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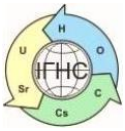

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RATIONAL USAGE OF RAW MATERIALS DURING ZAVALIVSKIY GRAPHITE DEPOSIT DEVELOPMENT

In the work on the basis of analysis of Zavalivskiy graphite deposit usage prospects, the ways of rational exploitation and integrated using of its raw materials, including the transition to underground and combined extraction of graphite ores, improvement of enrichment schemes, increasing the assortment of graphite production of the Zavalivskiy graphite plant, usage of spent quarry for overburden and tailings heaps discharge, are outlined. The important component of the rational of Zavalivskiy graphite deposit is the integrated using of its raw materials: (1) the pomegranate raw material has significant prospects for today, as the deposit is the only one in Ukraine which mines pomegranate ores; in terms of technical characteristics, the pomegranate concentrate of Zavalivskiy graphite deposit is not inferior to the world producers pomegranates; (2) the plant does not sell all mass of the overburden rock formations for building stone production, as it is possible; (3) the overburden sands, clays and loam are characterized by high technological indices and need the economic feasibility studying of their selective development; (4) graphite ore flotation tailings need further study for using in the building materials and glass industries; (5) the using of mineral pigments (ocher, seladonite) is possible with selective extraction, special separate storage and development of technology of enrichment and preparation for further use; (6) jasper, chalcedony and opal specimens of Zavalivskiy graphite deposit have high decorative, textural and consumer characteristics and are suitable for the production of various jewelry and decorative items; (7) among the host rocks of Zavalivskiy graphite deposit there are veins of unique, rare in the world mineral – grautite, mineralogical interest is the presence of barite, horsex, pyrite, galena, clusters of coarse-grained graphite, etc. The collection and sale of their specimens as a collection material, the organization of mineralogical excursions can also have some economic effect. The introduction of rational methods of development and integrated using of Zavalivskiy graphite deposit will allow to consider this object as strategically important for the economy of Ukraine.

Key words: *Ukrainian shield, Zavalivskiy graphite deposit, graphite ore, rational development of the deposit, integrated use of mineral resources.*

Introduction

The basis of scientific subsoil use, theory and practice of rational use of mineral resources are the ideas of V.I. Vernadsky and A.E. Fersman. At the present stage, in the context of the enormous scale of extraction and consumption of mineral resources, the problem of integrated subsoil development and rational use of mineral raw materials has not lost its significance, but has become more relevant. The formation of an effective system of subsoil use based on the integrated development and use of the entire combination of subsoil resources, the use of low-waste resource-saving technologies, the greening of production and the competitiveness of the production of the mineral resource complex in the world market is a difficult scientific and practical task.[14] [13]

The main way of rational use of minerals as sources of raw materials and energy is to improve production methods to increase their extraction rate from the subsoil during field development, reduce waste during production, in the process of enrichment and processing, and complete utilization of all useful components.

Obviously, the next step is to treat complexities as a part of rationality [20]. The most optimal is the supply of mineral resources for transmission, from one side, more

detailed live births at the stage of development, more expensive and more efficient operation, more integrated services, and more, there are several different components that are connected to each other. We have a wide range of industrial and mineral components, a comprehensive integrated mineral and mineral base, as well as large quantities and mineral reserves, as well as a large number of mineral products and mineral resources. The oaths of the puffy and skelny pork, as if I wrestled with the cistern of the Syrovini, the pink rose of corisene copalini for the car's method, hurriedly transmuted millions of tons in Ukraine.[21] [17] [29].

Today, graphite is an important industrial raw material for many countries of the world. Already, the United States, China and the European Union classify this mineral as of strategic importance. China, which produces graphite the most in the world, has introduced a 20% export duty (plus 17% VAT on the export of minerals from the country). China has also established an export licensing system in order to reduce the export of raw materials from the country and thereby more efficiently provide its own industry.

Ukraine, occupying one of the leading places in the world in terms of total reserves of graphite, has now found itself in a difficult position in providing crystalline graphite and products from it. Graphite production at the only Zavalevsky field under development has sharply decreased in recent years. The Zavalevsky graphite plant has a design capacity of 50-60 thousand tons of graphite per year, currently it produces no more than 10-12 thousand tons of graphite concentrate.

The directions of development of the graphite industry of Ukraine are spelled out in the "National Program for the Development of the Mineral Resources Base of Ukraine for the period until 2030", where the priority tasks are to identify active reserves of graphite in the territory of the Ukrainian graphite-bearing province, conduct appraisal work on already identified areas and modernize production at Zavalyevsky graphite combine.

