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DIGEST



**GOLD**

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FEDERAL STATE BUDGETARY EDUCATIONAL  
INSTITUTION OF HIGHER EDUCATION  
SAINT PETERSBURG MINING UNIVERSITY

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## Abstract

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*For centuries, gold has been one of the most sought-after precious metals. Due to its unique physical and chemical properties gold is widely used in various fields of human activities in the modern world. It is considered to be a high-demand metal in the industry and is used extensively in nuclear, electrical and electronic, space, chemical and many other industries.*

*The present digest includes articles published in the Journal of Mining Institute that are dedicated to the study of gold, its properties, development of gold fields, rational mining, application in different areas and archive data as an insight into the history of gold mining.*

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## Geology

*This section discusses various features of gold geology, practical use of gold and, in particular, data on ore-bearing potential and, an analysis of distributions of gold concentration in ores.*

**Sendek S.V., Chernyshev K.E. Theoretical justification for analyzing distribution of gold concentrations in ores of hydrothermal gold deposits // Journal of Mining Institute. 2015. Vol. 212. P. 30-39. <https://pmi.spmi.ru/index.php/pmi/article/view/5226>**



**Abstract.** The article covers theoretical justification for the analysis of the regular pattern of gold distribution within ores of hydrothermal gold deposits. The analysis is based on principles of entropy dependence of gold concentration distribution variability in different physical-chemical conditions of oreforming processes providing certain goldbearing parageneses of ore minerals. At this rate, distribution of gold concentrations in an ore paragenesis is subordinated to the log-normal rule, and, subsequently, on the binary (lognormal) scale of gold concentrations this certain paragenesis of ore minerals is reflected as the frequency maximum of one or another class of this scale. Using some methodical steps in processing channel sampling data, it is possible to reveal or confirm the presence of several gold-bearing mineral associations and compare their volumetric and quantitative ratios in orebodies and blocks of mining. Results of the performed analysis of gold concentration distribution in ores of different hydrothermal gold deposits, including the polystadial ones, prove the validity of this technique for estimation of the gold distribution in ores with the purpose of carrying out supplementary study of the genetic nature of ores, and their mining feasibility.

**Stepanov V.A., Mel'nikov A.V. Productivity of ore and placer gold deposits of the Priamur province // Journal of Mining Institute. 2015. Vol. 214. P. 5-12. <https://pmi.spmi.ru/index.php/pmi/article/view/5195>**



**Abstract.** The article discusses ore and placer gold deposits of the Priamur province formed as a result of the Late Mesozoic collisions of geoblocks of the south-eastern framing of the Siberian craton and the Amur composite massif. Metallogenic zoning of the province displaying metallogenic zones and ore-placer sites is described. The article shows that the Priamur province is one of the main gold-bearing provinces of Russia with the level of gold ore (about 180 tons) and placer (about 1132 tons) gold. The predominance of placer gold in gold mining indicates significant opportunities to identify new gold deposits.

**Evdokimov A.N., Fokin V.I., Shanurenko N.K. Geochemical features and prospects of ore content in black slates in Tajmyr-Severnaya zemlya gold formation // Journal of Mining Institute. 2016. Vol. 217. P. 13-23. <https://pmi.spmi.ru/index.php/pmi/article/view/5077>**



**Abstract.** Gold content, at least twice higher than the gold percentage abundance in Earth's crust, has been discovered in a number of black slates formations in Tajmyr-Severnaya Zemlya gold province. The article shows the measurement data on organic carbon and ore elements concentrations in carbonaceous sediments, with pyrite, being their constituent, in the region. The dependence of ore elements availability, including gold, on sulphidisation degree in rocks has been identified in an ore bundle of Golyshevskaja strata. The comparison of gold concentrations in sampled monocrystals and pyrite aggregates has been carried out. It has been empirically supported that the content of gold, lead, molybdenum, cobalt, nickel and copper normally grows with the increase of sulphides quantity. Concentrations of chromium, manganese, tin, vanadium decrease respectively; however, titanium and zinc content remains unchanged.

