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PROJECT APPROACH TO BENEFIT SHARING DURING INDUSTRIAL DEVELOPMENT OF THE RUSSIAN ARCTIC

The article addresses the issues of the project approach to interaction and harmonization of interests of mining business, indigenous people and local authorities during industrial development in the Arctic. The projects of gold extraction from mining waste, disturbed land reclamation, removal of gold refinery tailings storages and construction of tundra roads for the local population using the processed waste are substantiated as a case-study of the Kular gold field in Yakutia. The ecological, social and economic criteria are proposed for the efficiency evaluation of the projects and selected combinations of their financing charts. The implementation of the proposed projects can enable accumulated waste management, use of secondary raw materials in road construction, reclamation of mining-disturbed land and its return to the indigenous people for deer breeding and hunting, as well as removal of hazardous waste of a gold refinery.

Keywords: *mining industry, Kular gold field, interaction of parties concerned, Arctic, Yakutia*
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Introduction

The social and economic development and the industrial advancement are closely intertwined in the Arctic. These activities affect the environment, the climate and the land populated by the indigenous people of the North [1, 2].

One of the challenges of the top priority in the industrial development of the Arctic is the elimination of the accrued economic damage resulted from mining activities in the past. For instance, the 2020 Strategy for the Development of the Artic Zone in the Republic of Sakha (Yakutia) contains provisions on elimination of the accrued environmental damage of the past, in particular, the Kular gold mine field tailings [3].

The global experience displays the heavy environmental impact of gold mining [4]. The waste accumulated as a result of the past economic activities, first of all, mineral mining badly pollute the environment, occupy large areas and consume much money to maintain ecological safety. The past (accrued) environmental damage facilities are the feature of many countries. For example, silver mining operations at Potosi in Bolivia have been accumulating such waste since the 16th century. At Zaruma–Porto Bello gold mines in Ecuador, the desolate and disturbed lands, and the polluted water bodies appear since the early colonial times of the area.

The major environmental impact of mining, in particular, gold mining, embraces contamination of soil and water, nature and landscape degradation, killing of natural habitats and generation of waste which occupy a vast area. These ecological problems being typical of the industrial development in the Arctic anticipate investments in integrated development of manmade deposits (production waste and tailings) and elimination of the adverse effect exerted by the mining practice of the past on the environment.

On the other hand, depletion of many mineral deposits, including gold fields, as well as the technological advance in the sphere of waste management draws attention to manmade deposits which are the accumulated waste of mining and processing in the past. This approach allows benefitting from mining waste treatment and reduces the environmental stress [5]. In this respect, it is crucial to develop and implement integrated development projects in the Arctic with regard to the interests of all parties concerned—indigenous people, local authorities and mining business.

Materials and methods

The methodological framework for the studies is the concept of benefit sharing in implementation of mineral mining projects [6]. This approach needs interaction models and business control tools to concert the interests of all parties concerned, including appraisal and indemnification of damage caused to indigenous people because of mineral mining with a duly signed agreement between the mining business and local administration on the social and economic development in the indigenous territory.

At the present day, mining is carried out in the Russian Arctic under very stringent environmental standards. For instance, in 2010 the Republic of Sakha (Yakutia) enacted the Ethnological Expertise Law which settled evaluation of impact exerted by any envisaged activity on the ethnological environment. In this fashion, the project expertise is one of the methods to coordinate the interests of the parties concerned [7]. For harmonizing relationship of business, indigenous people and local authorities in manmade deposit management, it is proposed to use a project approach which defines the goal and objectives of the project, the sources of financing, the risks, as well as the ecological, economic and social effects. The approach includes also the calculation of NPV of the project, and shared financing of the environment-oriented projects.

Furthermore, the research used the sociological methods, the head counts to reveal the social and economic development priorities for the local population, as well as the on-site investigations. The local public inquiries should be oriented at selection of projects capable to solve the most critical and significant social problems [8]. A way of serving the interests of indigenous people and mining business in the North may be signing of conventions on social and economic development of the Russian Arctic.