The aim of the review work is to analyze the prospects for using the entire resource base of the Zavalievsky graphite deposit, to consider ways of its rational development and integrated use of raw materials.

The geological structure of the district Zavalievsky graphite deposits. The area of the Zavalyevsky graphite deposit is located within the southeastern part of the Ukrainian Shield and is part of the Pobuzh branch. Belotserkov-Odessa structural zone. The largest folded structures of the crystalline basement of the area are the Bandurovsky and Pervomaisk-Golovanevsky anticlinoria, separated by the Sinitsovsky syncline. The abovementioned antilinorisms in the gravitational field correspond to significant anomalies of gravity in size and intensity.

The Zavalevskoye deposit is located at the junction of the Bandurovskaya and Sinitsovskaya structures and is confined to the wings of a large synclinal folded structure and order, which is part of the Khashchevato-Zavalevsky synclinorium.

The geological structure of the region is characterized by the presence of two distinct structural floors: the lower, complex, intensively deployed crystalline products and their weathering products, represented by almost horizontally occurring rocks of the sedimentary cover.

The rocks of the basement belong to the Archean and the Lower Proterozoic. Sedimentary formations are provided by the Neogene system and Quaternary sediments.

In the general section of the territory of the district, the Cenozoic, Mesozoic eratemic (Phanerozoic) deposits and the Paleoproterozoic, Neo-Archean and Paleo-Archean eonotem deposits are distinguished.

The Zavallian graphite deposit is a constituent of the Zavallian syncline of 5 km long latitudinal extension up to 2 km wide, located in the field of migmatites and granites. The core of the structure is composed of carbonate rocks (calcifers). The middle part is composed of biotite-graphite and biotite-garnet gneisses and quartzites and is a productive column of graphite ores. The outer part of the structure is composed of biotite, amphibolite and nitroxene gneisses in the south wing of the structure, which in the north wing are transformed into blacks.

The deposit is located in both wings of the syncline, forming two zones of ore-bearing graphite-containing gneisses (North and South). The main part of the deposit is within the North Wing of the syncline. The total length of the Northern Ore Zone is 3.7 km, the capacity is from 150 to 390 m.

There are 6 sites in the deposit: in the Northern Ore Zone - the Southeast, the Middle and the Andriyivka Farms, and in the Southern Ore Zone - the Right Bank, the Southern and the Southern Strip sections (Fig. 1, Table 1).

The ore zone consists of a rhythmic interlayer of quartzites, biotite-graphite and biotite-garnet gneisses, garnet-quartz skorneids, as well as (to a lesser extent) sillimanite gneisses and calcifers. All lithological varieties are overlain by laminate and lenticular bodies with inflations and clamps. The overall extension thicker 290-300 ° fall almost vertical. Graphite is present in all rocks of the ore zone up to 1-2%, in biotite-graphite gneisses (ores) its content varies from 1-3 to 24%. The size of graphite scales reaches 1-2 mm.

An ancient weathered bark of area and linear types is common at the deposit. Depth of development of a linear bark of weathering is 100-150 m, but in the section

"Khutor Andriyivka" exceeds 200 m. Within the bark of weathering there are two technological types of ores - loose and half-baked. The ores below are dense. The boundaries between the types of ores are not fuzzy and gypsometric.