*Stepanov V.A., Mel'nikov A.V. Deposits of gold-quartz formation in the Priamur province // Journal of Mining Institute. 2017. Vol. 223. P. 20-29. DOI: 10.18454/PMI.2017.1.20*



**Abstract.** A description of gold-quartz formation deposits in the Priamur gold province is presented. Prevalence of gold-quartz deposits defines metallogenic profile of the province and presence of numerous rich placers. Deposits are attributed to frontal, middle and near-bottom parts of the ore pipe. Frontal part of the ore pipe contains a major part of the deposits. They are small and consist of scattered quartz, feldspar-quartz and carbonate-quartz veins. The ore is characterized by erratic percentage of gold, bonanzas can be found. Gold is free, ranging from fine to big grains and small nuggets. It is associated with arsenopyrite, galenite, sometimes with antimonite. Among trace elements can be copper, mercury, antimony and arsenic. Prevalence of frontal deposits in the province points to significant prospects of finding a rich deep mineralization in the middle part of ore pipe. Middle part of the ore pipe contains intermediate and small deposits. Ore bodies are often represented by veined and veinlet-disseminated zones, sometimes zones of metasomatites. For gold-quartz ores, free native gold can commonly be found, usually of fine and very fine grain size. Among ore minerals, apart from arsenopyrite, pyrite and galenite, scheelite is frequently observed. Small deposits of near-bottom ore pipe are quite rare. Ore bodies are represented by quartz veins and zones of metasomatites. Gold is mostly free, of fine and super fine grain size. The prevailing trace element is mercury. Attribution of gold-quartz deposits to a certain part of ore pipe can facilitate more precise estimation of their prospects. In its own turn, this will allow to choose more favorable objects for further evaluation.



*Fig. 1. MGS 22/221. Gold nugget. Miass, the Southern Urals*



*Fig. 2. MGS 22/184. The Pipe gold nugget, wire-like braided form, Beryozovskoe gold field, the Urals*



Artemiev D.S., Krymsky R.S., Belyatsky B.V., Ashikhmin D.S. *The age of mineralization of Mayskoe gold ore deposit (Central Chukotka): results of Re-Os isotopic dating* // *Journal of Mining Institute*. 2020. Vol. 243. P. 266-278. DOI: 10.31897/PMI.2020.3.266



**Abstract.** The article presents the results of the sulfide mineralization dating of the Mayskoe gold ore deposit using the Re-Os isotope system and isochron age estimation method of the main sulfide minerals: arsenopyrite, pyrite, and antimonite.

The complex multistage formation of the studied sulfides, as well as the close intergrowths of genetically different mineral phases, did not allow obtaining a single rhenium-osmium isochron corresponding to the formation time of sulfide mineralization. Isochrones for single minerals, collected from each sulfide sample, turned out to be the result of isotopically distinct components mixture (radiogenic crustal and non-radiogenic mantle) and do not make sense from the geochronological point of view. In terms of geology, the most significant result of the study is an age estimation of  $128.8 \pm 4.4$  Ma, obtained for the sulfide mineralization of Mayskoe deposit using Re-Os isotope dating of single fractions of pyrite and antimonite of the ore mineralization stage. While arsenopyrite is most closely associated with gold mineralization, one of the arsenopyrite varieties corrodes framboidal pyrite of the pre-ore stage, has a maximum of the crust component in the osmium isotopic composition and forms a mixing line in the isochron diagram with an apparent formation age of  $458 \pm 18$  Ma. The initial osmium isotopic composition of the studied sulfides indicates a mixed mantle-crust source of sulfide mineralization. The issue of simultaneous ore genesis and granitoid magmatism in the Mayskoe deposit remained unresolved (the age of granitoids according to the U-Pb zircon system is 108 Ma). However, a possible solution could be the further determination of the Re-Os isochron age of the ore mineralization sulphides from the single paragenesis of a specific sample containing both arsenopyrite and pyrite (+ antimonite) with gold.

