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Key aspects of mining projects investment

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Abstract. The development of mineral deposits is a complex and multifaceted process involving technical, economic and organisational challenges. Despite the high level of risk, however, the mining industry remains an attractive sector for long-term investment. This necessitates the development of robust approaches to supporting the participation of financial institutions in mining projects at different stages of the project life cycle. The objective of this work is to develop a methodology for investors’ financing approaches to development projects for mineral exploration and mining companies. Each stage in the development of a mining project is associated with a specific set of studies that also identify the risks related to mineral development. The results of these studies form the basis for pre-development documentation of varying levels of detail, which investors use as the basis for financing decisions. These documents provide a structured assessment of all Modifying Factors affecting mining and mineral processing, encompassing every aspect of the project from the mineral resource in situ to the final saleable product. As these factors become progressively better defined and the project risks and characteristics are more thoroughly understood at each reporting stage, the project advances to a higher level of development, typically accompanied by a significant increase in its value. This progression establishes a relationship between project maturity and value, forming the basis for a methodology for applying different financing approaches at different stages of project development. The study concludes that these changes in project development stage, when considered together with other project characteristics, form a relationship, which provides the basis for a methodology for applying different approaches to project financing. In turn, timely and appropriately structured financing enhances project performance throughout the project life cycle.

Keywords: industrial economics, mining industry, subsoil development risks, solid mineral resources, deposits development efficiency, investment in mining, project financing

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Ключевые аспекты инвестирования в горнодобывающие проекты

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Аннотация. Освоение месторождений твердых полезных ископаемых – сложный, многогранный процесс, сочетающий технические, экономические и организационные вызовы. Вместе с тем, несмотря на высокую степень рисков, горная промышленность остается

привлекательным сектором для долгосрочных инвестиций. Это вынуждает формировать подходы для обоснованного участия финансовых институтов в горнодобывающих проектах на разных этапах жизненного цикла. Целью работы является определение методики подходов инвесторов к финансированию проектов развития предприятий геологоразведочной и горнодобывающей промышленности. Каждой стадии развития горного проекта соответствует определенный набор исследований, который также выявляет риски недропользования. На основе исследований разрабатываются предпроектные документы разной степени детализации, которые принимаются инвесторами как основа для принятия решения о финансировании. В таких документах структурируются все модифицирующие факторы процессов добычи и переработки – особенности проектов от полезного ископаемого «в земле» до товарного продукта. Структурирование данных факторов, понимание рисков проекта и его особенностей в момент выпуска определенного документа влечет переход к более высокой стадии развития проекта, и, как следствие, скачок его капитализации. Результатом работы является вывод, что данные изменения стадийности в привязке к другим характеристикам проекта складываются в зависимость, на основе чего формируется методология применения разных подходов к финансированию проектов. В свою очередь, правильное и своевременное финансирование повышает эффективность проектов на всех уровнях.

Ключевые слова: экономика промышленности, горнодобывающая промышленность, риски освоения недр, твердые полезные ископаемые, эффективность освоения месторождений, инвестиции в добычу, проектное финансирование

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矿业项目投资的关键方面

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摘要: 矿床开拓是一个复杂、多维的过程, 涉及技术、经济和组织等多方面的挑战。然而, 尽管风险程度较高, 但它仍是对长期投资具有吸引力的行业。这迫使各方形成相应的方法, 以促进金融机构在矿业项目生命周期不同阶段的合理参与。 本研究的目的是确定投资者对地质勘探和采矿工业企业开发项目提供资金的方式方法。矿业项目发展的每个阶段都对应一套特定的研究工作, 这些研究同时也揭示出矿产利用的风险。基于这些研究, 编制不同详细程度的项目前期文件, 投资者将其作为投资决策的依据。在这样的文件中, 会整理出所有影响采矿和加工过程的因素——从地下矿产到最终商品的项目特点。系统化整理这些因素, 在特定文件发布时理解项目风险及其特征, 有助于推动项目进入更高的发展阶段, 从而实现资本价值的跃升。研究得出结论, 这些阶段性变化与项目其他特征的关联构成了一种函数关系, 并在此基础上形成了针对不同项目采用不同融资方式的方法论。而正确且及时的融资则能在各个层面上提升项目的效率。

关键词: 工业经济, 采矿业, 矿产资源开发风险, 固体矿产, 矿床开发效率, 采矿投资, 项目融资

Introduction

Investment in a mine is a complex and comprehensive task. Many investors face difficulties at the mineral project evaluation stage, since they are not always able to understand geologi-

cal risks and specific features of mining and processing operations, as well as factors that have an impact on long-term profitability. In view of this, the project potential may be underestimated or looked upon with skepticism, or, on

the contrary, mining prospects may be overestimated. Monitoring of projects and consulting of investors play a key role in such a situation [1]. Each solid mineral deposit is unique, and studies of a deposit should take account of all project aspects, from evaluation of in situ resources to output of the saleable product. The international practice refers to these aspects as Modifying Factors, which have a direct impact on the project configuration and performance.