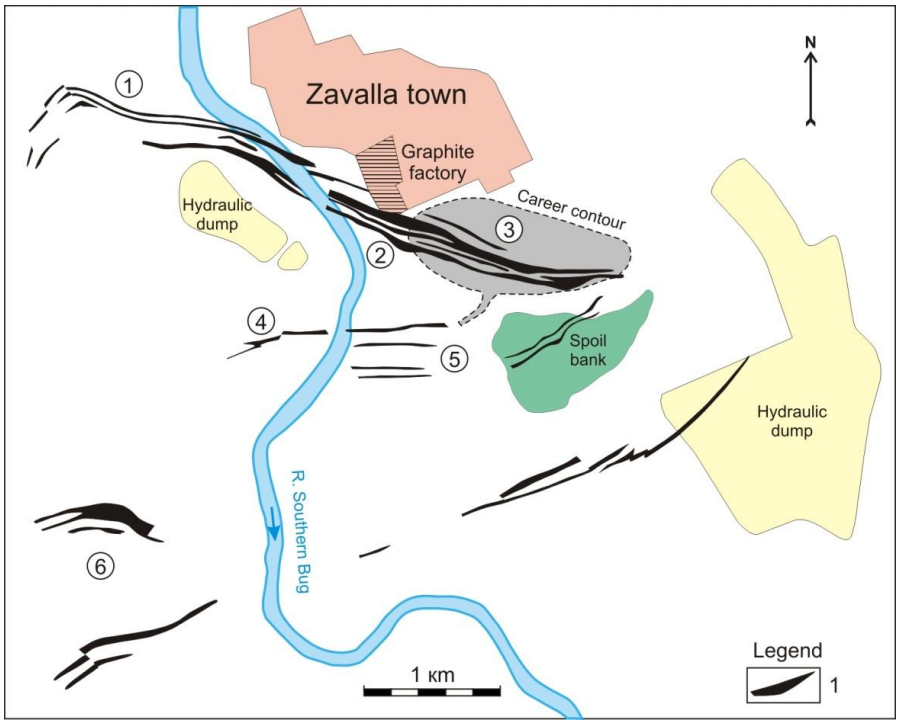

Рис. 1. Схема локалізації графітоносних ділянок Заваллівського родовища:
1 – графітові рудні тіла; цифри в кружках – графітоносні ділянки: 1 – Хутір Андріївка, 2 – Проміжна, 3 – Південно-Східна, 4 – Правобережна, 5 – Південна полоса, 6 – Зарічна
Fig. 1. Localization scheme of graphite-bearing areas of the Zavalivsky deposit:
1 – graphite ore bodies; numbers in circles – graphite-bearing areas: 1 – Khutir Andriyivka, 2 – Promizhna, 3 – Pivdenno-Skhidna, 4 – Pravoberezhna, 5 – Pivdenna polosa, 6 – Zarichna

The main raw material for the production of crystalline graphite is biotite-graphite gneiss, to a lesser extent, biotite-garnet-graphite, sillimanite-garnet-graphite gneiss. Depending on the degree of manifestation of hypergenic processes and physical condition, three industrial types of graphite ore are distinguished, which are associated with technological properties, their material composition, and physical and mechanical properties.

Graphite in dense ores is typically a metamorphic mineral; in loose and semi-loose, it belongs to residual formations. Graphite is clearly crystalline represented by a scaly variety of 0.1-2 mm in size, rarely vein formations and micro-formations. In dense ores, graphite is found in intergrowths with rock-forming minerals.

Contacts between different types of ores are gradual.

The content of graphite in ore in the northern ore zone varies from 4-6.5% (Southeast, Intermediate) to 10-12% (Khutor Andreevka), in the southern zone - 6.6-7.5%. The average content of graphite in ore at the deposit is 6.86%, incl. in the current Southeast section the average content 6.26%.

The distribution of graphite in the ore is mainly uniform; the scales of graphite are oriented according to gneiss.

Ore bodies have a complex morphology and are not always linked along profiles. At the school. “Andreevka Farm” established 3 ore bodies of sub-latitudinal strike. The thickness of the ore bodies is from 18 to 80 m. Over a length of 500 m.

The average carbon content in ore is 9.8%. Ore bodies are traced to a depth of 100-130 m. Intra ore layers have a thickness of 15 to 30 m and are represented by quartzites, garnet gneisses, and skarns.

Uch. “Intermediate” is characterized by the presence of 12 ore bodies of various thicknesses and lengths. All bodies lie subparallel, have a stratiform or, less commonly, a lenticular shape, an unstable thickness and are separated by interlayers and lenses of barren rocks of various thicknesses. The total thickness of ore bodies along exploration lines varies from 50 to 300 m, the total thickness of intra-ore layers is from 4 to 50 m.The fall of ore bodies is subvertical from 75 ° to 90 °, in some cases bends of ore bodies along the dip and along strike are observed.

The length of the ore bodies varies from several tens

of meters to 1.4 km. The average carbon content in the ore at the site is 6.12%. Intra-ore interlayers are represented by skarnoid, calciphyres, garnet gneisses, and quartzites.

Uch. "Southeast" is characterized by the development of 14 ore bodies of various thicknesses and lengths. All of them were opened by the current quarry and a significant part of them was worked out by a fall of 30-130 m. All bodies lie subparallel, have a steep drop, a stratiform shape, varying thickness and morphology, and are separated by interlayers of gneisses, skarns, quartzites. The total thickness of ore bodies along exploration lines is from 25 to 190 m, the total thickness of barren interbeds is from 13 to 70 m. The average carbon content in ore, according to Southeast is 6.26%.

