

**JUSTIFICATION OF THE EXPEDIENCY OF COMPLEX  
PROCESSING OF BASALT RAW MATERIALS AT PRJSC  
"RAFALIV QUARRY"**

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## **Summary**

This work is devoted to the study of the feasibility of implementing a research and production site for the extraction of copper concentrate and related metals from basalt mining mass at PrJSC "Rafaliv Quarry". In particular, issues of description of the technical essence of the project, possible areas of application of the extracted copper concentrate, assessment of the scientific and technical level of the project, technical and organizational conditions of project implementation, assessment of project implementation terms, results of marketing research of the product market, organization of advertising, assessment of entrepreneurial risks during implementation are considered.

Since complex processing of metal-containing basalt raw materials has not been carried out in Ukraine, and the presence of native copper in it is unique, there is a need to analyse the material composition and technological properties of each of the rocks in the ore preparation processes.

As a result of the study, it was established that the main carriers of copper mineralization are basalts, basalt tuffs and lava-clastic breccias with a very uneven content of copper in rocks of different petrographic composition. The copper content in basalts, tuffs and lava-classical breccias is up to 5%.

The developed approaches will make it possible to implement rational processing technologies for the extraction of copper concentrate and related metals from basalt mining mass at the experimental site of PrJSC "Rafaliv Quarry".

## **Introduction**

In the Rivne region (Ukraine), there are more than 600 mineral deposits, which are represented by 18 types. At the moment, 242 deposits are registered by the state balance sheet of mineral reserves, 84 of them have been developed by industry and 59 mining enterprises operate on their basis [1-3].

The program for the development and industrial development of mineral and raw materials resources of the Rivne region for the period until 2030 is aimed at the development of priority areas of geological research in order to provide the economy of the region and Ukraine with those types of mineral raw materials that are found on the territory of the Rivne region.

State and regional priorities include program projects, which provide for the continuation of geological prospecting for copper and diamonds.

There are also prospects for the discovery of industrial native copper deposits within the Rafaliv copper ore cluster and positive signs for the discovery of native diamond deposits in the northern regions.

Ukraine's projected needs for 2022-2025 will amount to more than 170,000 tons. Currently, Ukraine has no explored reserves of copper ores, but the prospects for discovering them are quite significant.

### **Prospects for extraction of copper from the deposits of the Western region of Ukraine**

The search for native copper deposits is conducted by the Rivne Geological Expedition of the Northern State Regional Enterprise "Pivnichgeologiya" in four areas: Tursko-Lugov, Kuhotsko-Volyn in the territory of the Volyn region, and Mid and Rafaliv in the Rivne region.

Exploratory drilling was conducted to test basalt rocks for copper and potentially possible precious metal mineralization within the Rafaliv ore complex. A total of 56 wells with a depth of 4 to 178 m, with a total volume of 5,493 linear meters, were drilled. 746 samples were selected for determination of copper content, 35 samples for determination of physical properties of rocks, 44 samples for conducting other studies [3, 4].

As a result of the performed works, a clear timeliness of copper mineralization to lava breccias and unaltered basalts at the bottom of lava basalt flows was established.

The range of copper mineralization reaches several meters with copper content from 0,1 to 0,76%.

Native copper was also found in the lava breccias of the lower basalt flow in the southwestern part of the Rafaliv quarry on an area of 2,5 hectares.

The Rafaliv ore node is located in the western part of the Rivne region. The Kyiv-Warsaw railway and highway pass through its northern part.

The prospect of native copper mineralization is confirmed by the large volumes and wide area development of ore-bearing rocks, the presence of several ore horizons with established industrially significant copper contents in ores, the native nature of mineralization, manifestations of accompanying mineralization, the possibility of complex use of ore-bearing rocks, favorable mining and technical conditions for the location of ore horizons, ecological safety of ore processing [5-7].

Copper mineralization is represented mainly by native copper in the form of finely fine-grained, lamellar dendrites and nuggets weighing up to 700 g. The distribution of copper in the rock is uneven. It is concentrated in the cement of lava breccias, in the spatial association and nests of the analcime mineral. The copper content varies from 0,05 to 5,24%.

