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The Hayvoron migmatite deposit as a constructively organized landscape-technical system in the conditions of the interzonal «Forest Steppe-Steppe» geoecotone of the Right Bank of Ukraine

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SUMMARY

The Hayvoron migmatite deposit is a landscape-technical system located within the interzonal geoecotone «Forest Steppe-Steppe» of the Right Bank of Ukraine. It is confined to the Central Protrusion of the Belotserk block of the Ukrainian shield. Industrial development of the mineral began in 1938. The research is based on the principle of natural-anthropogenic coexistence. It has been done with using such methods: expeditionary, landscape mapping, decoding of aerial photographs of the physical surface, mathematical and instrumental methods.

Migmatite has a layer-like horizontal occurrence. The average length is 1100 m, the average width is 580 m, the thickness is from 70.4 m to 90.8 m. The loam also has a layer-like horizontal layer. The average length of the body is 530 m, the average width is 310 m. The power is from 3.10 m to 20.6 m (average – 11.8 m). Balance reserves of the field as of January 1, 2018 amount to 18,987.7 thousand m^3. The field of application is building stone, brick and tile raw material. Today the deposit is being developed by the mining company Hayvoronsky Specialized Quarry. In order to mitigate the destructive impact of quarry operations on the natural environment, remediation measures are being carried out.

Introduction

The high level of transformation of natural conditions and natural resources of Ukraine caused the formation and development of the most diverse groups, classes and types of man-made landscapes. Technical and natural blocks form a constructively organized landscape system, which in modern conditions can function as such, which is able to ensure the balanced functioning of these components. The dominance in the structure and development of the man-made landscape of the technical block is the main feature of the landscape-technical systems. Therefore, the study of the peculiarities of the organization, functioning and development of modern landscape technical systems is the actual scientific problem of anthropogenic landscape science. The model territory of the research is the interzonal geoecotone «Forest Steppe – Steppe» of the Right Bank of Ukraine. The object of the research is the Hayvoron migmatite deposit as the landscape-technical system. The subject of the research is the history of economic development, modern structure and geological structure of the Hayvoron migmatite deposit.

Method and Theory

The research of the Hayvoron migmatite deposit as the landscape-technical system is based on the principle of natural-anthropogenic coexistence. The following research methods were used during the study of the Hayvoron migmatite deposit: expeditionary, landscape mapping, deciphering of aerial photographs of the physical surface, instrumental methods of assessment by types and quantities of expected waste, emissions (discharges), water and air pollution, soil and subsoil, noise, vibration, light, heat and radiation pollution, as well as radiation, which arise as a result of the implementation of preparatory and construction works and the implementation of planned activities.

Results

The Hayvoron migmatite deposit is located in the Golovaniv district of the Kirovohrad Oblast, 0.5 km from the southern outskirts of the town of Hayvoron, on the left bank of the South Bug River at the confluence of the Tashlyk River. The settlements closest to the deposit are the villages of Solgutiv, Hayvoron, Solomiya, Khashchuvate, Bugove, and Stavky. The quarry is connected to the town of Hayvoron and other settlements by a cobblestone or asphalt road suitable for motor vehicle traffic at different times of the year. The distance from the town of Hayvoron to the Kyiv – Odesa highway is 38 km. The total area of the deposit within the limits of the special permit is 48.73 hectares. The geographical coordinates of the Hayvoron deposit are given in the Table 1 (Shereshevsky, 2020).
In terms of orography, the research object is located on the Dnieper Highlands. The deposit consists of two sections, Northern and Southern, which are separated from each other by a deep beam, which is covered with overburden and reclaimed. The amplitude of fluctuations of the physical surface marks is within 180-214 m. The minimum surface marks of the deposit area are confined to the floodplain terrace of the South Bug River. The deposit is part of the left root bank of the South Bug River, it is a gentle hill rising above the surrounding area. The natural boundaries of this area are a ravine that limits the area from the northeast, the valley of the Tashlyk river from the north, the valley of the South Bug River from the west, and a ravine that flows into the river valley from the south. Outcrops of migmatites and granites are observed in the river bed and in its floodplain. In the northern part of the Hayvoron field, its left tributary, the small river Tashlyk, flows into the South Bug River.
The Hayvoron migmatite deposit is located on the southwestern part of the Ukrainian Crystalline Shield within the Dniester-Bug megablock. Precambrian metamorphic formations and Cenozoic sediments take part in the geological structure of the deposit area. Precambrian crystalline rocks form the lower structural section and are covered by a layer of sedimentary rocks of the Cenozoic period. The surface of the crystalline foundation is inclined to the south and southwest. The relief of the crystalline base within the area of works is quite calm, fluctuations of absolute marks here only in some areas reach 50 m in the valley of the South Bug River. Outcrops of crystalline rocks are