Uch. The South Strip is located in the south wing of the Zavalevsky structure. The geological structure and ore content is significantly different from the site. “Intermediate” and “Southeast”. The total thickness of the ore-bearing stratum ranges from 60 to 160 m. There are up to 8 ore bodies within the site, however, the main reserves of graphite ore are concentrated within the same body, which is closest to carbonate rocks.

The ore-bearing stratum is oriented mainly along the azimuth of 60 °. The main features of the site are: the small thickness of the ore bodies, their simple structure, the prevalence of the environment of the host rocks of amphibole-containing rocks. The total length of the ore-bearing thickness is 1450 m. The thickness of the ore bodies varies from 3 to 20 m. The average graphite content in the area is 6.75%. The ore content coefficient in the site reaches 0.97.

Uch. “Right-bank” is characterized by the development of one ore body, the strike of which varies along the azimuth of 55 ° - 82 °. The ore body has

stratiform shape, lies in accordance with the host rocks. The total length of the ore body is more than 1000 m. The thickness of the ore body along the strike varies from 16 to 34 m. The fall in the northern rhambes is 80 ° - 85 °. The average grade of graphite in the ore in the site is 6.59%.

Uch. Zarechny is one of the deposits of the Zavalievsky field. The river section is confined to the lower horizon of graphite gneisses of the Khaschevo-Zavalevsky Formation of the Lower Proterozoic.

According to the ore body, it lies with enclosing gneisses and pegmatites steeply falling to the north (75 ° - 80 °) and form a large mono deposit with a thickness of 80-1..0 m and a length of 550 m. Ores are represented mainly by biotitra and phyto differences of gneisses, less often graphite – garnet differences.

Areal and linear weathering crusts are developing above the ore deposit. The thickness of the areal weathering crust ranges from 10 to 50 m, linear to 200-250 m and more along tectonic faults. Within the Northern deposit of the Zarechny site, several transverse tectonic disturbances have been identified that limit the deposit from the east and west. The average ore grade in the Zarechny block is 5.3

Currently, the development of the field is conducted in an open way. Most of the industrial reserves are located entirely under the floodplain of the Southern Bug River, an enrichment plant and a settlement. For further mining operations, the construction of a dam and a drainage channel, the transfer of an existing processing plant and the alienation of 400 hectares of land are provided in an open manner. The total cost of these preliminary estimates significantly exceeds the cost of underground passage of graphite production. In this regard, it is envisaged the mining of the field in a combined way, ie. career development and transition to underground mining.

To make the transition to underground development requires the choice of opening schemes and method of preparation of the mine field, transport of ore and overburden, ventilation and environmental protection, justification of the possibility of using a chamber development system with the laying of the developed space with tails of enrichment[1].

Within the rock deposit, they form a syncline fold of the sub-latitudinal direction, in which the limestone lies in the core, and fringe its granites: from the northeast - black cherts, from the southeast - magmatites. The productive suite is traced on both wings of the fold in the form of two, almost equally oriented poloc (north and south).

The existence of a quarry at the "Southeast" site adjacent to the "Intermediate" makes it feasible to continue further exploration of the field in a combined way: refinement of the field at the "Southeast" section with an open pool to the mark of -19 m. underground method of production at the site "Intermediate". The "Intermediate" section is located on the north band of graphite rocks. Stretching rocks - northwestern, the fall is almost vertical (80 - 90 °). The ore-bearing strata is represented by alternation of biotito-graphite and biotito-garnet gneisses with skarnids, limestones and quartzites. The thickness of the ore-bearing thickness is 300 - 350 m. Graphite in the gyno-owl thickness was formed in the process of metamorphism due to the carbonaceous compounds contained in the primary-sedimentary thickness. Industrial concentrations of graphite are confined to kaolinized and chloritized gneiss differences. Separation of graphite is represented by aggregates of needle crystals or accumulations of scales 0.1 to 10 mm in size. Ore bodies are called enriched with graphite packs and layers. Their power ranges from 1 - 2 to 25.2 mm. Often ore bodies are wedged, joined together or split, which causes the number

of ore bodies in sections to vary from 4 to 8. The skornoid bodies traced within the ore thickness have the same morphology as ore bodies. The power of the bodies of the skarnoids ranges from 4 to 28 m in the west of the site and from 1 to 24 m in the east. The number of bodies of the skarnoids varies in sections from 4 to 6 [28] [26].