Based on the long-standing experience in interaction with investors, banks and major mining companies, IMC Montan group¹ assists in development of a strategic approach towards assessment of the economic potential of a mining project and financing. Since the authors of the article pioneered establishment of a robust system for mining project financing and IPOs² of mining companies, it helps to identify the target investors in line with the project development stage and its specific features, to select the relevant financial instruments and cooperation methods, and to analyse the real profitability, which may be referred to as the “potential project capitalisation” in technical and economic models of mines. Besides, while developing the investment system, the authors provide a comprehensive description of key risks and mitigation methods, which helps to build trust and ensures a steady interest in successful implementation of project initiatives.

The objective of this study is to develop a methodology for investors' approaches to financing of mineral exploration and mining companies development projects.

The study is based on the experience of international mining and geology consultants in auditing of mineral deposits and mine construction projects.

¹ IMC Montan is an international consulting group that provides services in geology, mineral mining and processing. Available at: <https://www.imcgroup.ru> (accessed on 23.04.2026).

² IPO or Initial Public Offering is the process where a company gets listed at a stock exchange and offers shares to any investor for the first time.

Study Results. Investment in Mining Projects

A mining project has specific features that affect its attractiveness and perception from the financing perspective:

1. A mine is always viewed as a hazardous production facility with complex and multilevel risks associated with safety, including geotechnical, environmental and technological threats.

2. A company's core value is not limited to equipment or buildings, that are viewed as individual fixed assets, but relies on the prospects of mineral mining and processing. Fixed assets, equipment, production facilities and utility lines lose much of their value and become low liquidity assets if a company doesn't have an operating mineral deposit.

3. All key project parameters, from mineral resources to process efficiency, are tentative [2]. It means that any estimates of resource tonnage and quality, recovery and expenditure involve a certain margin of error at each stage of studies and engineering.

4. Projects are very capital intensive, especially at the stages of construction and commencement of mineral processing, in particular, when a project involves refining, e. g. production of a pure metal instead of concentrate.

5. Location and availability of transport and power supply infrastructure often play an important role when an investment decision is taken, since most of the promising projects in Russia are now situated in hardly accessible regions.

6. Prices of many commodities are very volatile not only because of the commodity use areas but because of global instability. Operating expenditure depends on tariffs, railway transportation, power supply and many other factors.

7. Each mineral deposit is unique, and its development implies numerous technical and technological risks that evolve from project risks at the stage of studies and construction to operational risks at the stage of mining. Risks disappear at the mine closure stage only, after mineral reserves have been mined.

In view of these specific features, investors are cautious about mining projects. Unlike other businesses or projects, there is no standard algorithm that can be applied to assess a mining project, since each mineral deposit has its own

specific features. Direct comparison of projects is not applicable in most cases. Even if it is the same mineral, the occurrence conditions, mining and geological conditions, mineral quality, impact of external factors, etc. are always different. Regional mining parameters can be applied sometimes, but they cannot characterise the entire project or indicate to its feasibility.

However, it should be noted that Russia has the world's largest resource base. Although large-scale prospecting goes on in many regions, and junior companies³ involved in such activities have been developing in the last decade, the legislative framework applicable to exploration of new mineral deposits is still underdeveloped and is a constraining factor. Nevertheless, it is expected that development of numerous deposits of various minerals will start. With regard to import independence, it should be understood that Russia is able to produce any goods using its own resources. On the other hand, production or synthesis of such goods may require considerable investments. Hence, adequate review of Modifying Factors, reliable evaluation and systematic risk management ensure significant and sustainable return on investment in mineral deposit development [3], which is a secure long-term area of financing.

The first international standards for disclosure of data on mineral resources and reserves were developed as early as 1972 to overcome uncertainties and introduce universal business process standards. The most notable example is the JORC Code (Joint Ore Reserves Committee Code)⁴, the Australasian standard which sets basic requirements and principles and provides recommendations on public reporting of exploration results, mineral resources and ore

reserves. It was adopted by CRIRSCO (Committee for Mineral Reserves International Reporting Standards)⁵. The Committee established the framework for global alignment of approaches towards mineral resource and reserve reporting. Over the last 10–15 years many countries have published their own codes for reporting of mineral resources and reserves. It allowed to establish a transparent and comparable system for provision of data on mineral resources and reserves.