Description of the Kular gold field and adjacent land

We discuss the proposed project approach as a case-study of placer gold mining waste in the Ust-Yana district in Yakutia. The district is the most industrially advanced Arctic area in Yakutia. The economic basis of the district is tin and gold mining, fish processing and deer breeding. The Kular gold field lies in the Arctic region of Yakutia (**Fig. 1**). Kular gold mining started in 1963. Since that time (between 1963 and 1994), the Kular deposit produced more than 155 t of gold.

Gold mining with removal of overburden up to 16 Mm^3/m yearly makes a colossal environmental impact. Moreover, the local mining activities affect the interests of the Omoloi indigenous stem community engaged in deer breeding and in other kinds of traditional trades of nature use. For a long time, this stem community was the only in Yakutia to dig gold in the former sites of KularZoloto gold company which went to liquidation in 1994 [9].

A new trend of the mineral production and marketing in Eurasia, including the Republic of Sakha (Yakutia), is economic management of resources contained in the manmade deposits. For instance, in 2018, Arctic Capital launched a project of gold production at Kular by means of waste treatment and processing. By estimates, the manmade dumps here contain more than 17 t of gold. So, again, it is highly important to share benefits between all parties involved—indigenous people, local authorities and mining companies.

On the ground of the environmental, social and economic analysis of the test area, the authors of this paper propose and substantiate some investment projects on: (1) extraction of minerals (placer gold) from accumulated mining waste; (2) mineral production from primary raw material; (3) mining-disturbed land reclamation; (4) elimination of the environmental damage caused by the tailings storage of the local gold refinery; (5) construction of tundra roads for local population using the waste material after its processing and beneficiation.

Substantiation of the projects and description of the interests of the parties involved used the methods of sociology and civil interrogation. The polls show that a local population majority think the signing of an agreement on cooperation with a mining company is not only an influential tool of keeping the own interests but also a guarantee of protection of people's rights in the sphere of traditional nature management. The areas supportable by a mining company are the: transportation infrastructure (30.9%), employment (28.5%), social infrastructure (11.4%) and environmental development (8.2%) [10, 11].

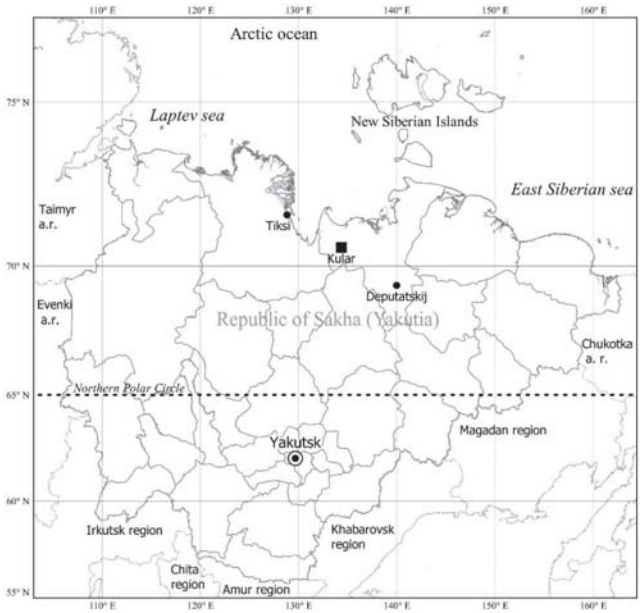

Fig. 1. Kular gold deposit location in the Russian Arctic zone

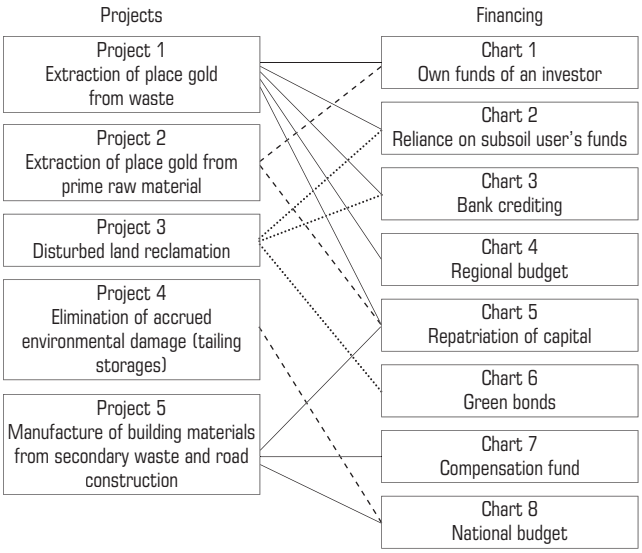

Fig. 2. Model of financing of investment projects on integrated manmade deposit development with regard to projects and their sourcing