Given the conditions of the ore body and the terrain, we can conclude that it is advisable to use one of the two main options for opening the Zavalievsky deposit in the Intermediate area:

1. An inclined barrel and four adits traversed from the southwestern side of the quarry.

2. Three vertical trunks and four adits.

Further mining operations at the Zavalievsky graphite deposit are recommended in a combined manner, i.e. completion of the quarry to the level of -19 m and the transition to underground mining. The main result of this transition is the uninterrupted supply of graphite to its main consumers, the preservation of employment and the maximum possible preservation of the ecological balance of the region

Таблиця 1. Балансові запаси корисних копалин по Заваллівському родовищу графіту
Tabl. 1. Mineral reserves on the Zavalievsky graphite deposit

Area	Mineral reserves				
	Graphite ore graphite, thousand t	Overburden rock, thousand m^3	Garnet ore garnet, thousand t	Clay, loam million m^3	Black earth, thousand m^3
Khutor Andriyivka	6305 597				
Promizhna	41300,9 2546,0	70705	16300 2808		
Pivdenno-Skhidna	22594,3 1481,8	52722,2	4014,5 615,5		
Pravoberezhna	5177 322,9	6032			
Pivdenna polosa	5028,1 310				
Zarichna	18949,6 1052,2	33962			
All over the field	99354,9 6309,8	163421,2	20314.5 3423,8	2,0	
In addition, in a special dump			1739,2 271,8		19,0

In general, the rational development of the Zavalievsky graphite deposit involves:

1. Transition to underground and combined production of graphite ores, which will increase the volume of active reserves of graphite ores available for the Zavalivsky deposit without degrading environmental performance;

2. Improvement of graphite ore enrichment schemes at the mill, which will significantly reduce the loss of raw materials, ensure profitability of involvement in the development of poorer ores, as well as involve in the reprocessing of flotation enrichment tails containing significant additional volumes of graphite;

3 Due to technical innovations, increasing the range of the graphite products of the plant, which will increase its competitiveness;

4 In parallel with the development of Zavallovsky field to develop a network of subsidiary small and medium-sized enterprises, with ore enrichment in place. Exactly such enterprises produce 85% of graphite in the world.

5 Utilization of the (current) Southeastern Quarry for waste heaps and tailings.

One of the most important components of the rational development of the Zavalli field is the integrated use of its raw materials. At Zavalevskoye field, in addition to graphite, quarrying is conducted, reserves of pomegranate are calculated, and there are a number of other minerals. Thus, now Zavalevskoye field is considered a complex object, the raw material potential of which is still far from being exhausted.

Building stone (rock crystalline rocks) [15]**.** Currently, only overburden rock, represented by carbonate-silicate (calciphyres, skarnoids) and silicate (charnokites, migmatites, gneisses, quartzites) rocks, occurring in the form of large massifs (charnokites, calciphyres) are mined in the Zavalievsky graphite deposit at present. and steeply falling stratiform deposits alternating with ore bodies (gneisses, skarnoids, quartzites, etc.).

The rocky outcrop in the contours of the active quarry

of the Zavallevsky deposit of graphite is represented by carbonate-silicate (calcifers, skarnids, dolomitized rocks) and silicate (blackheads, migmatites, gneisses, quartzites) rocks occurring in the form of relatively large black rocks, bodies mainly of sub-latitudinal extension and steep, close to vertical, falls, interbedded with ore bodies (gneisses, quartzites and others). Of many varieties of crystalline rocks as a building stone of practical interest are the homogeneous thicknesses of calcifiers of the Buz series and migmatite-chernokitoids of the ultrametamorphic complex complex, among which the degree of surface weathering is distinguished by these unstained and unstable processes.).

Calcifiers are the most widespread group of carbonates of rocks, which surround the thickness of graphite rocks from the south flank within the southeastern part and, as a whole, form the central part of the Zavallian structure. Along with calcifers with gradual transitions lie small lenses of calcite-dolomite marble. The horizontal power is thicker in the central part of 1500-1800 m, in the eastern part sharply decreases to 50m.

Charnokitoids (black-migmatites and enderbit migmatites) occur in the northern and northeastern parts of the Southeast.

Scarnoids, calcifiers, quartzites, biotite-garnet gneisses, which lie in the ore zone between graphite gneisses, can also be used as raw material for rubble and rubble.

Комплексом лабораторных испытаний образцов скальных пород вскрыши (минералогические, физико-механические, петрографические и др.) определена возможность применения свежих и затронутых выветриванием скальных пород для применения их в строительстве и для производства будівельного щебеню і бутового каменю.

The total reserves of construction stones in the Zavallovsky field, which are calculated in four sections - Intermediate, Right Bank, Zarichna and Southeast, make 163421,2 thousand m3 (Table 1).