observed within the South Bug River valley in the section from the town of Hayvoron to the village of Zavallya. The geological structure of the work area is based on the results of geological surveying works on a scale of 1:200,000 carried out in 2009 (Shereshevsky, 2020).

Table 1 *Geographical coordinates of the Hayvoron migmatite deposit (Shereshevsky, 2020)*

Coordinates (Pulkovo, 1942)					
Corner point	Northern latitude	Eastern longitude	Corner point	Northern latitude	Eastern longitude
Northern section			Southern section		
Point 1	48^0 19' 45"	29^0 52' 54"	Point 1	48^0 19' 13"	29^0 53' 01"
Point 2	48^0 19' 43"	29^0 52' 59"	Point 2	48^0 19' 11"	29^0 53' 11"
Point 3	48^0 19' 40"	29^0 53' 00"	Point 3	48^0 19' 13"	29^0 53' 08"
Point 4	48^0 19' 30"	29^0 53' 04"	Point 4	48^0 19' 16"	29^0 53' 10"
Point 5	48^0 19' 24"	29^0 53' 07"	Point 5	48^0 19' 04"	29^0 53' 28"
Point 6	48^0 19' 23"	29^0 53' 07"	Point 6	48^0 18' 49"	29^0 53' 34"
Point 7	48^0 19' 23"	29^0 52' 56"	Point 7	48^0 18' 40"	29^0 53' 20"
Point 8	48^0 19' 31"	29^0 52' 52"	Point 8	48^0 18' 41"	29^0 53' 18"
Point 9	48^0 19' 37"	29^0 52' 47"	Point 9	48^0 18' 46"	29^0 53' 17"
Point 10	48^0 19' 38"	29^0 52' 50"	Point 10	48^0 18' 49"	29^0 53' 15"
Point 11	48^0 19' 38"	29^0 52' 52"	Point 11	48^0 18' 54"	29^0 53' 13"
Point 12	48^0 19' 41"	29^0 52' 51"	Point 12	48^0 18' 57"	29^0 53' 11"
Point 13	48^0 19' 44"	29^0 52' 54"	Point 13	48^0 18' 58"	29^0 53' 11"
			Point 14	48^0 19' 00"	29^0 53' 09"
			Point 15	48^0 19' 01"	29^0 53' 10"
			Point 16	48^0 19' 02"	29^0 53' 09"
			Point 17	48^0 19' 03"	29^0 53' 10"

The Hayvoron deposit is composed of crystalline rocks of the Hayvoron complex (AR1gv) with remnants of the Dniester-Bug series (ARIdb), loams, and a soil-vegetable layer of Quaternary age, which cloak Precambrian crystalline rocks. The age of Precambrian crystalline rocks is about 3 billion years (Yangolenko, 2008).

Quaternary rocks include: soil-vegetation layer, man-made deposits, pale-yellow loess and yellow-brown dense loams. As of January 1, 2016, the deposits of quaternary rocks in the Northern section have been completely removed. In the southern part of the deposit, Quaternary deposits are present in the north and east of the deposit.

The main part of the mineral is thin-striped gneiss-like enderbite of quartz-diorite or plagiogranite composition, greenish-dark-gray color, medium-fine-grained structure and thin-striped gneiss-like texture. The microstructure is hypidiomorphogranular, pseudocataclastic. The main feature of these varieties is the heterogeneity of the composition, which is expressed in the alternation of strips enriched or depleted in iron-magnesium silicates. Accordingly, the composition of the rock changes from diorite to plagiogranitoid.