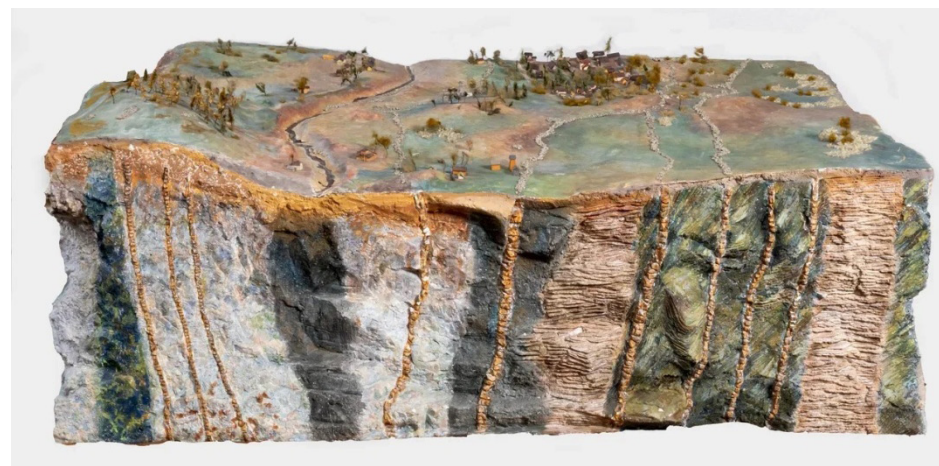


Fig. 3. BN<sub>2</sub>-17-1. Beryozovskoe gold field model, the Urals

Guzev V.E., Terekhov A.V., Krymsky R.S., Belyatsky B.V., Molchanov A.V. *Morozkinskoye gold deposit (Southern Yakutia): age and ore sources* // *Journal of Mining Institute*. 2021. Vol. 252. P. 801-813. DOI: 10.31897/PMI.2021.6.3



**Abstract.** The paper presents the results of the comprehensive isotope geochemical (Re-Os, Pb and  $\delta^{34}\text{S}$ ) study of sulfide mineralization of the Morozkinskoye deposit. The ore zones of the deposit are localized in the syenite massif of Mount Rudnaya, which is located within the Central Aldan ore region (southern Yakutia). Gold mineralization is represented by vein-disseminated or vein type mineralization and is manifested in acidic low-temperature metasomatites – beresites (Qz-Ser-Ank-Py). For the first time we obtained an age estimate of the gold mineralization  $\sim 129 \pm 3$  Ma, which the synchronism of the hydrothermal ore process in the beresites, which formed the Morozkinskoye deposit, and magmatic crystallization of the syenites of Mount Rudnaya ( $\sim 130$  Ma). The osmium initial isotopic composition of the studied sulfides indicates a mixed mantle-crust source of sulfide mineralization. New lead isotopic data of syenites indicate the predominance of mantle lead and an insignificant role of the lower – crust lead, while the isotopic composition of pyrite denotes the presence of the upper crustal material in the ore genesis. The sulfide  $\delta^{34}\text{S}$  values vary from  $-2.3$  to  $+0.6$  ‰ and indicate a predominantly magmatic source of sulfur in the ores.

*Kissin A.Y., Pritchkin M.E., Ozornin D.A. Geological and structural position of the Svetlinsky gold deposit (Southern Urals) // Journal of Mining Institute. 2022. Vol. 255. P. 369-376. DOI: 10.31897/PMI.2022.46*



**Abstract.** The paper presents the geological and structural position of the large Svetlinsky gold deposit in the Kochkar anticline (Southern Urals), localized in the zone of the Late Paleozoic ( $D_3$ ) deep thrust of the western dip. The study confirms and clarifies the notion of its mult phase and polychronism.

The thrust caused bending moments in its wings, subsidence of the lying crust, emergence of a shallow marine basin with rapid accumulation of terrigenous carbonate sediments ( $C_{IV}$ ), and formation of numerous landslide structures. The heating of rocks in the anticline core was accompanied by granitization and dome formation. A small Svetlinsky dome formed in the immediate vicinity of the thrust, creating a thermobaric gradient field ( $C_2$ ). The zone of dome dynamic influence also includes the adjoining thrust area, complicated by a series of sub-vertical thrusts of submeridional strike and numerous steeply dipping subparallel cracks of the latitudinal strike, synchronously filled with vein quartz and accompanied by hydrothermal metasomatic rock transformations. The formation of the gold deposit occurred during the post-collisional relaxation stage (from  $P_1$  to, probably, the Early Jurassic). The association of gold mineralization with the Svetlinsky dome is indicated by the presence of native gold in Neogene ravine placers in the dome area and marbles of the Svetlinsky deposit, in association with fluorite, F-phlogopite, Cr-muscovite, pink topaz, pure quartz, and native sulphur. The presence of native gold in Neogene ravine placers in the dome area and marbles of the Svetlinsky deposit, in association with fluorite, F-phlogopite, Cr-muscovite, pink topaz, pure quartz, and native sulphur, indicates the association of gold mineralization with the Svetlinsky dome.