The NAEN (National Association for Subsoil Audit)⁶ Code is also applied in Russia. It is a part of the CRIRSCO family of reporting codes and may be used not only in friendly countries. It is still included in the LSE (London Stock Exchange)⁷ listing rules. Application of standards contributes to building investors' trust, regulates provision of technical and economic information, and establishes the basis for determining reasonable amount of funds and the relevant financing mechanisms [4]. The approach towards financing depends directly on the deposit type and the current stage of development (from early exploration to full-scale production).

The author's experience demonstrates that the most common forms of financing include the following:

- private investing and co-financing;
- bank lending;
- project financing;
- offtake agreements;
- financing through venture and specialty sector funds; and
- initial public offering (IPO), secondary public offering (SPO), bonds, depositary receipts and other instruments offered at stock exchanges.

³ A junior company is a company that has an objective of receiving a licence, normally at a company's request, for prospecting and exploration of mineral deposits. If a company's activities are successful, it gets officially acknowledged as the first one to discovery a deposit, and a deposit is included into the state register.

⁴ JORC Code (Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves); 2012. Available at: https://admin.ponen.kz/uploads/files/libraryDocuments/izdannyyi_perevod_JORC_2012.pdf (accessed on 26.04.2026).

⁵ CRIRSCO. Available at: <https://crirSCO.com> (accessed on 26.04.2026).

⁶ NAEN Code. 2025 Edition. Russia Code for the Public Reporting of Mineral Resources and Mineral Reserves. Available at: https://naen.ru/np_naen/kodeks/ (accessed on 26.04.2026).

⁷ London Stock Exchange. Available at: <https://www.londonstockexchange.com> (accessed on 08.04.2026).

Private financing is still the most flexible and accessible form of support at all stages of the project life cycle, from geological exploration to achievement of the target production capacity. Private investments largely rely on personal relationships. However, even in this case every investor should understand the amount of required funds, the payback period and the level of risks related to future activities.

Bank loans are normally accessible only to operating mines, those that are able to pay back a loan due to a steady sales revenue [5]. Banks and investors require reliable guarantees such as pledge of property, equipment or other liquid assets. This form of financing is hardly applicable at the early stages, when there is no operating history and reliable collateral.

Project financing in the mining industry is a specific instrument [6] that a few financial institutions are interested in. The Project Finance Factory⁸ has been operating since 2017 and combines bank syndicates. But there are not many banks that would apply the classic model, even among public banks. For example, project financing should not provide for shareholder recourse. Therefore, banks often act as institutional investors and take an equity stake in operating companies, instead of a standard pledge of a mining company's shares. This approach enables them to maintain flexibility and participate in long-term returns, normally, with an option to sell the shares.

The structure of investment takes account of the scale and complexity of a project, and negotiating capacities of the parties. However, the key condition of external financing is almost always a considerable participation of the project's owner [7]. The experience of the recent years demonstrates that at least 30% of capital should be provided by a mining company. This is perceived as confidence in success and reduces the risk assumed by potential partners and lenders.

⁸ The Project Finance Factory operated by VEB.RF is a mechanism that provides syndicated loans for investment projects in priority sectors of the Russian economy. Available at: <https://b36.ppf/biznesu/fabrika-proektnogo-finansirovaniya/> (accessed on 29.04.2026).

Offtake agreements are another common instrument of support. A company in fact receives advance payment for future products. The period may vary from one year to three years. However, advance payments for future products normally cover current expenditure only or a part of construction expenditure for development or expansion of production facilities. It is actually impossible to finance a capital intensive project by signing offtake agreements [8].

As for IPO and other public offerings of securities (bonds or depositary receipts), it becomes a realistic option only at the later stages of the project implementation, and can be used mostly by operating companies⁹. There could be exceptions at some exchanges such as TSX (Toronto Stock Exchange)¹⁰ where it is possible to enter the market at the earlier stages. Besides, Russian junior companies started operating at SPB Exchange, Eastern Exchange¹¹ and Moscow Exchange¹² in 2025. However, the process of preparation for public offering requires a lot of time, considerable financial resources, profound transparency and compliance with strict requisites of regulators.

The review shows that each of the forms of financing listed above is efficient in a certain context. None of them is universal, since its applicability depends on the stage of the project development, level of detail of technical and economic estimates, level of studies, designing and analysis of mineral resources (**Table 1**).

