

## Strategic Directions for the Rational Development and Beneficiating of Mineral and Resource Potential of the Krivbass Subsoils

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Basic systemic factors of developing the methodology of extraction and enrichment of the Krivoy Rog iron ore basin at various stages and life cycles are highlighted.

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### Introduction

Urgency of the issue of rational use of mineral and resource potential of the Krivbass subsoils is determined by the fact that iron ores are the most important factor of forming the nation's and region's budget and, of course, prosperity of the majority of Krivoy Rog population, and the use of modern mechanisms of state regulation and complex development of mineral resources of the basin will provide the competitiveness of the national economy.

Currently, in the Krivoy Rog Iron Ore Basin three main types of iron ore are extracted: the rich ores, which are directly used in metallurgy, magnetite and oxidized ferruginous quartzite, requiring beneficiating processing.

Rich oxidized ores (reserves of which according to the industrial categories number over 1 billion 200 million tons) are deposited mainly among oxidized quartzites, creating about 300 ore deposits. Mass content of iron in them is from 46 to 67% and harmful impurities (phosphorus, sulfur, etc.) - hundredths of a percent. Mining rich ore is carried out mainly by underground methods.

Magnetite quartzites with Fe content 22-45% are beneficiated magnetically at mining and beneficiation complexes of Krivbass.

Oxidized ferruginous quartzites, which are simultaneously extracted from magnetite quartzites are currently not beneficiated, but stored, forming technogenic deposits. Development of magnetite and oxidized ferruginous quartzites is performed

predominantly opencast. Depth of most mines of Krivoy Rog Basin exceeds 300 meters, and underground mines - more than one kilometer. Along with the extraction and processing of iron ore Krivbass created huge technogenic deposits, what significantly complicates the ecological environment area.

### Methodology

Issues of managing subsoil use of Krivbass were discussed several times and from different points of view [1, 2]. The general conclusion can be formulated as follows: the market (market environment) can not provide effective development and use of areas of iron ores (rich oxidized ore, magnetite and oxidized quartzites) and therefore it is necessary to regulate it (to some extent) by the state.

The limited number of the best sites on the one hand allows their owners to receive an additional (rental) income on the other - can lead (under certain conditions) to its irrational exploration, development without beneficiation.

It should be mentioned that the concept of "rational development of the Krivoy Rog Iron Ore Basin," according to the companies and society (represented by the state) are significantly different, as they are determined by differences in views on the value of natural resources and its change over time.

### Results and Discussion

The objective was to study the rational use of

mineral types of iron ore raw materials both original and technogenic Krivbass deposits.

During the subsoil use there is always a pair (set) of interrelated subjects: deposit (subsoil area) that is state property and the entity, enhanced and developed (on license or contract basis).

In practice, the convergence of interests in a pair of «economic entity-deposit» for Krivbass is rather more exception than the rule. Over time, the development of iron ore raw materials is a fundamental change, the role of the deposit as the root cause of subsoil use process is reduced (as if "disappears").

The economic results of the deposit development "dissolve" in the economy of the organizational structure which owns the right to use this deposit. A striking example of this statement is that the amount of tax on extraction of iron ore raw materials does not depend on economic conditions of a particular deposit developed by a mine or quarry, but determined by the ratio of the UAH and dollar rate and the price of manufactured products on the international market. Eventually, each deposit as an object of economic activity is "dissolved" in the organizational structure of the company to which it belongs on a leasehold basis. And the company's business-how and in what way to represent the economic and, consequently, the production data on a full cycle of development and beneficiation process stage of the deposits area.

However, analysis of economic indicators dynamics, taking into account all the complex of the beneficiating processing at the level of each mine, quarry is important, especially because the costs of their development have been steadily growing as the exhaustion of reserves and deepening during the development of each mining-engineering object. A very reliable growth factor of economic indicators of deposit development and complex beneficiating processing of the mined ore is the introduction of new technological solutions for the final commercial products of iron ore raw materials from underground and opencast mines.

With large reserves of iron ore raw materials characterizing the long-term provision of existing enterprises of mining complex, it is necessary to develop and implement modern technologies of production and ore beneficiating, ensuring minimal loss of iron in the waste. Existing technologies allow obtaining market products that meet the highest international standards ores from both original and technogenic deposits.

For obtaining high-purity iron-ore concentrates the best raw materials are rich oxidized ores of

underground mining. At each Krivbass mine ore with Fe content 42-46% is stored. Its advanced processing will provide the simplified technology of beneficiating iron-ore concentrate with Fe content 65-66%. The essence of this technology lies in the ore magnetic beneficiating with pre-selective flocculation and desilting of disperse non-metallic particles.

Rationally processing oxidized iron ore with concentrate production, suitable for the manufacture of ferrites substantially provides the company with additional money.

Studies in recent years, showed that it is possible to regulate the behavior of the surface properties of metallic and nonmetallic mineral grains directionally by using mechanical activation methods during ore preparation of raw materials in the presence of modifier reagents.