The performed works revealed two zones of mineralized lava breccias with a thickness of up to 1,6 m, which extend in the meridional direction for a distance of 1,0 and 1,5 km, respectively, with a width of 200-400 m.

Precious metal mineralization is developed in copper-bearing lava breccias and minor volumes: silver 5,4 g/t, gold up to 0,007 g/t.

The State Geological Service of Ukraine developed and approved the "Program for the Search and Exploration of Native Copper Deposits within the Rafaliv Ore Node", which provided for the completion of searches within the Rafaliv Square and conducting prospecting and evaluation works in its most promising areas [1, 5].

After completing the search in the South Rafaliv area. Technical and economic considerations were made according to 8 options: commercial products (copper concentrate and copper metal), with an on-board content of copper in the ore of 0,1; 0,2; 0,3; 0,4% using 75% enrichment tails. Positive profitability is achieved with an on-board content of 0,3; 0,4%.

According to the results of the geological and economic assessment, a site with an area of 23,6 km<sup>2</sup> with promising resources of the P<sub>2</sub> category in the amount of 761 thousand tons of copper was allocated, on which works of the exploration and evaluation stage are being performed [2,7].

The main tasks of this direction are:

carrying out prospecting and evaluation works at the Rafaliv ore node for the preparation of prospective ore deposits (deposits) for exploration;

exploration of one of the best discovered deposits and its preparation for industrial development with estimated reserves of 1 million tons of copper.

**Justification of the implementation of the research and production site for the extraction of copper concentrate and related metals from basalt mining mass**

*Brief description of the technical essence of the project*

Currently, the area of the Volyn copper ore district has been studied by geological surveys and deep geological mapping. Geological mapping was accompanied by geophysical research: gravity, magnetic, electrical exploration, profile seismic exploration.

According to the State Department of Ecology and Natural Resources, there are several hundred deposits of various minerals in the Rivne region. From an economic point of view, copper deposits are the most interesting. According to preliminary calculations, the resources of this metal in individual deposits near Rafaliv can reach from 100 to 600 thousand tons in terms of pure copper. Currently, two search areas have been allocated on the area of the ore node measuring 40×50 km - Midsk and Rafaliv.

According to the indicators of the assessment of the native copper deposit of the Rafaliv site on the area of ore horizons of 4,85 km<sup>2</sup>, the forecast resources of copper are 1.4 million tons, gold - 24,0 c.u., silver - 600 c.u., platinoids - 20,0 c.u. Estimated resources of multi-component ore - 20,4 million tons, copper - 1,326 million tons. The mining life span is 13,6 years.

It is proposed to organize a research and production site for the mining and extraction of native copper and related materials in the conditions of the active basalt quarry for the purpose of further sale on the market of Ukraine. It is also proposed to work out an effective processing technology for the development of a technical task for the creation of a larger-scale enterprise.

Currently, the work has established the regularities of extraction of copper nuggets with different methods of crushing and classification of basalt and tuff. The regularity of the formation of the core of valuable components (containing 90-95% of minerals) during hydraulic washing and hydraulic transportation of the mining mass was previously established. On this basis, the technology of finding the core of minerals and its selective extraction was developed.

The end product of production is native copper or a concentrate (since there are joints of copper with host rocks).

The second product of copper enrichment is pure basalt or tuff. Currently, basalt is used only as a building material in the form of crushed stone of various fractions. But factories in Ukraine have mastered the petrological technology of making ecologically clean

heat-insulating wool from molten basalt, which is widely used in construction.

After enrichment and extraction of useful components, tuff is a ready-made material for the manufacture of water filters, it is used as a feed supplement for livestock and poultry, and also as an ameliorant for sod-podzolic soils. Tuff flour is suitable for the production of building ceramics, high-quality bricks and expanded clay.