*Felitsyn S.B., Alfimova N.A. Gold in biogenic apatites of the Baltic-Ladoga phosphorite basin // Journal of Mining Institute. 2022. Vol. 255. P. 470-475. DOI: 10.31897/PMI.2022.47*



**Abstract.** The distribution of gold in biogenic apatites from the Ordovician deposits in the northwest of the East European Platform shows that the maximum concentration of gold in apatites is found within the Ladoga-Baltic suture zone. Gold mineralization has a superimposed character, which is confirmed by

the dependence of the gold content on the size of apatite particles and a number of isotope geochemical systematics in biogenic apatites. Gold is present in the form of high fineness particles to 20  $\mu\text{m}$  in size on the surface of biogenic apatite fragments (phosphate brachiopod shells and conodont elements) and is easily extracted. In 10 % of samples of biogenic apatites, the total content of rare earth elements is more than 1 wt.%.

## Metallurgy and concentration

*This section contains articles on the experience, study and technology of enrichment of gold-bearing ore, as well as highlights, some trends in gold metallurgy.*

**Voropanov L.A., Kokoeva N.B. A technique for selective extraction of ions of gold and silver from hydrochloric solutions with tributylphosphate // Journal of Mining Institute. 2016. Vol. 222. P. 823-827. DOI: 10.18454/PMI.2016.6.823**



**Abstract.** Extraction is studied by tributylphosphate (TBP) of ions of gold and silver from hydrochloric solutions during the portional and single time feed of extractant in dependence of the initial concentration of metal ions, temperature, concentration of hydrochloric acid, the ratio of organic O and water

W phases O:W. The initial solutions contained soluble complex chlorides of gold and silver. When dissolving metal chlorides in the solution of common salt and hydrochloric acid, water soluble coordinate compound are formed that contain complex anions  $[\text{AuCl}_2]^-$ ,  $[\text{AuCl}_4]^-$ ,  $[\text{AgCl}_2]^-$ ,  $[\text{AgCl}_3]^{2-}$ ,  $[\text{AgCl}_4]^{3-}$ , et al. As an extractant we used the tri-butyl ether of phosphoric acid  $(\text{C}_4\text{H}_9\text{O})_3\text{PO}$  hat belongs to oxygen containing neutral extractants. The formation of coordinate (complex) compounds of TBP and metal polychlorides may be treated as the process of solvation of the extracted metal salt by the extractant. For selective extraction of ions of gold and silver from their hydrochloric solutions by tributylphosphate it is run feeding the extractant portionally to the solution at the minimal time of contact between the solution and the extractant; it helps extracting gold almost completely with the few first portions of the extractant at concentrations of 2n HCl 240 g/dm<sup>3</sup> NaCl and the temperature  $t = 60^\circ\text{C}$ . Meanwhile the extraction of silver is kept to a minimum. Silver is extracted almost completely after the extraction of gold is over; it is done with tributylphosphate as well at concentrations of 3n HCl, 240 g/dm<sup>3</sup> NaCl and the temperature  $t = 20^\circ\text{C}$ .

**Zhmurova V.V., Nemchinova N.V. Experience of integrated use of gold-bearing raw material in the production of precious metals // Journal of Mining Institute. 2018. Vol. 233. P. 506-511. DOI: 10.31897/PMI.2018.5.506**



