

Development of Methods for Determining Differentiated Rates of Mineral Extraction Tax in Recovery of Solid Commercial Components from Technogenic and Natural Fields

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Abstract

Background: The article presents differential methods to determine ad valorem Mineral Extraction Tax (MET) rates for commercial components extracted from technogenic raw materials and from secondary mineral resources. **Methods:** Proposed objectives include restrictions on the minimum level of MET rates. MET is calculated by reference to stock exchange prices for finished products in formulas 1 and 2. This tax is calculated relying on the estimated value of extracted minerals in formulas 4 and 5. The forecasted MET potential is estimated as present value of expected payments to the budgets of the RF budget system. **Findings:** Increasing the complexity of the use of mineral resources through the development of state regulation of economic measures aimed at stimulating subsoil usage involves determining the optimal ad valorem tax rates on mining operations, which provide cost-effectiveness of the investment project organization engaged in the development of technogenic deposits. For this purpose, the study has developed and scientifically validated methods in terms of mining rent, where mining-and-geological (mill head grade) and technological (the value of throughout recovery of the component to the finished product) criteria have been highlighted in its structure which are prerequisite to establish economically justified level of tax exemptions of mineral extraction tax. Frequency of revision of MET rates is still debatable, whether it will be a period of development of the deposit or another period of imposing the tax rate. **Improvements:** The presented methods can be used in working out the directions of Russian tax system development, as well as the implementation of regional investment projects aimed at developing, in the first place, technogenic deposits under a separate license.

Keywords: Differentiated Tax Rates, Mineral Extraction Tax (MET), Solid Minerals Extraction, Technogenic Field (TF)

1. Introduction

This article considers that the ad valorem tax is preferable to the specific tax in term of the dynamic Hotelling model for non-renewable resources^{1,2}.

According to D. Lund³, ad valorem tax is neutral for well-diversified companies. The issue of obtaining an exactly optimal tax rate can be solved using the procedures proposed by the authors of the present article.

S. Bambrick⁴, R. U. Ayres⁵, J. Graham and D. Rogers⁶, C. W. Smith and R. M. Stulz⁷, H. E. Leland⁸, M. Miller

and F. Modigliani⁹, D. Mayers and C. Smith¹⁰, M. Ross¹¹, P. Tufano¹², K. Froot, D. Scharfstein and J. Stein¹³, H. Zhang¹⁴ consider the solution of problems in terms of income tax, not considering the impact of the mineral extraction tax on the tax base formation.

The techniques of determining ad valorem mineral extraction tax rates for solid commercial minerals cannot be applied for the taxation of crude hydrocarbons¹⁵.

K. Pittel and L. Bretschger¹⁶ analyze sectoral heterogeneity as regards the extensive use of natural resources.

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Each technogenic field, similar to each natural deposit, is unique; and, as it has already been mentioned in this study, the contents of commercial components in technogenic fields can be even higher than those in the natural ones. Peculiar features of mineralogical materials in these fields call for differentiating approach to establishing Mineral Extraction Tax (MET), when these deposits are commercially developed.

It has already been noted that the commercial components, which could be extracted applying new technical solutions within the framework of the investment projects, are subject to MET taxation principles.

In this regard, there is a need to collect and analyze information on the investment projects that imply development of technogenic fields, subsequently classifying and dividing those fields into commercially extractable deposits and the deposits that cannot be processed; for the latter, the conditions for further recycling should be determined.

Today, no formalized approaches have been adopted to determine MET rates for the deposits extracted from technogenic fields.

Trying to establish MET taxation methods, this study aims at taking into account the balance of the interests of the state (defining tax potential) and the interests of a subsoil user (economics of the investment project).

To develop the methods for calculating ad valorem MET rates, this study provides the analysis of natural resources taxation in Russia and abroad, introduces mining rent theories and operational practices of subsoil users. Thereat, it has been highlighted that the content of the useful component and the amounts extracted into the prime product are the prerequisites for establishing economically justified levels of taxation at the stage of extracting different types of commercial minerals and in the course of complex reprocessing of mineral raw materials.

To develop each field, an investment project is prepared taking into account all operational indicators of an organization. However, the investment projects in developing technogenic deposits are seldom implemented.

Considering the stable links existing between the elements of the process under investigation, a conclusion can be made that optimal ad valorem MET rates for the commercial components extracted from technogenic deposits should be determined within the framework of the relevant investment projects by applying the methods of solving optimization problem (body of mathematics).

Investment projects deal with not only the key performance indicators but also with mining and geological factors (content of useful component in the base mineral materials) and the amounts extracted into the prime product.