Results and Discussion

Each project is mated with a financing chart including such sources as the capital base of a mining company, bank credits, regional and national budget, etc. Furthermore, it is planned to embrace such new sources of project financing as green bonds, repatriation of capital from offshore zones as well as indemnification funds. Within this framework, the financing modeling is performed for the projects to be implemented in the area of mining waste management in the Ust-Yana district in Yakutia (**Fig. 2**).

The scope of the research encompassed evaluation of positive and negative money flows in implementation of the projects. The positive money flow, alongside with the mineral mining, includes elimination of the accrued environmental damage which should be treated as the economic benefit gained in the form of the prevented ecological deprivation.

The positive effects of all projects being considered include the creation of new jobs for the local population, the cost saving in mineral exploration and prospecting owing to mineral mining and processing waste management, the use of inert materials in road construction, and the return of the mining-disturbed and reclaimed land in the economic activities in the form of deer breeding. The positive flows of funds after implementation of the disturbed land reclamation projects are evaluated in the framework of economic appraisal of the reclaimed and economically reactivated land, as well as the determination of income gained by the local population on the economically reactivated land (deer breeding, wild harvesting—berries, mushrooms, medicinal herbs, hunting).

During implementation of mineral mining projects, the local authorities replenish the budget with charges and taxes, which allows promoting employment, tundra road construction and hard-to-reach land

accessibility. Moreover, construction uses multi-processible materials such as sand and gravel, which favors ecological improvements.

The national-scale benefits include removal of hazard class I tailings storage of Kular gold refinery, which is an accrued environmental damage facility, as well as reduction of ecological and climatic risks in the Arctic zone of the country. More importantly, implementation of the whole group of the Arctic projects considered aims to support the indigenous people of the underpopulated North, to fight poverty and to develop diverse infrastructure [12].

The compensation funds are pooled from the own sources of a mining company within the program of loss compensation of indigenous people in the zone of a project implementation [13, 14]. For example, the projects on mineral extraction (placer gold) from prime raw materials and from waste, considering the value and commercial orientation of the projects for a company, may be supported by the own assets of the company, money of an investor, bank credits, repatriation of capital and green bonds. The project on disturbed land reclamation may be sourced by a mining company, regional budget and compensation fund established within the framework of indemnification of the indigenous people in the North in the influence zone of a mineral mining project.

The project of Kular gold refinery tailings storage removal is included in the Federal Target Program of the Accrued Environmental Damage Elimination, and is to be supported by the national budget. Financing of the project on manufacture of building materials from secondary raw material (mining and processing waste) and road construction for local population is to use the regional budget, green bonds and compensation fund.

Efficiency of the projects and combinations of their financing charts was evaluated using the ecological, social and economic criteria. The economic criteria were the Net Present Value, Internal Rate of Return, Investment Profitability Index and the Payback Period. The ecological criteria were the reduction of the accrued environmental damage and the river pollution prevention. The social criteria included the involvement of the local population in the mining company activities and the creation of jobs for indigenous people.

The calculations have found that, taken plainly economically, the disturbed land reclamation project is inefficient as its NPV is negative in any combination of the sources of finance. At the same time, this project has a high ecological and social weight as the land returns to the economic performance and utilization by the indigenous underpopulation of the North for their traditional trades. The projects of the accrued environmental damage elimination and road construction for the locals are economically ineffective but highly critical in terms of the environmental improvement, as well as the social and transport infrastructure development. The project of road construction for the local population will be implemented by a mining company under the Social and Economic Territorial Development Agreement and at will of the local community as per the outcome of the public consultations on the project.