The key stages of taking decisions on the deposit development in Russia include the Technical and Economic Justification (TEO) of Final Exploration Parameters, Technical Solutions Justification (OTR), Construction and Operation

⁹ Bank of Russia Regulation No. 714-P of March 27, 2020 (as amended on September 30, 2022) "On the Disclosure of Information by Issuers of Securities" (registered with the Ministry of Justice of Russia on April 24, 2020, No. 58203). Available at: https://www.consultant.ru/document/cons_doc_LAW_352306/ (accessed on 27.04.2026).

¹⁰ Toronto Stock Exchange. Available at: <https://www.tsx.com/> (accessed on 08.04.2026).

¹¹ SPB Exchange. Available at: <http://spbexchange.ru/> (accessed on 27.04.2026).

¹² MOEX Moscow Exchange. Available at: <https://www.moex.com/> (accessed on 27.04.2026).

Design, and the full scale TEO of the project. Their counterparts in the international practice are the Scoping Study (SS), Pre-Feasibility Study (PFS) and Feasibility Study (FS), see **Table 2** (based on the author's experience). These are the stages when fundamental decisions [9] are taken to ensure effectiveness of all subsequent mineral mining operations. The flowsheet is developed, production facilities are selected, investments are estimated, and key risks of construction and operation of mining and processing facilities are identified at these stages. A deposit is viewed as a real production facility, rather than a geological site, and selection of production methods is reasonable.

However, the level of reliability of such decisions depends directly on quality of previous studies. It is impossible to start a Preliminary TEO (Pre-Feasibility Study, PFS) or a TEO (Feasibility Study, FS), or full-scale engineering with-

out comprehensive preliminary studies. These include detailed geological, hydrogeological, environmental, social, geodetic and technological studies. Technical and economic solutions can be adopted at the sufficient reliability level only on the basis of comprehensive detailed studies [10]. This approach makes it possible not only to substantiate feasibility of a project, but to mitigate key risks related to the project implementation.

If prospecting and exploration of a deposit are carried out not by a holding, but by small-scale private or junior companies, financing of studies is very limited. While there are three types of sampling undertaken in the course of geological exploration – routine sampling (quality and composition), technical sampling (physical and mechanical properties of rocks), and metallurgical sampling (washability parameters), the focus is normally on routine sampling.

Table 1

Possible types of financing at different stages of field development

Form of financing	Project stage
Direct private financing	Any stage
Bank lending	Operating company
Project bank financing	Construction stage
Offtake agreements	Any stage
Investment funds, venture capital	Scoping Study, construction stage
IPO (shares, liabilities – depositary receipts, bonds, etc.)	Operating company (except for TSX and junior exchanges)

Table 2

Comparison of design stages

Approval of mineral reserves	Russian format	International format
Technical and Economic Comparison (TES)	TES, Technical and Economic Calculation (TER)	Concept study
Technical and Economic Proposals, TEO of Temporary Exploration Parameters	Preliminary Investment Justification, Preliminary TEO	Scoping Study (50%)
TEO of Final Exploration Parameters	TEO	Pre-Feasibility Study (25%)
Update of mining parameters, if necessary	Construction and Operation Design	Feasibility Study (up to 15%)
	Construction Design / Detailed Design Documents	Detailed Engineering (up to 5%)

It certainly increases the risks of the project development. However, since every subsequent design document should have a lower level of error, all types of comprehensive studies are inevitable, since they make risks of construction and operation understandable. The same applies to all types of engineering, environmental and other studies that have to be undertaken to develop design documents and to have them approved.

The international format document, Feasibility Study, doesn't have to be submitted to Russian state expert review authorities. However, Feasibility Study solutions should comply with local laws, as well as environmental, industrial and legal standards of the project implementation region [11]. This ensures economic and legal feasibility of a project, and compliance with environmental, industrial and social standards. Therefore, such documents, along with reports compliant with the CRIRSCO family codes, should be prepared by a team of experts, capable to identify and estimate every aspect of the future operation (Modifying Factors defined by international codes), and should be signed by Competent Persons, accredited in professional organisations included in the list of RPO (recognized professional organizations)¹³. OERN (Russian Society of Subsoil Use Experts)¹⁴ is one of the recognized professional organizations.

Hence, as more reliable studies are undertaken, mining companies and investors gain a clearer understanding of risks. Increased geological confidence and a higher level of detail of technical and economic solutions reduce uncertainty, enhance investors' confidence and expand the range of potential sources of financing.