For the purposes of taxation, the vision of “technogenic field” should be defined as follows: “technogenic field” is secondary mineral resources generated as processing losses in the course of mining and complex reprocessing of mineral raw materials, and the extraction of mineral resources of which is subject to separate licensing in accordance with the subsoil use legislation.

2. Research Methods

This approach suggests that each Technogenic Field (TF) should be developed within the framework of the relevant investment project. To realize this approach, the data on technogenic deposit fields in Russia should be recorded in TF cadastral register including the indicators as follows:

- Mining and geological factors;
- Amounts extracted into the prime product, prices, costs, volumes of reprocessed secondary mineral raw materials, costs of development, etc.

To develop an integrated system of taxation, this study provides recommendations on creating cadastral registers of secondary mineral materials; the information contained in those registers should be used for the purposes of taxation including the development of differential approach to determine tax rates for the commercial components extracted from technogenic fields under special licenses. The criterion for determining MET rates is represented by maximum MET potential across all commercial components extracted from TF.

The sequence of solving the optimization problem is described below:

- The number of technogenic fields to be considered should be identified;
- For each investment project, the minimum internal rate of return should be determined at which a project is deemed practicable and profitable (the rate can vary depending on the region and the deposit);
- Duration of the project should be established according to the business plan;
- The percentage of the commercial components contained within one ton of the extracted mineral materials in this deposit should be determined according to the business plan;

- Direct and indirect costs for extracting one ton of each useful component are calculated according to the business plan (in presentation currency, for example, US dollar);
- The prices should be forecasted for the products made of this particular type of useful component (VAT excluded), US dollar per ton for the period of the investment project implementation;
- Net Present Value (NPV) is calculated taking into account MET rates at the anticipated rate of return;
- An equation to calculate the forecasted potential MET revenues is included into the field development budget, formulae (1.1), (1.2) and (1.4), (1.5) are applied to determine optimal ad valorem MET rates for each component of the technogenic field by means of solving the relevant optimization problem;
- This optimization problem can be solved by Excel Search for Solution add-in.

To formalize this method, assume the designations as follows:

M – the number of technogenic fields under study;

r_m – minimum rate of return (which can vary for each particular region) at which the project in developing m field is practicable;

K – The amount of different commercial components in all TFs;

t_m – The duration of m -investment project;

c_{mt} – Expenses for investment project m in year t adjusted for amortization;

q_{mtk} – Obtained finished products, weight of chemically pure metal, tons (this value is the result of multiplying the weight of the extracted mineral raw materials by the content of the useful component (g/t) in this extracted material and by throughout recovery value of k -component at field m in year t according to the adopted technological process;

p_{tk} – forecasted stock exchange price (VAT excluded) of component k in year t ;

η_k – MET rate for k -useful component;

d_t – discount rate in year t , that can be defined as zero coupon government stock rate.

$$F(x) = \begin{cases} 0, & x < 0 \\ 1, & x \geq 0 \end{cases}$$

This is Heaviside function, unit step function, which is equal to zero for the negative value of the argument, and is equal to one for the positive value¹⁹.

Project in developing m -field will be implemented if its Internal Rate of Return of the investment project (IRR) proves to be not lower than r_m . Or, which is the same, if the project's NPV, calculated at rate r_m , is greater than or equal to zero.

If MET is calculated based on stock exchange prices of the finished product sales, then NPV equation will be as follows:

$$NPV_m(r_m) = \sum_{t=1}^{t_m} \frac{\sum_{k=1}^K ((1-\eta_k)q_{mtk}p_{tk}) - c_{mt}}{(1+r_m)^t} \geq 0 \quad (1)$$

The forecasted mineral extraction tax potential for TF development will amount to:

$$NPV_{TF}(\eta_k, k=1, \dots, K) = \sum_{t=1}^{\max(t_m, m=1, \dots, M)} \frac{\sum_{m=1}^M F(NPV_m(r_m)) \sum_{k=1}^K \eta_k q_{mtk} p_{tk}}{(1+d_t)^t} \quad (2)$$

ARGMAX $[NPV_{TF}(\eta_k, k=1, \dots, K)]$ (function whose value is equal to x that affords maximum to function $f(x)$) gives optimum MET rates from the perspective of taxation potential. Finding maximum in Equation (1.2) is a complex non-convex optimization problem.

As a first step, exhaustive algorithms can be recommended to select the best values of η_k , $k=1, \dots, K$.