#### *Possible areas of application of the product*

The use of copper is quite diverse and covers all branches of mechanical engineering, instrument building, electrical engineering industry, transport (trolley of trains, trolleybuses, trams), radio-electronic industry, etc. Considering the shortage of copper in Ukraine, the realization of the product does not cause difficulties. The use of basalts for construction and the chemical industry will continue in the established order with the search for new areas of application.

The use of tuffs has not been mastered by various areas of the national economy, therefore, first of all, it is necessary to carry out a set of technological studies of their properties and develop technical conditions and recommendations for expanding their use. But even now, tuff, following the example of the "Tashki" deposit in the Slavut District, is an important raw material component for the fodder base.

#### *Evaluation of the scientific and technical level of the project*

The shortage of copper in Ukraine is quite noticeable, so the search for this important non-ferrous metal has been intensified. According to the state program "Copper of Ukraine", scientific research in this direction began to be conducted more actively. Only the scientists and specialists of the implementing organizations of this project published monographs, dozens of articles in special publications, trained doctors and candidates of sciences, created more than a dozen inventions on specific problems of technology and equipment. For several years, research and the search for technological solutions for industry have been conducted with the participation of academic science.

The results of this work made it possible to draw up a regional program of comprehensive development of Volyn basalts for the extraction of native copper and other valuable metals.

### *Technical and organizational conditions of project implementation*

Implementation of this project can be submitted in 3 stages.

1st stage - research and production area. Pre-industrial preparation of technology and equipment for copper mining. Production will be organized at a basalt quarry in the form of an experimental site (at the first stage). On this site, the most effective equipment will be selected for the implementation of the technological scheme of the enterprise, semi-industrial research will be conducted on the extraction of copper or its industrial product, the equipment of the premises for the staff of the work stations, storage areas and premises for all types of products, communication and transport networks will be allocated.

The 2nd stage is the expansion of the city's enterprise and the mastering of the fine technology of extraction of associated metals, which are in the processed mining mass (gold, silver, platinum, etc.). Volcanic tuff contains most of iron, titanium, manganese, zeolites, smectites.

The development of the technology of their extraction can be carried out together with the main process, but the development of a new technology increases the range of innovative products and increases the profitability of the enterprise.

The 3rd stage is the comprehensive processing of basalt raw materials using a waste-free technology that is environmentally friendly.

This stage develops mainly due to the increase in the volume of the enterprise. Its implementation is planned for the second five-year period of this project.

According to the project, the creation of a research and production site is planned on the territory of the Rafaliv basalt quarry (Ivanchi village, Volodymyretsk district, Rivne region), which produces basalt for the needs of the construction industry. Associated materials in the basalt deposit, such as tuff and lava breccia, are only partially used.

On the territory of the quarry in the safe zone there is a one-story building, which is currently not in use and, upon agreement with the quarry management, can be rented out. It requires repairs, the cost of which is provided for in the estimate of this project.

The total area of the territory leased for the plot is 820 m<sup>2</sup> (20,5×40 m), including the production premises of 220 m<sup>2</sup>. It consists of four separate

rooms with areas of 25 m<sup>2</sup>, 33 m<sup>2</sup>, 133 m<sup>2</sup> and 25 m<sup>2</sup>, respectively. In these rooms, it is planned to place the equipment of the site.

The territory of the site is located 600 m from the crushing and sorting area of the quarry crushing factory and one kilometre from the quarry management house.

There are no communications (water, heat, electricity) in the house. It is necessary to install a power transformer and connect a power transmission line.

The site requires a fence, improvement of the territory, and heating of the premises in the cold season. There are access roads to it both from the side of the quarry and from the side of quarry management.

#### *Assessment of project implementation terms*

The launch of the research and production site is planned to be carried out within 4 months. During this period, it is planned to perform the following works:

- purchase of the main site equipment - 3 months;
- construction and installation work on the site - 2 months;
- to carry out the development of the technical task, the development of the site project - 1 month.

It is planned to carry out scientific and research works, as well as works related to obtaining technical conditions in permitting authorities (State Inspection, SES, ecology, energy inspection, etc.) and licenses within 18 months.