**Abstract.** With the depletion of rich gold-bearing ores, the processing started to use polymetallic ores, which, in addition to precious metals, contain other elements that could be valuable after recovery. The problem of using such ores is extremely difficult because of the high cost of recovery of associated valuable components. The paper presents the results of studies on the integrated use of extracted gold-bearing raw materials based on the example of the Be-rezitovoye deposit (Amurskaya oblast), they have low content of precious metals and many heavy non-ferrous metals (copper, lead). Experimental work was carried out to obtain copper by the method of cementation from solutions formed after the leaching of the impurities of gold-containing cathode deposits with hydrochloric acid. The cementing metal was iron turnings (waste products of the turning shop of the enterprise). Next, it was proposed to use cemented copper as a collector during re-melting of slags – wastes of processing of low-grade polymetallic ores containing precious metals. The authors obtained ingots of alloyed gold with gold weight fraction of 16 %, which meets the requirements of TU 117-2-7-75 on the content of non-ferrous metals. During hydrochloric acid treatment of cathodic deposits silver partially passed into the solution, it was recovered together with cemented copper and, in subsequent melting, passed into alloyed gold. Thus, the method proposed by the authors helps to reduce the content of precious metals in the “incomplete production cycle” of the gold recovery factory. The opportunity of selling the cementation copper at the enterprises specializing on manufacturing of jewels is shown; the expected economic effect at the same time amounted to more than 1.8 million rubles.



*Aleksandrova T.N., Heide G., Afanasova A.V. Assessment of refractory gold-bearing ores based of interpretation of thermal analysis data // Journal of Mining Institute. 2019. Vol. 235. P. 30-37. DOI: 10.31897/PMI.2019.1.30*



**Abstract.** The article presents the results of a study on the possibility to assess refractory gold-bearing ores using thermal analysis data. It studies the flotation concentrates obtained during the enrichment of double refractory sulfide gold-bearing ores. This type of ore is complicated by the fine impregnation of gold in sulphide minerals and the presence of sorption-active scattered carbonaceous matter, which is in close association with sulphides. The results of thermogravimetric and mass spectrometric studies of refractory gold-bearing ores are presented. The obtained fragments for kerogen  $\text{CH}_3^+$  ( $m/z = 15$ ),  $\text{C}_2\text{H}_5^+$  ( $m/z = 29$ ) and  $\text{C}_3\text{H}_7^+$  ( $m/z = 43$ ) indicate the presence of various types of carbonaceous matter in the studied samples. It is justified that the degree of sorption activity of carbonaceous matter depends on the presence of kerogen and bitumen in the ore. High sorption activity of scattered carbonaceous material significantly affects the processing technology of ores and concentrates, both flotation and pyro- and hydrometallurgical methods. Thermogravimetric and mass spectroscopic analyzes can be used to determine the degree of preg-robbing of refractory gold-bearing ores. The obtained results predetermine the direction of creating new methods and technologies in the field of decarburization of refractory gold-bearing ores in the integrated development of solid minerals in the mining regions of Russia.

*Fedotov P.K., Senchenko A.E., Fedotov K.V., Burdonov A.E. Studies of enrichment of sulfide and oxidized ores of gold deposits of the Aldan shield // Journal of Mining Institute. 2020. Vol. 242. P. 218-227. DOI: 10.31897/PMI.2020.2.218*



**Abstract.** The paper presents the analysis of studies of the enrichment of sulfide and oxidized ores in Yakutia deposits. The ore of the deposit is a mixture of primary, mixed and oxidized ores. The main useful component of the studied ore samples is gold with a content of 1.5 to 2.8 g/t, the silver content is low – 5-17 g/t. Ore minerals are represented by sulfides, among which pyrite predominates. The total sulfide content does not exceed 3-5 %. The presence in the ore of free

and associated gold with a grain size from fractions of a micron to 1.5 mm. Gold is represented by nuggets in intergrowth with sulfides and also forms independent inclusions. Ores are classified as easily cyanidable. It was found that the content of amalgamable gold is 10-49, the share of cyanidable gold ranges from 66.67-91, the share of refractory gold is 9.0-33.33 %, which in absolute amount equals to 0.24-0.8 g/t. The extraction of gold in gravitation concentrate varies depending on the gold content in the ore and the yield of concentrate and for ores with a gold content of 1.5-2.8 g/t from 40 to 60 %. The direct cyanidation of all studied ore samples established the possibility of extracting gold into solution up to 86.7-92.9 %, the gold content in cyanidation cakes is 0.2-0.3 g/t. Investigations of the gravitation concentrate by the method of intensive cyanidation showed that with an initial gold content of ~ 500 g/t, up to 98.9 % is extracted into the solution. The gold content in intensive cyanide cakes will be 6-15 g/t. A set of studies carried out by the authors of the article at various institutes showed that it is advisable to process ore from the deposit using cyanidation technology with preliminary gravitational extraction of gold.