If MET is calculated based on the imputed value of the extracted minerals, where:

c_{mtk} is a part of the costs attributed to useful component k in line with the active taxation system.²⁰

$$c_{mtk} = c_{mt} \frac{q_{mtk}}{\sum_{k=1}^K q_{mtk}} \quad (3)$$

NPV equation for the investment project will be as follows:

$$NPV_m(r_m) = \sum_{t=1}^{t_m} \frac{\sum_{k=1}^K (q_{mtk} p_{tk} - (1+\eta_k)c_{mtk})}{(1+r_m)^t} \geq 0 \quad (4)$$

The forecasted mineral extraction tax potential for TF development will amount to:

$$NPV_{TF}(\eta_k, k=1, \dots, K) = \sum_{t=1}^{\max(t_m, m=1, \dots, M)} \frac{\sum_{m=1}^M F(NPV_m(r_m)) \sum_{k=1}^K \eta_k c_{mtk}}{(1+d_t)^t} \quad (5)$$

In the first example (formulae 1.1 and 1.2), the solution of the problem is given for three conditional technogenic fields with fixed amounts of the processed raw materials and stock exchange prices of the finished product sales.

For the purposes of calculation, the content of the useful component has been assumed based on the data on the contents of such non-ferrous metals as nickel, copper and zinc.

Ore dilution factor is not applied, as this field has already been classified as technogenic.

To solve the problem, the prices have been sourced from Bloomberg data²¹.

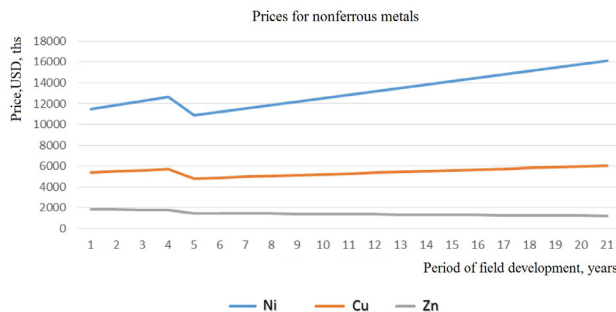


Figure 1. Anticipated prices for finished products.

Note: It is compiled based on Bloomberg data as of 28.10.2015.²¹

The amount of reprocessed secondary mineral materials is fixed, insofar as this is not a natural deposit and neither production scale-up nor mining allotment expansion is envisaged.

Calculations according to the method described in this section (formula 1.2) showed that the optimal MET rate for nickel amounted to 17.7 %; for copper it amounted to 0.2 %; for zinc, the rate was negative, minus 15 %.

The negative value of MET rate, obtained in the course of solving the problem, means that preferential taxation should be applied to the operations related to extracting this particular component, zinc, in line with the provisions set in the Tax Code of the Russian Federation, or, this component should not be extracted into the prime product.

According to conditional example (formula 1.2), potential MET amounts to USD 78 mln, or, RUB 4.9 bln

at the US Dollar exchange rate of 63 Rubles for one US Dollar as adopted in 2016 budget.

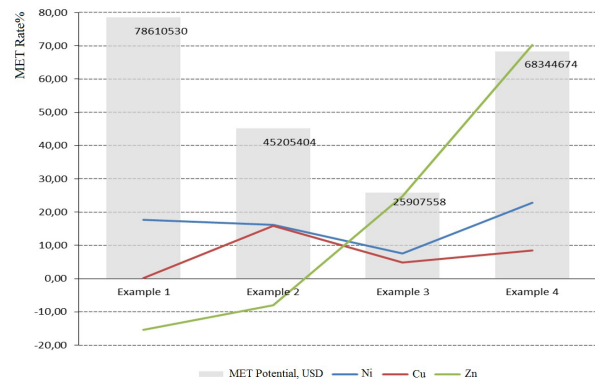


Figure 2. MET rates based on stock exchange prices for finished products.

To solve the optimization problem, Excel Search for Solution add-in has been applied.

In the second example, that makes use of the same initial data, optimal MET rates are calculated according to formula 4.5 based on the imputed value of the extracted mineral resources (Clause 3, Paragraph1, Article 340)²².

The results show that no preferential taxation principles should be applied here, as MET rates are positive and the forecasted MET revenues amount to USD 71 mln, or RUB 4.5 bln at the US Dollar exchange rate of 63 Rubles for one US Dollar.

The second option solves the problem under the conditions identical to those set for the first option, but with the forecasted price altered as of 10.20.2015 (see graph Forecasted prices for finished products), and with year-on-year output of finished product decrease by 10 %, insofar as in the course of developing technogenic fields the production is not, as a rule, increased, and the extracted raw materials are either developed alongside with natural deposits or are covered by processing agreements.

Calculations according to the abovementioned method (formula 1.1) for three conditional technogenic fields with decreasing amounts of the developed materials and stock exchange prices for the finished product sales, showed that optimum MET rate for nickel amounted to 16%, for copper it made 15%, and for zinc the rate was again negative, minus 8% shown in Table 1.

With negative value of MET rate, a separate decision should be made as regards the practicability of extracting

this component and as regards the taxation principles to be applied.