Mechanical activation was carried out on equipment that allows to perform repeated activating effect on the grains of metallic and nonmetallic minerals in a single cycle. It was established that the modification on a unit of repeated effect on iron ore raw material improved the concentrate quality in 1-2 % and the loss of iron in the tails decrease by 3-4 %.

Mining of iron ore raw materials opencast compared to other directions of work requires more intensive use of industrial and natural resources.

Statistics analysis of more than 20 years of storage of slightly magnetic ferruginous quartzites does not fully point their proper quality and it would be very useful for both the state and for Krivbass if Krivoy Rog Mining and Processing Works of Oxidized Ores was built up and processed oxidized ferruginous quartzites of both current production and technogenic deposits with the primary shares ownership by the state.

The technology of processing oxidized quartzites has been currently developed and tested with production 65-66% Fe concentrate. Great interest to the complex use of oxidized ferruginous quartzites of Krivbass was showed by a delegation of high level engineers from the US company "Cleveland Cleaves", which has 150 years of experience in high performance processing of iron ore by means of environmentally friendly technology and intends to cooperate with our experts. There was developed a magnetic separation technology for magnetite quartzites of Krivoy Rog Basin without flotation finishing with production of concentrate with 67-68% iron.

Performed studies give reason to believe that the creation of advanced technology of

development and beneficiating of the Krivoy Rog Basin subsoils will not only allow efficient use of production resources, but also to achieve higher, compared to achieved ones, technical and economic indices of mining iron ore deposits in the designed circuits.

There is a number of different developments on complex processing of iron ore raw materials in the Krivoi Rog region.

Counteract the tendency of unsustainable development and use of mineral resources of Krivbass can be achieved in the following circumstances:

- by the competitive environment in the industry, i.e. the situation in which the company's subsoil users could not dominate the market and determine the level of allowable costs (economic reasons), and predict their dynamics;

- by prompting companies to continually improve techniques and technology of mining, ore raw materials beneficiating, the application of new approaches to the exploration and rational development of deposits;

- an effective system of state regulation and control of processes of subsoil use, including clear, transparent and goal-based system of monitoring, control, and most importantly, responsibility of the subsoil users for the state of the process of development and management of mineral resources of Krivbass.

The situation in the Krivoi Rog Basin is currently characterized by the fact that companies in the past few years actively used optional separate iron ore mining technologies, giving pay off in short term (without complex processing, together with magnetite quartzite and incidentally-produced oxidized quartzites).

Moreover, in recent years there has been increasing in the process of monopolization of the Krivoy Rog Basin subsurface use. Companies have considerable freedom to maneuver resources and capabilities in terms of switching the emphasis from one enterprise, processing iron ore deposit area, to another.

Much more complicated situation occurs when a company not only develops and designs a few deposits, but when these deposits were put into the development in different economic conditions and in different times. The latter means, for example, that one company came into the final stage of production and processing, the other is at its height, and the third is to be explored.

In this case, the state should regulate by legislation all developed areas and deposits of Krivbass and influence on the processes of

recultivation of the developed subsoils of each deposit, the newly formed waste heaps or ferrous mineral varieties which currently are not processed.

The main objective for all developers of subsoils of Krivoy Rog Basin is a life extension of the developed deposit through a complex treatment of all mineral varieties.

In order to provide high degree of extraction of ore minerals when developing the Krivoy Rog Iron Ore Basin it is necessary that companies contributed to the development of new technical solutions, both in their design and the beneficiating. For this purpose it is mandatory to invest for development of new, more advanced and highly effective solutions for the rational utilization of mineral resources of Krivbass, for complex processing of ferrous varieties on the basis of the developed methods of ore beneficiating with specific parameters of iron losses in waste production, corresponding to the best examples of foreign mining and processing enterprises.

### Conclusions

As a result of measures taken at different levels of the state, the country's mining industry, raw material base of Krivoy Rog Basin in the nearest future can be diversified by engaging in the development and beneficiating new types of ferriferous raw materials, as well as through the establishment of modern production facilities for its deep processing.

1. Iron ore raw materials of Krivbass have enough opportunities to ensure the state's economy by commercial products of the required quality by both current ore processing and technogenic deposits.

2. Rational development and beneficiating of the subsoils of Krivbass on the basis of regulatory documents should encourage companies to develop new and more advanced technologies.

3. Development of attractive terms for privatization of Krivbass if Krivoy Rog Mining and Processing Works of Oxidized Ores and its implementation for the processing of 0.5 billion tons of stored hematite ores and incidentally mined during quarrying.

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### **Стратегические направления по рациональной разработке и обогащению минерально-сырьевого потенциала недр Кривбасса**

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Отражены основные системные факторы при разработке методологии добычи и обогащения железорудного сырья Криворожского бассейна на различных этапах и жизненных циклах.