*Ivanik S.A., Ilyukhin D.A. Flotation extraction of elemental sulfur from gold-bearing cakes // Journal of Mining Institute. 2020. Vol. 242. P. 202-208. DOI: 10.31897/PMI.2020.2.202*



**Abstract.** Currently, in the development of the raw materials base of the gold mining industry, there is a tendency to reduce the quality of the initial mineral raw materials due to the depletion of reserves of rich gold-bearing ores. The article discusses the technology of extraction of refractory gold-bearing concentrates based on low-temperature leaching of pyrite concentrate. A decrease in the parameters of the autoclave oxidation of sulfide minerals, such as pyrite and arsenopyrite, leads to the incomplete extraction of gold into the solution and, consequently, its losses during subsequent cyanidation. As a possible option for a more complete extraction of gold using low-temperature oxidation technology, a method of flotation separation of elemental sulfur from leaching cakes is proposed. According to the basic process flow chart, the flotation process designed for gold extraction is carried out after autoclave oxidation, but before cyanidation. A series of experiments were carried out with varying reagent conditions and the dependence of gold losses on the extraction of elemental sulfur in the flotation tailings was

established. As determining factors, pH and solid content in the initial pulp were considered. The paper justifies the separation of elemental sulfur from autoclave cake to enriched sulfur concentrate. The cake flotation modes after autoclave oxidative leaching of pyrite concentrate are investigated. The distribution of elemental sulfur and gold by flotation products makes it possible to conduct the tailings cyanidation process with acceptable indicators.

**Kungurova V.E. Evaluating the effectiveness of fine gold extraction technologies on the example of titanomagnetite beach placers of the western coast of Kamchatka // Journal of Mining Institute. 2021. Vol. 252. P. 840-853. DOI: 10.31897/PMI.2021.6.6**



**Abstract.** The material on the gold content of coastal-marine deposits of the western coast of Kamchatka is analyzed and the resource potential is briefly characterized. A review of gold technological estimates obtained from the study of gold-bearing samples taken in promising areas of the coastal-marine strip, from the Bolshaya Vorovskaya River in the north to Cape Levashova in the south, is presented. Stock materials supplemented by our studies were used. Gold-bearing deposits with very fine (0.05-0.1 mm) and fine (0.1-1.0 mm) gold amounting to 94.6 % were tested, as well as samples with gold up to 2 mm and more in addition to fine gold. The content of freely recoverable gold reached 91.9 %. In the case of significant gold reserves in placers, prospects for their commercial development open up. experiments on the enrichment of gold-bearing coastal-marine deposits of Western Kamchatka indicate the possibility of extraction of free gold and other valuable components from them. Gravity technologies and modern equipment developed by OAO Irgiredmet and JSC ITOMAK are the most effective for their extraction. enrichment of gold-bearing formations with simultaneous extraction of several useful components from them, which is possible with the use of fluoride technology, can also become economically advantageous.

## Mineral resources development and rational subsurface use

*This section contains data on the environmental aspects and cost-benefit analysis for the performance of gold mining companies.*

**Mironova Z.V., Kuzina L.N., Bogdanovskaya S.F., Shul'gina K.A. Environmental aspect of cost reduction for gold processing enterprises of Krasnoyarsk territory // Journal of Mining Institute. 2014. Vol. 208. P. 36-42. <https://pmi.spmi.ru/index.php/pmi/article/view/5327>**



**Abstract.** Technology is based on the phenomenon of concentration of powerful non-ferrous metals contained in industrial wastewater by bio-substances in industrial and domestic wastewater and construction of buildings to create hydraulic dump tailings gold processing plants.