The existing production of rubble from the rocks of the Zavallevo deposit has a capacity of 60 thousand m3. per year. In addition to the volume of rock deposits in the area, there are rubble and stone rubble production companies, the Gayvoronsky Special Career and the Chernokit LLC, which have significant reserves of high quality rocks and the necessary development infrastructure.

Garnet.] Ukraine has one of the most powerful raw material bases of garnet in Europe [12].[4]. Garnet reserves have been explored at a number of sites in the Kirovogradskaya (associated reserves of garnet Zavalevsky graphite deposits) and Vinnitsa (Ivanovo granite deposits with associated reserves of garnet) regions. Significant volumes of garnet raw materials can be mined as a by-product during the development of Krivoy Rog iron ore deposits [11] [2] [25].

Nevertheless, garnet raw materials are not mined, although research results indicate that Ukraine's garnet are promising abrasive raw materials, their technical properties are not inferior to garnet of world producers and are competitive in the world market [18] [7] [9].

Garnet raw materials of the field today have significant prospects. In the productive stratum of the deposit, along with biotite-graphite gneisses, biotite-garnet gneisses are widely spread, which have been studied and evaluated as a source of abrasive garnet production. Garnet-biotite gneisses are developed in the ore zone in the form of lens strips, up to 1 km long, with a thickness of 1-2 to 100 m, often of a complex configuration, in contact with graphite gneisses, charnockites, and skarnoids. Garnet is represented mainly by almandine with a fineness of mm in the form of grains, accumulations of grains. Garnet crystals have microcracks; in the zone of development of the kaolinite weathering crust, garnets are replaced by iron hydroxides; in the disintegration zone, garnets are destroyed by fracture. The garnet content in the ore ranges from 6 to 300 kg / t, an average of 167 kg / t.

As the results of the study showed, grenades of the Zavalievsky deposit with M28 grit are completely, in their abrasive properties, identical to Wiop grenade W2 (of the same grit) [18].

Conducted by A.A. Kalashnik et al.[7] studies of the fracturing of garnet particles from the concentrate of the Zavalevsky deposit show that they are characterized by low values (0.550-0.590 mm-1), which indicates the high quality of the obtained garnet concentrate by this indicator

The deposit estimated reserves of biotite-garnet gneiss (abrasive) in the amount of 26.8 million tons.

Clay and loam. The bulk of the rocks at the deposit are clayey rocks, which are represented by Baltic red-brown clays and Quaternary loam. Macroscopically from the bottom up the section can be distinguished the following varieties:

- greenish-gray, gray, viscous, dense plastic clays, with a capacity of 0.5 to 6.5 m (Baltic age, Neogene). Distributed in the slope of the plateau in the area of the South-East;

- red-storms and storms that cover the Baltic almost everywhere. Sandy, viscous, containing carbonate couplings. Power 1-20 m;

- red-brown and brown loam (lower-middle-quarter). Dense, with limestone buttresses, 13-188 m thick

- fawn-yellow, microporous, carbonate, with fine

limestone shallows loess-like loam (upper quaternary). Power of 3-12 m.

All these varieties belong to low-melting, less often to high-melting raw materials with medium and low content of carbonates. According to the results of loam tests, their possible use as raw materials for brick production. A brick of light terracotta color was obtained by the method of plastic molding of grades 100, 125, 150. Loams can be used in the production of ceramic materials as an additive or as the main raw material with additives of other components to obtain expanded clay. Almost all types of clay syrovini can be used for virology, including for the reconstruction of hydraulic equipment for gentry work.

The total loam volumes during quarry reconstruction are over 2.0 million m3.

Thus, the results of the study of the technological properties of clay rocks from the Zavallevsky deposit of graphite indicate high quality of products from these raw materials and low cost, taking into account the development of mining operations for the extraction of graphite ore.

Sands. In the Zavalli field, sand in the form of lenses with a capacity of 1-10 m is distributed among the rocks of the Neogene Baltic world and Quaternary sediments, a considerable amount of sand mass is also concentrated in the production waste. Today, it will be appropriate to test the sands according to the new regulatory requirements in order to use them as a basis or component of mixtures in the construction of roads and airfields; as ballast material in landscaping and planning works; as small aggregate of concrete (heavy, light, fine-grained, special purpose, etc.), mortars, dry mixtures, aggregate and component for production of dense concrete of dense structure, cellular concrete of autoclave and autoclave curing, silicate brick, stones, etc.