The thickness of the mineral in the Northern section up to the absolute mark of +9 m is: migmatites affected by weathering vary from 0 m to 2.4 m, and fresh migmatites – from 48.0 to 151.2, on average 101.6 m. In the southern section, the thickness of mineral resources up to +76 m mark (calculation of reserves) is: migmatites affected by weathering – from 0 m to 7.4 m, on average 2.9 m and fresh migmatites – from 36.1–89.8, on average 66.8 m. Hayvoron deposit of migmatites according to the complexity of the geological structure, mining and technical conditions and the quality of the mineral is assigned to the I group (Shereshevsky, 2020).

From the point of view of anthropogenic landscape science, the Hayvoron migmatite deposit is a landscape-technical system located within the interzonal geoecotone «Forest Steppe – Steppe» of Right Bank Ukraine. The natural landscape structure is formed by the following types of landscapes:

loess highlands, strongly dissected by ravines and beams cut into crystalline rocks, with typical low-humus and podzolized chernozems, with hornbeam forests; meadow-swamp, meadow steppe floodplains (National atlas of Ukraine, 2007).

The research of the geological and geomorphological structure of Ukraine were conducted by professors of Kyiv, Kharkiv, Odesa and Lviv universities at the end of the 18th and the beginning of the 19th centuries. The first information about the geological structure of the Hayvoron district of the Kirovohrad Oblast was made public by Kyiv University professor K.M. Feofilaktov. In the 1880s and 1900s, geologists R. Prendel and V. Przemyskyi studied this area. From 1900 to 1914, various geologists explored the Antonyovo-Khaschuvatsk iron-manganese deposit. From 1916 to 1921, exploration work in this area was carried out by A.V. Krasovsky, who first discovered deposits of graphite gneisses near the village of Zavallya (Yangolenko, 2018).

In 1937, the Ukrainian Geological Administration carried out preliminary exploration of the Hayvoron migmatite deposit. In 1938, the deposit was explored in detail by the moscow office of search and design of the Soyuzdor project of the GuSHOSDOR of the NKVD of the USSR. The work was supervised by geologist V.A. Aprodov. Exploration was carried out on an area of 15 hectares with the help of clearings and pits. As a result, reserves of crystalline rocks with a volume of 4.5 million m^3 were discovered (Yangolenko, 2008).

The industrial development of the mineral began in 1938. The development of the Hayvoron migmatite deposit began from the Tashlyk River in the southeast direction from the place that the local residents called «the rock». Today, the site of the crushing and sorting station No. 1 is located here. In total, 4 explorations were carried out in the area of the modern Hayvoron deposit of migmatites. Exploration work was carried out by drilling wells. In 1962, exploration work was conducted by the Kyiv Geological Expedition. The search team was headed by geologist V.F. Drobyshevskyi. Exploration works on an area of 20 hectares in the «Central» (today it is the Northern section of the deposit) and «Southern» sites revealed 8.4 million m^3 of stone reserves in categories A + B + C1 (Yangolenko, 2018). During 1969–1970, preliminary exploration of the deposit was carried out by the Kyiv Geological Expedition on an area of 33 hectares, stone deposits were explored to a depth of + 76 m. The volume of discovered migmatite reserves in categories A + B + C1 was 23 million m^3.

The next exploration was carried out in 1990–1991 by the department of quarries of the «Ukrdiprodor» Institute in the southern part of the deposit for the purpose of exploration and evaluation of loams among overburden rocks for their suitability for the production of ceramic bricks. The author of the project is N.V. Seminyk. It was planned that the loam would be the raw material for a brick factory, which the Republic of Yugoslavia intended to build to provide bricks for facilities being built by Yugoslav firms in Ukraine. The volume of explored and evaluated loams is 1.8 million m^3. At the same time, 8.2 million m^3 of migmatites lying under loams were additionally explored in this area.