Fig. 4. TI 144. Gold washer of the Miass Gold Mining Company, model

*Kradenykh I.A., Barchukov A.V. Problem-oriented analysis of efficiency of gold mining enterprises in the Far East // Journal of Mining Institute. 2015. Vol. 211. P. 43-53. <https://pmi.spmi.ru/index.php/pmi/article/view/5247>*



**Abstract.** The subject of the article is the analysis of a current state and efficiency of economic activity of gold mining enterprises in the Far East engaged in development of gold-bearing placers. The purpose of the article is research on the situation developing in modern gold mining, identification and systematization of factors influencing the efficiency of the enterprise activity. Methods of economic, system and strategic analysis and graphic modeling are used in this article. The following scientific results are received in the course of the research: the relations between criteria “cause-consequence” and “meanseffects” are established based on a graphic method, the hierarchy of institutional and organizational, economic, and scientific and technical problems is determined and presented in the form of a cause-and-effect chart of a “problem tree”, which logically results in the creation of a “tree of goals”. This approach allows structuring goals of the gold mining enterprises aimed at increasing their economic efficiency hierarchically. The scope of the results received may contribute to elaboration of a number of measures on the development of the gold mining enterprises of the Far East region at the level of government or municipal institutions. The approaches and methods stated in the article can be used during the planning, forecast and assessment of economic efficiency of the enterprises. The results presented in the article allow further study into problems of forming effective management of the gold mining enterprises.

*Zaitsev A.Y. Methodological approach to substantiation of capital investments of gold fields based on unit costs // Journal of Mining Institute. 2019. Vol. 238. P. 459-464. DOI: 10.31897/PMI.2019.4.459*



**Abstract.** Issues of assessing capital expenditures for setting mineral deposits into operation are considered. Existing methods have a number of advantages and disadvantages, but they are determined separately for each type of fixed assets of the field. A simple method, that allows to quickly and easily determine the amount of capital costs for setting gold deposit into operation, based on data on ore reserves, as well as unit costs, taking into account the degree of infrastructure development at the deposit, is proposed. Presented methodology allows one to determine the real amount of initial capital expenditures of a gold deposit, calculate their marginal (recommended) value, and also assess the balance of capital investments in the development of a particular deposit, taking into account the existing one in the company’s investment portfolio. The methodology is based on analysis of empirical material, which used real capital costs for development of gold deposits (and foreign-metal impurities) by Polymetal International plc. As a result of a statistical study, method for determining the marginal cost of a field is obtained.



## Historical insight

*This section includes abstracts to the articles on deposits and geological material of gold fields in Russia.*

**Zavaritsky A.N.** *Some of the geological materials from Tsaryovo-Alexandrovsky field in Miass area // Journal of Mining Institute. 1912. Vol. 3. P. 124-126. <https://pmi.spmi.ru/index.php/pmi/article/view/15488>*

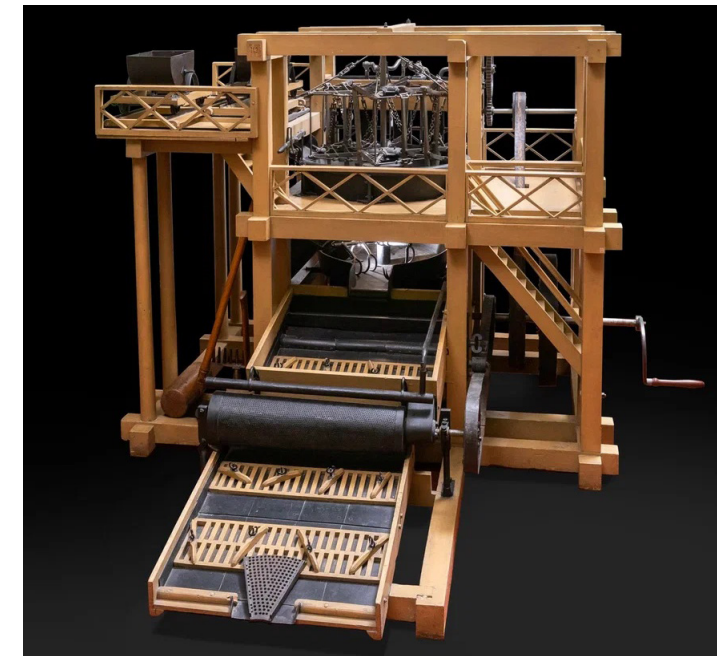


**Abstract.** The data on petrography of Tsaryovo-Alexandrovsky gold fields in the area of Miass that became famous due to the discovery of the biggest gold nugget (app. 36 kg) are quite scarce – there are only short notes for the most part. Geological maps of the area are schematic and given in the article written by the mining engineer Kulibin. The rocks are marked in the maps but not described. The author listed discovered gold mines and described a number of nuggets.

