	21,16		Zn	20
Fe_2O_3	6,37		Mn	185
SiO_2	37,91		Nb	1,6
Al_2O_3	8,48		Zr	4
MnO	0,39		B	0,5
MgO	3,91	п. 10^{-4}	Pb	8
CaO	8,68		Co	70
K_2O	1,46		Ni	8
Na_2O	1,85		Cz	90
SO_3	0,74		V	60
Cr_2O_3	0,06		Sn	1,3
SrO	0,05	п. 10^{-5}	Mo	18
H_2O^-	0,04	п. 10^{-6}	Ag	2
H_2O^+	0,94	п. 10^{-3}	La	1,4
CO_2	0,77		Y	1,1
			P	422
			Ti	1028

Cenozoic deposits overlying crystalline rocks and forming a loose cover of minerals have been developed at the Volodarsk site. Loose deposits have a plane spread throughout the site, their capacity ranges from 13 to 66 m; represented by soil-vegetation layer, sandstones, sands, limestones, loam and clay. The loam is suitable for use as a brick-tile raw material; rocks are suitable for the production of rubble. Loose and rocky rocks (38 m thick on average) require careful physical and mechanical investigation for further use in the country's economy.

CONCLUSION

According to the results of researches within the Volodarsk area, the geological characterization of the deposit of complex apatite-ilmenite-titanomagnetite ores, information on the volume of ore and the content of its main useful components have been provided; three deposits are of interest for industrial development - northern, central and southern.

A comprehensive assessment of apatite-bearing rocks makes it possible to isolate two types of ore components - apatite and ilmenite.

A small thickness of loose and rocky rocks (an average of 38 m) allows the extraction of ore-containing ore (an average thickness of 250 m) in an open manner. Loose and rock formations are suitable for use in construction.

The Volodarsk apatite field needs careful exploration work to produce phosphate fertilizers. Profitable development of the deposit is possible either provided implementation of all received production, or the change of market conjuncture on separate types of raw materials.

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