Understanding of risks makes it possible to assess feasibility and cost effectiveness of a project [12]. If a project is indeed potentially interesting, its risks are mitigated as higher level studies are undertaken, and the project effectiveness improves. This statement is supported by the following: The level of verified risks is inversely proportional to the potential capitalisation of a project.

Experienced specialists may see the potential of the future deposit and its value for business and national economy at the early stages of prospecting and evaluation of sites and prospects, based on expert statements. The correlation becomes evident if a junior company really intends to find a good deposit and not just cover the costs by all means, even by misleading investors. The correlation may be affected by actual market transaction parameters.

Hence, it could be concluded that projects at the early stages of development attract only private or strategic investors, who are ready to handle high risks. In fact, these are venture investors [13]. But as studies are undertaken, and activities reach the next stages of designing, the level of uncertainty gets lower. At this stage, the pool of investors expands to include banks and funds, followed by public investors through stock exchanges.

It should be noted that the potential capitalisation, often expressed as NPV (net present value) for the life of mine (LOM), is not equal to the market value of a business. It is a forecasted economic indicator, estimated on the basis of a model with certain assumptions, and is not a real market price of an asset. It is necessary to distinguish clearly between the following two notions in the course of mining and financial audit:

- income-based project evaluation, which uses real discounted cash flows (e. g., estimation of NPV + TV (Terminal Value); and
- estimation of the mining company's business value which may be taken into account for borrowing, M&A (Merger and Acquisition) deals, or estimation of a collateral.

These approaches are taken to fulfil different tasks and may lead to significantly different results [14]. Misunderstanding of these notions

¹³ CRIRSCO RPOs. Available at: https://crirSCO.com/wp-content/uploads/2023/12/CRIRSCO_Organisational_Statutes_v2_1_Septmber_2019.pdf (accessed on 15.03.2026).

¹⁴ Russian Society of Subsoil Use Experts. Available at: <https://oern.expert/about>. https://naen.ru/partners/obshestvo_expertov_po_nedropolzovaniyu_oern/ (accessed on 15.03.2026).

may lead to unreasonably high expectations and mistakes in taking investment decisions. Engineers and geologists are not business appraisers and don't analyse financial performance of a legal entity. However, they are able to analyse technical aspects of a project.

When financial institutions consider participation in project financing, most of them normally require a Feasibility Study (FS) or a TEO of a project to be in place. These documents are a basis for taking reasonable decisions and contain detailed technical and economic data and verified information on expenditure, income and risks. Nevertheless, the practical experience demonstrates that in some cases credit committees may approve financing at an earlier stage, before completion of a BFS (Bankable Feasibility Study). This approval sets the limits of a loan, but is tentative, and normally sets some conditions such as verification of mining parameters, approval of design documents (outcomes of the state expert review, including environmental expert review, and the permit for construction), completion of certain construction stages or achievement of the target production capacity. A high-quality Pre-Feasibility Study (PFS) may become an important stage of the project implementation. It is mostly based on calculations, supported by studies, but still may contain assumptions and references to similar projects. This approach demonstrates feasibility and compares a few development options, which is particularly helpful, since no alternative options can be selected at the BFS stage, where all technical solutions should be developed and adopted. Moreover, a Pre-Feasibility Study at $\pm 25\%$ error is the first serious argument in interaction with potential partners and investors, and indicates to transition to a new phase of the project, from a concept to a real investment opportunity [15].

International reports such as Evaluation of Mineral Resources and Reserves in Compliance with the JORC Code or NAEN Code, Pre-Feasibility Study and Feasibility Study may be viewed as detailed business plans. The key advantages of these documents include a clear structure, logical presentation of information, and comprehensibility to the general public. Therefore,

banks find this format more useful, compared to Russian design documents. The fundamental difference of international reports (within the framework of the CRIRSCO Template) is the requirement that consultants, involved in preparation of reports, should be independent. Authors and signatories of such reports are Competent Persons, who should be unbiased and maintain professional freedom during evaluation, irrespective of interests of a project's owner and investor, and fees. This ensures trust on the part of banks and financial institutions.