The **table** describes the recommended financing charts for the projects in the zone of manmade deposit development.

The expert evaluation of the proposed criteria used a point system (from 1 to 10).

Solution of the problems connected with selecting the top-priority investment projects assumed determination of the highest indicators and best preferences on the bases of evaluation criteria using the following algorithm: compilation of investment projects, substantiation of financing charts and share participation structure, economic efficiency evaluation of projects and their financing charts, generation of a criterion system for selecting investment projects and appraisal of their value. The mechanism of substantiation of manmade deposit development projects also includes the priority assessment and selection of project implementation scenarios using the proposed criteria.

Recommended financing charts and their combinations for projects in mineral mining zone

Project	Recommended financing chart (combination)
Project 1	Own sources of mining company and bank crediting at a ratio of 60%:40%
Project 2	Own sources of mining company and capital repatriation at a ratio of 90%:10%
Project 3	Own sources of mining company, regional budge and compensation fund at a ratio of 20%:70%:10%
Project 4	National budged at 100%
Project 5	Regional budget, green bonds and compensation fund at a ratio of 80%:10%:10%

As a result of the research, the economic mechanism has been developed for selecting the top-priority investment projects on the development of Kular manmade deposit using the ecological and economic criteria and with regard to the feasibility study, implementation support and social orientation of the projects.

Conclusions

1. One of the trends of the circular economy and resource-saving connected with repeated use of waste and secondary resources is the integrated development of manmade deposits as a new source of mineral resources [15]. This trend is intrinsic to gold placer mining worldwide, including the Republic of Sakha (Yakutia).

2. The new validated sources of finance for the projects in the Russian Arctic include green bonds, repatriation of capital from offshore zones, and compensation finds.

3. The proposed economic mechanism of appraisal and selection of the investment projects on integrated development of manmade deposits in the Arctic uses the ecological and economic criteria with regard to the feasibility study, implementation support and social orientation of the projects.

4. The implementation of the proposed investment projects and the model of interaction between the parties concerned enables efficient mineral mining, creation of the sustainable development conditions for the indigenous people and traditional trades, preservation of local ethnos and reduction of the environment pollution in the Russian Arctic.

5. A promising area of research is the comparative analysis of interaction between business, government and indigenous people in the framework of mining project implementation in the Arctic countries such as Russia, Norway, Canada, US (Alaska) etc.

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MODELING CUMULATIVE AVAILABILITY CURVE OF GOLD RESOURCES

The article presents the authors' approach to evaluation of economic availability of mineral resources. The approach uses the cumulative availability curves plotted for certain minerals, which is a common way of solving such problems abroad. The curves represent the cumulative volumes of mineral resources at the deposits ranked in the sequence from the best to the worst versus the estimated cost of the mineral product. These costs should cover all expenses connected with mining and thus provide a zero net present value of extraction of certain mineral resources. The curves imply that as deposits having the worst mining conditions and containing low-quality minerals are involved in the development, the estimated costs increase. The cost calculation of is a very time-consuming process, and the main difficulty is the cost estimation of mineral mining and processing. The authors propose an approach to modeling the unit costs of mineral mining and processing depending on the deposit development probabilities estimated for a set of mineral bodies of the same genetic type. Using the developed cost estimation models and the information from the US Geological Survey on mineral resources, the cumulative availability curves are plotted for primary gold deposits in the world. On this basis, the forecast rates of the increase in the mineable mineral resources are compared with the rates of the increment in the costs of their development, and the express-appraisal of economically available resources is done.

Keywords: *mineral resources, mineral resource availability, development probability, resource depletion, peak models, cumulative availability curve, gold*
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Introduction

The recent period features fairly extensive usage of nonrenewable mineral resources. Mining practice depletes and exhausts mineral wealth. The future resource-richness raises concerns in this respect. Many researchers tend to ascertain future availability and amounts of mineral resources.

In Russian vocabulary, the term *availability* in the context of mineral resources represents difficulties connected with mineral extraction because of unfavorable geography or geology of mining operations. The United States Bureau of Mines uses the term *mineral availability* in plotting cumulative availability curves [1]. In Russia the term *mineral availability* is understood as the