Mineral pigments [30]**.** Minerally studied at the field are also mineral pigments. In the area of Khutir Andriyivka, during the geological exploration and further development, the ocher-red bark of weathered iron quartzite was detected. Within the northern ore zone within the quarry of the Southeast a number of development sites of clay-hydromica, siliceous-celadonite rocks with gray-green, green color have been established. Previous laboratory studies have shown satisfactory qualitative characteristics of these natural pigments. The fundamental possibility of their use in aqueous emulsion paints of dark colors is established. Their use is possible with selective recess, special separate storage and development of enrichment technology and preparation for further use.

Colored stones/ [23] [24]**.** At the Zavalievsky deposit, epigenetic low-temperature processes are widely manifested - chloritization, kaolinization (argillization), opalization, silicification and silicification, pyritization, limonitization. Currently, there is evidence that these processes are not only due to the development of a powerful linear and areal weathering crust, but are also a consequence of superimposed hydrothermal processes at the final stages of the development of the Zavalevsky structure [5] [28] [26]. Intensive “weathering” is due to the permeability of the zone for solutions and the nonequilibrium nature of the rocks performing it [30]. As a result, in the local areas of intensive hydrothermal processing and weathering of gneisses, skarnoids and calciphyres, a peculiar complex of rocks and minerals was bred, which is of interest both as raw materials for jewelry making and as a valuable collection mineralogical material.

The manifestations of jasper in the Zavalivskoye field are confined to the rupture disturbances, in which powerful bark of linear and square type weathering was formed.

Most of the jasper rocks formed in linear weathering bark are dated to kaolinite and kaolinite-chlorite-hydromica weathering, which develop along biotite-graphite and biotite-garnet gneisses. Here, within the Zavalivsky field, jasper occurs in the form of veins, veins, lenses with a capacity of 5-40, sometimes up to 80 cm or more. The color of jasper is mainly greenish-brown, white-brownish-green. Mineral composition of jasper: chalcedony (80-95%), quartzine (up to 10%), iron hydroxides (2-5%), seladonite (1-2%).

Linear weathered bark is associated with highly decorative pits, mainly with spherulite and spherulite-veined texture. Colors - mainly in brownish-yellow-green, dark green, white-yellowish-brown and other colors. Jasper is well processed and accepts mirror polishing. By the sizes of fragments and coloring they can be used both for production of jewelry (cabochons, inserts, necklaces, etc.), products (balls, eggs, pyramids, table decorations), and as collections.

The second type of jasper is associated with area bark of weathering formed on calcifiers. They occur in the form of minor veins of siliceous-glandular cavernous fines, 1-10 cm thick. Jasper color is mostly brown, yellow-brown. As well as the jasper from linear weathered bark, it is well processed and accepts mirror polishing. These jasper can be used for the manufacture of cabochons, various inserts, as collection specimens, rarely for the manufacture of small products [27] [19] [3].

Thus, the Zavalivsky quarry has a high decorative, textural and consumer characteristics (nice color and texture, large debris) and is well processed. Due to this, they have excellent consumer characteristics and are suitable for a variety of jewelry and jewelry.

The deposits of this jasper are within the current career. Therefore, their extraction as associated raw material, which now goes to the waste heaps, does not

require significant investment and can be carried out individually (in a "diligent" way) subject to change of legislation that will allow such activity.

In addition to jasper, in the areas of superimposed low-temperature processing and weathering crust in the quarry walls and dumps, highly decorative agates are found that can be used as ornamental stones and collection material [10].

Collection mineralogical material. Among the host rocks of the Zavallevo deposit there are veins of a unique, rare in the world mineral of grautite [8] [22]. Mineralogical interest is also the presence of barite, horsexite, pyrite, galena, clusters of coarse-grained graphite, etc.

Collection and sale of their specimens as a collection material, the organization of mineralogical excursions can have some economic effect [16] [6].

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Таблиця 2. Перспективи раціонального використанна сировини при розробці Заваллівського родовища графіту
Tabl. 2. Prospects for rational usage of raw materials during Zavalivsky graphite deposit development

Raw materials	Localization of raw materials types						Promising Applications	Economic importance	Recommendations for rational usage of raw materials
	Crystalline wall rocks	Secondary alteration zone	Weathering crust	Overburden rocks	Waste of ore concentration	Spoil			
Graphite	●	●	●		●		Refractories, electrodes for metallurgy, rechargeable electric batteries, fuel cells, products for nuclear plants	Countrywide	Product range expansion. Optimization of enrichment schemes
Garnet sand	●		●			●	A wide range of abrasives, drinking water filtration	Countrywide	Innovations in enrichment technology
Rubble stone	●					●	Crushed stone, rock debris	Local	Increase in production
Sands				●	●		Ballast material in construction, silicate brick, concrete	Local	Testing according to new regulatory requirements
Clays, loams				●			Ceramic materials: brick, expanded clay	Local	High quality raw materials of low cost
Quartz-feldspar raw materials					●		Glass industry	Local	Additional testing of dump materials
Ocher, Seladonite		●	●				Mineral pigments for construction	Local	Development of enrichment technology
Jasper, Opal, Agate, Grautite		●	●			●	Jewelry and decorative products; collectible mineralogical materials	Aesthetic	Trial batch of products
Black earth						●	Reclamation of dumps and spoil	Local	Reclamation plan development

Conclusions.