Based on the practical experience of their specialists, public and commercial banks often use their own terms to define formats of audits and design documents. The international document known as Due Diligence¹⁵ may be presented as a Technical Expert's Statement, Technical and Economic Audit of the Deposit Development, Analytical Substantiation of Investment Attractiveness, or Report on Technical Audit Results. Similarly, a Pre-Feasibility Study is often called Preliminary TEO, OTR, Preliminary Effectiveness Assessment, or Preliminary Justification Stage. However, the essence of such documents is the same, regardless of the title. The structure, level of detail and contents of these documents are in line with the level of geological confidence and comply with international standards, such as JORC, NAEN, etc. They may look different, but are similar in nature. Hence, despite the local titles, such reports are viewed by investors and banks as reliable, transparent and compatible with the international practice. This makes them a key instrument for decision making and finance sourcing.

With regard to analysis of the process of financial decision making, and taking account of banks' viewpoints, it could be noted that actions are structured and standardised. A brief review of this mechanism demonstrates that key criteria of selection of a form of financing include verified cost effectiveness of a project, and reliable

¹⁵ Due Diligence is a comprehensive audit of a project, data, etc. The format depends on specific features of a project, and the level of detail of investigation into project aspects and Modifying Factors.

collateral. These aspects are inter-related, and deterioration of one aspect requires improvement of the other one. However, clear and comprehensive forms of financing become available only if the cash flow model is created properly and takes account of reliability of input data at a specific stage of the project development. This model (and a financial and economic model in place) makes it possible to assess the project viability, to forecast payback, and to substantiate selection of pledge instruments (**Table 3**).

Each form of bank financing requires a relevant type of collateral, which may become available only at certain stages of the project development. The higher the risks, the more reliable collateral should be. Lending without an external support and collateral is almost impossible at the early stage when there are no assets and cash flows. Exceptions include projects implemented by large holdings, where an additional collateral can be secured, e. g., guarantees of a parent company or pledge of other available assets. However, this is not a case of classic project financing, but corporate support within the group's limits.

The question 'Why do investors and banks select this approach?' becomes understandable if

such key factors as the risk level at each stage, reliability and confidence in mineral reserves, level of detail of technical and economic calculations, the sum of required investment, and the expected capitalisation of a mining company are considered. The higher the uncertainty, the stricter requirements for investment protection are.

Expenditure for studies make a small percentage of the future capital expenditure at the initial stage of the project development. But as expenditure grows, the uncertainty level gets lower. At some point, a prospecting project brings about good results, that the TEO of Temporary Exploration Parameters is based on. A prospecting area or site is classified as a deposit, and its resources are included in the state register of resources. At this stage a mining company gets a licence for geological exploration and subsequent mineral mining, and starts studies to substantiate final parameters and to estimate mineral reserves. Then a Scoping Study is undertaken. This is the first preliminary document, which shows prospects to investors, and this is the stage when the project's potential capitalisation starts growing, and comparative and income-based methods are applied to evaluation, rather than the cost method.

Table 3

Opportunity for banks to participate at different stages of project development

Lending	Project financing	Equity participation	IPO/SPO
<i>Profitability</i>			
Loan interest verified by the financial and economic model and actual profit	Loan interest verified by the financial and economic model	Capitalisation growth verified by the financial and economic model, market, and regular audits	Capitalisation verified by the financial and economic model, including financial auditors' modifications, and market
<i>Collateral</i>			
Reliable: pledge of available assets, revenue	Pledge of shares, founders' guarantees, pledge of other assets (seldom)	Shares (pledge, option)	Sale of shares or securities, reputation of underwriters and auditors
<i>Project / operation development stage</i>			
1 – OPERATING, 2 – UNDER CONSTRUCTION, 3 – UNDER REVIEW	2 – OPERATING, 1 – UNDER CONSTRUCTION, 3 – UNDER REVIEW	3 – OPERATING, 2 – UNDER CONSTRUCTION, 1 – UNDER REVIEW	1 – OPERATING, 2 – UNDER CONSTRUCTION, 3 – UNDER REVIEW

Note: 1 – the most suitable deposit development stage, 2 – theoretically possible stage, 3 - unlikely stage.

Correlation shown in **Figure 1** is based on the authors' practical experience and results of audits of mining companies and deposit development projects. Data, describing mining projects, are generated in the course of mining audit. Apart from physical indicators of mining and processing activities associated with specific timeframes, the study considers economic indicators, such as detailed capital and operating expenditure, and results of financial and economic modelling. Processing and interpreting of data indicate to a correlation between the increase of investments, growth of capitalisation, and stages of technical and economic studies. Figure 1 shows a typical trend of a mining project. The project value and expenditure make a small percentage of the total expenditure, in particularly of a capital intensive project, and the access to financing is limited at the early stages, when uncertainty is high. As the data are gathered, risks are mitigated, and detailed engineering starts (OTR/PFS → design documents/FS), the investors' confidence improves. This makes it possible to attract larger capital and to increase the potential capitalisation, hence, to carry out market valuation of an asset.