**Kell' G. G.** *Of geologic materials from the small part of the Semipalatinsk gold field. // Journal of Mining Institute. 1912. Vol. 4(1). P. 4-10. <https://pmi.spmi.ru/index.php/pmi/article/view/15414>*



**Abstract.** The article is the result of the primary study of a gold deposit, under taken in summer of 1911 on the fields of the Southern Siberia Gold Mining Company located on the Layla river in Kuludzhun volost', Ust-Kamenogorsk uyezd. The fields occupy the area of 22 sq. km. Small excursions were taken in different directions to the nearby granite Kaindinsky woods. Thus, the whole examined area takes 100 sq. km. Genesis of the quartz veins containing gold is identified. Their appearance is probably associated with the intrusion of granites. Fracture-filling veins, consistent with the strike of rocks and caused by primary dynamic processes, were formed as a result of thermal activity.



*Fig. 5. TI 143. A model of a gold-washing dish of the Kamarnitsky system with lower washing dish and riffle*

**Murashev D. F.** *Ayatskoe gold and sulphide fields // Journal of Mining Institute. 1915. Vol. 5(4-5). P. 361-381. <https://pmi.spmi.ru/index.php/pmi/article/view/15168>*



**Abstract.** The described field is located in Ekaterinbourg uyezd of Perm gubernia in corner 0 of the 109th quarter in Ayatskoe area of the Upper Iset District 1. The vein of eruptive nature, piercing the adjacent formation in the dike manner are porphyritic rocks. Sometimes it has clear structure when big albite grains are extracted and vary from 0 to 4. The bulk consists of small extruded crystals of albite, quartz and tiny grains of orthoclase which cannot be examined optically but can be revealed by chemical analysis. Inclusions of apatite, pyrite, tourmaline and antimony ore are seen almost everywhere. Based on the completed work the mentioned field as it is now has no industrial significance, although it should be noted that much valuable data have not been obtained yet.



*Yuzefovich V.K. Geodesy and underground survey of the Uralzvetmetzoloto institute in Beryozovsky area in 1931 // Journal of Mining Institute. 1934. Vol. 8. P. 97-135. <https://pmi.spmi.ru/index.php/pmi/article/view/15256>*



**Abstract.** The article contains the description, geodesy and underground survey for the development of network for trigonometric and polygonometric positions in the area of Beryozovsky field and field survey. The field with the administrative centre as a part of the Beryozovsky mining plant is located 12 km to the north-east of Sverdlovsk in the woods on the bank of the Pyshma river. The gold field is present in aquiferous beresites that resulted in difficulties with matching of shafts survey and choosing undersurface points. Closed area demanded complex connected network and the construction of high signals. Along with the network development preliminary works for execution of the field layout and mining and geometrical analysis were held. This task included archive studies and the addition of previous points into the new network.



*Fig.6 MGS 6/131. Cluster of pyrite cubic crystals, Beryozovsk, the Urals*

*Chubik P.S., Nikiforov S.I. The contribution of the representatives of the Siberian (Tomsk) mining and geological school to the development of mineral raw material base in Russia and Abroad // Journal of Mining Institute. 2017. Vol. 228. P. 688-694. DOI: 10.25515/PMI.2017.6.688*



**Abstract.** This paper is devoted to the maturation and development of Siberian (Tomsk) mining and geological school – one of the leading schools in Russia, which was created in the first third of the 20 th century in Tomsk Technological Institute by V.A.Obruchev and M.A.Usov known to be outstanding Russian and Soviet geoscientists and members of the Russian Academy of Science. The article touches upon the participation of representatives of Siberian (Tomsk) mining and geological school to the exploration and development of mineral and raw material base of Siberia, Russia's Far East, Central Asia. The information about the most important geological discoveries made by nurslings of Siberian (Tomsk) mining and geological school is provided.

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