Integrated use of raw materials is one of the most important components of rational field development. This is especially relevant for the Zavallian graphite deposit, as the potential for integrated use of its raw materials is far from being exhausted (Table 2): (1) the pomegranate deposit has significant prospects today, as the deposit is the only one in Ukraine to develop pomegranate ores; the technical characteristics of the pomegranate concentrate of the Zavallevo deposit are not inferior to the pomegranates of world producers; (2) the enterprise does not realize all the rock volume of the overburden for the production of building stone; (3) the sands, clays and loam of the rocks of the disclosure are characterized by high technological indices and need to study the economic feasibility of their selective development; (4) the raw materials of the graphite ore flotation tails deserve further study for use in the building materials and glass industries; (5) the use of mineral pigments (ocher, seladonite) is possible with selective extraction, special separate storage and development of technology of enrichment and preparation for further use; (6) Jasper, chalcedony and opal formations of the Zavalovo deposit have high decorative, textural and consumer

characteristics and are suitable for the production of various jewelry and jewelry; (7) among the host rocks of the Zavallevo deposit there are veins of unique, rare in the world mineral of grautite, mineralogical interest is the presence of barite, horsex, pyrite, galena, clusters of coarse-grained graphite, etc. Collection and sale of their specimens as collection material, the organization of mineralogical excursions can also have some economic effect. The introduction of rational methods of development and integrated use of Zavallian graphite deposit will allow to consider this object as strategically important for the Ukrainian economy

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РАЦІОНАЛЬНЕ ВИКОРИСТАННЯ МІНЕРАЛЬНОЇ СИРОВИНИ ПРИ РОЗРОБЦІ ЗАВАЛЛІВСЬКОГО РОДОВИЩА ГРАФІТУ

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У роботі на основі аналізу перспектив використання ресурсної бази Завалліського родовища намічено шляхи раціональної розробки і комплексного використання його сировини, що включає перехід на підземний та комбінований видобуток графітових руд, вдосконалення схем збагачення, збільшення асортименту графітової продукції комбінату, використання відпрацьованого кар'єру для відвалів розкривних порід та хвостів. Важливішою складовою раціональної розробки Завалліського родовища є комплексне використання його сировини: (1) гранатова сировина родовища має на сьогодні значні перспективи, оскільки родовище є єдиним в Україні, що розробляє гранатові руди; за технічними характеристиками гранатовий концентрат Завалліського родовища не поступається гранатам світових виробників; (2) підприємство не реалізовує всі обсяги скальних порід розкриву для виробництва будівельного каменю; (3) піски, глини та суглинки порід розкриття характеризуються високими технологічними показниками і потребують вивчення економічної доцільності їх селективної розробки; (4) сировина хвостів флотації графітових руд заслуговує на подальше вивчення з метою застосування в галузі будівельних матеріалів і для скляного виробництва; (5) використання мінеральних пігментів (вохри, селадоніт) можливе при селективній виїмці, спеціальному окремому складуванні та розробці технології збагачення та підготовки для подальшого використання; (6) яшми, халцедоніти та опалоподібні утворення Завалівського родовища мають високі декоративно-текстурні і споживчі характеристики і придатні для виготовлення різноманітних ювелірних і ювелірно-декоративних виробів; (7) серед вміщуючих порід Завалліського родовища зустрічаються жили унікального, рідкісного у світі мінералу граутиту, мінералогічний інтерес представляє присутність бариту, горсейкситу, піриту, галеніту, скупчень крупнозернистого графіту, та ін. Збирання і реалізація їх зразків як колекційного матеріалу, організація мінералогічних екскурсій також може мати певний економічний ефект. Впровадження раціональних методів розробки і комплексного використання сировини Завалліського родовища графіту дозволить розглядати цей обєкт, як стратегічно важливий для економіки України.

Ключові слова: *Український щит, Завальевське родовище графіту, графітова руда, раціональна розробка родовища, комплексне використання мінеральних ресурсів*