The correlation shown above is tentative and can't be applied as a universal template to all projects, since each solid mineral deposit has its own specific features. The figure above shows a typical trend only if the project's key parameters are verified or improved at every next stage of technical and economic studies [14]. However, the practical experience demonstrates that growth of the confidence level doesn't always increase capitalisation. In some cases, more detailed studies reveal deviations from initial assumptions. These may include a lower commercial component grade, difficulties related to rock mechanics or water inflow, lower recovery of metals or yield of concentrate, growth of capital and operating expenditure, or infrastructure problems. Besides, the saleable product market conditions may change rapidly. These changes may require a revision of economic parameters, and the project value may decrease. In some cases, results of detailed studies are so unfavourable that the deposit development becomes uneconomic or the project implementation is temporarily suspended.

Most of expenditure is associated with three key periods: the initial phase when geological

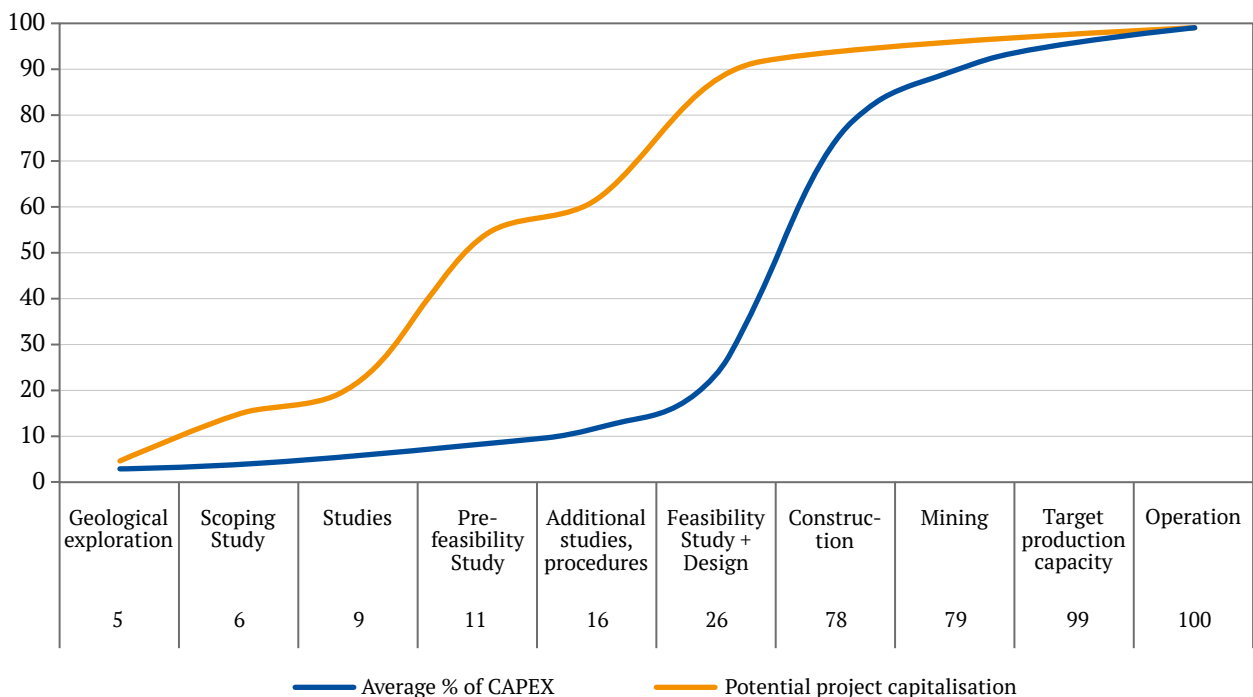


Fig. 1. Average statistical relationship between field development costs and potential capitalization

exploitation is carried out; research and development, and pre-design studies; and construction of mining and processing facilities when expenditure reaches its peak. At the same time, capitalisation fluctuation doesn't depend on growth of expenditure. Changes occur when important stages of studies are completed, and their findings are documented. This is when the risk level becomes more understandable, and information gets systematised and comprehensible to investors. The largest growth of value happens after completion of a Pre-Feasibility Study and then a Bankable Feasibility Study, along with cost estimates, approved by state expert review authorities [16]. These documents become a milestone and a project acquires new qualitative properties.