#### *The results of marketing research of the product market*

The offered products are: native copper (main product), crushed basalt, tuff (by-products). Subsequently, after improving the technology of enrichment of the extracted mining mass and establishing the amount of associated metals that the technology will allow to extract, its products will additionally be valuable metals. The product will be sold directly by the customer and with the help of dealers.

Product market analysis. A significant need for copper in Ukraine is met by imports (currently about 250,000 tons per year). Copper is not mined in Ukraine - only geological exploration work is being



carried out, which has already shown that its reserves in the bowels of the country make it possible to conduct pre-industrial preparation.

There are a small number of native copper deposits in the world. Its development was carried out in the past centuries with the appropriate technique and technology, therefore, modern technologies, among other things, take into account the peculiarity of the host rocks and the geology of the deposits, based on new possibilities.

*Assessment of business risks during the implementation of the proposal*

During the design of the experimental site, project risk assessments were also carried out, which are presented in Table 1.

*Advertising organization*

For the successful sale of final products, the following advertising measures are planned:

1. Participation in industry exhibitions, scientific and practical conferences and symposiums.

2. Advertising in specialized international periodicals. Publication of scientific and scientific-practical materials on extraction and effective use of the entire range of innovative products. Proposals for the implementation of a new technology of production and use of products.

Table 1

Project risk assessments		
Possible risks	Risk level	Level justification
Risks associated with changes in the market		
Market trends	Very low	- market trends are positive both in the short term and in the long term. - positive dynamics of the demand in Ukraine for innovative products according to the project.
Terms of competition	Very low	- the presence of advantages in consumer characteristics and significantly lower cost of innovative project products compared to imported ones. - lack of competitors in the country, as this type of technology is being used for the first time. - presence of significant demand in the domestic market.
Inflationary and devaluation processes	Very low	- most costs at the enterprise are largely independent of exchange rate factors and can be repaid at the expense of the price of final processing products, which practically keeps the level of profitability unchanged.
Risks associated with management		
Lack of personnel	Low	- the developing enterprise has at its disposal experienced and qualified scientific and engineering-technical potential, which ensures a high level of technology. - the labor market in the area of the construction of the research and production site is able to provide the enterprise with the necessary qualified personnel. - the need for specialists of all professions under the project is met by educational institutions of Ukraine.
Risks associated with production		
Production process	Low	- the production program according to the project takes into account the lowest copper content in basalt and tuff deposits, but fluctuations in the content can be tenfold. Therefore, the production process must ensure the planned indicators of native copper extraction at a high technical level.

3. Advertising in periodicals of Ukraine. The natural uniqueness of native copper deposits allows to simplify the technology of its extraction, and the possibility of having chemically pure copper as the final product significantly changes the technology and improves the products of the customer enterprises. This refers to the electrical engineering industry.

4. Creation of your own website on the Internet with constant renewal of its information about the volume of production, examples of wide industrial use of all innovative products, recommendations for their use in non-traditional sectors of the economy and proposals for implementation. And here it will be important to show finished products, examples of their use as documentary tapes at specific enterprises.

### **Conclusions**

According to the results of geological surveying, prospecting and thematic works, four ore nodes were identified in the region: Gornikovsk, Kuhotsko-Volsk, Rafalivsk and Shepetilivsk.

The potential resources of each of them are estimated at 5-7 million tons of copper.

It was established that the main carriers of copper mineralization at PrJSC “Rafaliv Quarry” are basalts, basaltic tuffs and lava-clastic breccias with a very uneven content of copper in rocks of different petrographic composition.

So, for example, if in basalts and tuffs there is native mineralization with a copper content of up to 1% in the ore interval of 1,5-2,0 m, then in lava-classic breccias it varies from 0,04% to 5,0%. It has been established that copper deposits are promising for production and require further study and preparation for experimental and industrial copper mining.

The justification for the use of the work results in the form of the efficiency calculations of the innovative construction project use of the site for complex processing of basalt raw materials in the production cycle of the quarry has been developed.

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