During 24 years, only 5 thousand m^3 of balance loam was mined. In 2014–2015, the question arose about the organization of excavation work in the southern part of the deposit. There were no sites for storing the developed loam, there are no consumers of loam in the area. All this became an argument for the loam deposit to be written off from the state balance sheet in 2015 (Yangolenko, 2018).

In 2003–2004, additional exploration was carried out by the Right Bank Geological Expedition of the Northern State Regional Geological Enterprise «Pivnich Geologiya». The responsible executor is a geologist of the 1st category V.M. Ozerko. Preliminary exploration tasks: to calculate the stone reserves in the contour of the project quarry in the northern part of the deposit, taking into account its deepening by 67 m (to the possible depth of development within the limits of the existing mining right-of-way); perform a complex of works on radiometric survey of stone both on the surface of mining horizons and up to the design depth of mining. The calculated stone reserves in the Northern section within the project contour amounted to 9 million m^3. According to the degree of radioactivity and the nature of the distribution of rocks with different content of radionuclides, the deposit belongs to the 1st group of classification of building materials according to the total specific activity of natural radionuclides (Yangolenko, 2008).

In 2010, the Right Bank Expedition carried out drilling (2 wells) in the Southern section. In 2011, «Magma» LLC conducted a geological and economic assessment of the Hayvoron deposit. According to the results of the work, reserves in the amount of 21,046.7 thousand m^3 were calculated, including by categories: A – 10817.9 thousand m^3, B – 5884.4 thousand m^3, C1 – 4344.4 thousand m^3 of crystalline rocks. According to the protocol of DKZ of Ukraine № 3669 dated 13.10.2016, the balance reserves of the Hayvoron deposit in categories A+B+C1 were approved in the amount of 18680.5 thousand m^3, including category A – 10645.5 thousand m^3, category B – 5780.0 thousand m^3, category C1 – 2255.0 thousand m^3 (Adjustment of the working project, 2008).
Mining of migmatites is carried out by ledges up to 12 m high. The slope angles of the ledges are working – 80°, non-working – 70°. Horizons +81.0 m, +93.0 m, +105.0 m, +117.0 m, +129.0 m, +141.0 m, +151.0 m are knocked down by 3 ledges with a total height of 36.0 m, protective berms were left on horizons +93.0 m, +129.0 m and horizon +165.0 m with a width of 8-10 m. The bottom of the pit is at +57 m. In the near future, the development of the Northern sections with two working ledges – +93 m, +105 m. Removal of overburden is planned for the southern section. Overburden is developed in steps of 10 m. The slope angles of the steps are working – 60°, non-working – 35° (Shereshevsky, 2020).
Migmatite has a layer-like horizontal occurrence. The average length is 1100 m, the average width is 580 m, the thickness is from 70.4 m to 90.8 m. The loam also has a layer-like horizontal layer. The average length of the body is 530 m, the average width is 310 m. The power is from 3.10 m to 20.6 m (average – 11.8 m). The composition of migmatites includes the following main minerals: potassium feldspar (10%), quartz (10–40%), clinopyroxene (3%), pyroxene (3–15%), plagioclase (50–80%). The chemical composition of the crystalline rocks of the deposit: SiO_2 – 48.8–68%; Al_2O_3 – 12–15.28%; F_2O_3 – 0.57–2.08%; FeO – 2.57–10.63%; TiO_2 – 0.11–1.41%; CaO – 4–11.04%; MgO – 1.55–7.40%; K_2O – 0.8–2.8%; Na_2O – 2.8–3.55% (Sytnyk *et al.,* 2021).

Conclusions

Balance reserves of the field as of January 1, 2018 amount to 18,987.7 thousand m^3. The field of application is building stone, brick and tile raw material. As of today, the deposit is being developed by the mining company Hayvoron Specialized Quarry. In order to mitigate the destructive impact of quarry operations on the natural environment, remediation measures are being carried out.
The enterprise has an established waste management system. Waste generated as a result of production and economic activity is subject to: identification; rationing; sorting; collection; marking; accounting; timely removal from production sites; placement in specially designated places; transfers for disposal; transfers for disposal (destruction); transfer to burial.

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