From the banks' perspective, especially in case of project financing, the key requirement is the payback reliability. An ideal collateral is the future company's shares, but a bank accepts it only if the key project parameters are assessed reliably and are comprehensible. Therefore, lending institutions normally focus on the top right corner of the diagram (see Fig. 1), when a project is at the later stages with a high level of confidence. This minimises the risks, but excludes an opportunity of making high profits resulting from early involvement in the project implementation. Instead, banks prefer stability, supported by guaranteed payment of interests and a manageable payment schedule. Nevertheless, as mentioned above, each project is unique [9]. Financial institutions may approve financing even at the Pre-Feasibility Study stage, especially if there is a strong sponsor, government support [17], favourable market conditions, or a deposit is strategically important.

Private investors, willing to take an equity stake in an operating company, often assume high risks to get involved in the project implementation at the earliest possible stage of the project life cycle. Their objective is to see a potential rapid growth of capitalisation which happens at transition from high uncertainty to verified cost effectiveness [18]. The earlier an investor enters the project, the larger the gap is between expenditure and the future value of an asset, and, consequently, the higher the potential profitability is. However, this approach can be justified only

if all factors that impact the project feasibility and profitability are considered thoroughly and comprehensively. The value doesn't fluctuate for no reason. Changes occur only if a deposit has a real potential, supported by quality of mineral, scale and conditions of mineral reserves occurrence, location, external infrastructure, technical and technological solutions. Not every project is capable to ensure sustainable effectiveness even in favourable market conditions. Most of the projects are marginally profitable and are affected by price fluctuations. Therefore, pre-design studies play a key role.

Conclusion

The review of aspects of the various factors' impact on the project makes it possible to set up a system and to understand the logic and conditions of participation of banks, funds, investors and other financial institutions in financing of mining assets. Hence, a coordinated interaction between mining companies and financing sources is established. The earlier an investor gets involved in a project, the more risks an investor faces, but, at the same time the higher the potential profitability is. This process could be described by an algorithm which contributes to improvement of relationships between stakeholders and the level of transparency of project initiatives, and to development of a successful strategy of joint efforts. Timely financing enables to commence deposit development operations, and to improve cost effectiveness of the entire project, that the potential capitalisation directly depends upon.

The article reviews the mining project investment methods applied at various stages of the deposit development, including relevant documents and collaterals. Effectiveness of investment, and in particular, interaction between mining companies and financial institutions has a direct impact on economic parameters and viability of a mining project. Assessment of the potential return on investment also depends on the level of risks.

Today these approaches are extremely relevant. After a long period of suspension due to macro-economic factors, mining projects in Russia start developing actively. It should be noted

that another important factor is the system of government regulation of subsoil resources use, from estimation of a licence price (at an auction) to mechanisms of support through public-private partnership. In these conditions, constructive interaction between mines, financial institutions and engineering companies is the foundation for success. Hence, efficient cooperation and professional approaches ensure that

many projects receive the timely support and are implemented successfully.

This article will be useful to scientists and operations managers. The authors are ready to continue providing expert assistance, consulting services and technical support for all subsoil resources users to ensure sustainable and technologically advanced development of the Russian mining industry.

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Author Contributions

S.B. Nikishichev – (lead author) evaluated the application of various investment approaches and developed the relationship linking the potential investment returns of projects at different stages of deposit development to the extent of technical studies and the risks associated with mineral development. He drafted the manuscript and prepared its final version.

A.A. Tverdob – analysed the risks associated with the development and mining of hard-rock mineral deposits, identified the key risk factors, established the relationship between international and Russian pre-development and project documentation, and prepared Table 2. He also revised Table 3.

A.V. Zhura – analysed investment projects and identified financing approaches used in the mining industry. He revised the manuscript and contributed to the development of the proposed relationship by identifying project costs and calculating performance indicators.

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Никишичев С.Б. – (основной автор) выполнил оценку применения разных инвестиционных форматов и сформировал зависимость потенциальной доходности проектов на разных стадиях развития месторождений в зависимости от глубины исследований и рисков недропользования. Разработал проект статьи, выпускал итоговую версию статьи.

Твердов А.А. – выполнил анализ рисков освоения месторождений и добычи твердых полезных ископаемых. Сформулировал риски. Определил взаимосвязь международной и российской проектной и предпроектной документации, разработал таблицу 2. Провел корректировку таблицы 3.

Жура А.В. – выполнил анализ инвестиционных проектов и определил формы финансирования в горнодобывающую промышленность. Вносил правки в статью, помогал разрабатывать зависимость, выделяя затраты по проектам и расчетные показатели эффективности.

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