Table 1. MET rates based on stock exchange prices for finished products (nonferrous metals)

	MET rates for k-commercial component, %			
	Ni	Cu	Zn	MET, USD
Example 1	17.72	0.18	-15.33	78,610,530
Example 2	16.11	15.90	-8.05	45,205,404
Example 3	7.60	4.78	24.72	25,907,558
Example 4	22.78	8.51	70.22	68,344,674

According to this example, the forecasted MET potential amounts to USD 41 mln, or RUB 2.6 bln at the US Dollar exchange rate of 63 Rubles for one US Dollar as adopted in 2016 budget.

The second option, example two (formulae 1.4 and 1.5), under the conditions identical to those set for the first option, namely, with decreasing amounts of the developed materials and with the costs of the minerals estimated based on the imputed value of the extracted mineral resources (Clause 3, Paragraph 1, Article 340)²² showed that optimal ad valorem MET rate for nickel made 9%; for copper it amounted to 18%, and for zinc it was 12%. The obtained MET rate was not negative, which means that the component should be extracted and the taxation principles should be in line with the established procedures.

The forecasted MET potential amounts to USD 39 mln, or RUB 2.4 bln at the US Dollar exchange rate of 63 Rubles for one US Dollar as adopted in 2016 budget shown in Table 2.

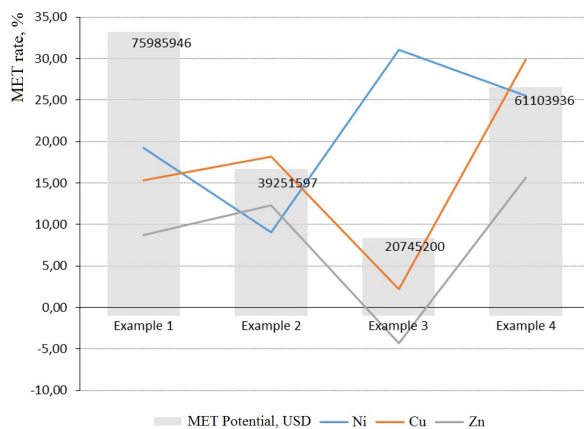


Figure 3. MET rates based on the estimated value of the

formation of solid minerals taxation.

Table 2. MET rates based on the estimated value of the formation of solid minerals taxation

	MET rate for k-commercial component			
	Ni	Cu	Zn	MET, USD
Example 1	19.23	15.32	8.70	75,985,946
Example 2	9.01	18.15	12.27	39,251,597
Example 3	31.08	2.17	-4.34	20,745,200
Example 4	25.55	29.89	15.63	61,103,936

To apply the methods described in this section for large-scale developments of technogenic fields, the cadastral register of secondary mineral materials should include the data as follows:

- Capital and operational expenses for implementing the project in developing each technogenic field;
- Annually extracted amounts of each useful component within the framework of the relevant investment project when NPV exceeds zero at the anticipated rate of return;
- Forecasted prices for all the components contained in the raw materials, given for the period of the investment project implementation.

As the task is further specified and actualized, it would be advisable to develop more efficient specialized algorithms for optimization.

The methods of determining MET rates by solving optimization problems make it possible to estimate the forecasted tax potential of minerals extracted from technogenic field for the purposes of long-term budget planning in the Russian Federation. These methods could be applied to developing the new areas of taxation system of the Russian federation within the context of state-private partnership and also for the purposes of implementing regional investment projects focused on enhanced development of secondary mineral resources under special license, including the areas of introducing differentiated taxation principles and further improvements to regional taxation system in the mineral resources production sector. There is still an issue of how often MET taxation rates should be revised: whether the period between revisions should be predetermined by the duration of the field development or by some other tax rate estimation procedure.

Suggested methods for establishing MET rates for technogenic fields, also representing the efforts to find

scientific criteria for differentiating MET principles for natural deposits, have been supported by the calculations performed for the examples of natural deposit fields as follows:

Kamchatka Copper Company, LLC, investment project Maletoyvayamskaya Area Mining and Processing Plant Construction, estimated at RUB 534 mln, VAT incl. (for purposes of calculating MET potential and determining optimal MET rates the costs were taken excluding VAT), project implementation period is 20 years, forecasted resources are 140 tons.

Bystrinsky Mining Company, CJSC, investment project Kumroch Mining and Processing Plant Construction, estimated at RUB 10 590 mln, VAT incl. (for purposes of calculating MET potential and determining optimal MET rates the costs were taken excluding VAT), project implementation period is 15 years, stocks are 30 tons, resources are 170 tons.

Sector profile of the projects is represented by mining ores, sands and precious metals (gold, silver, platinum, and palladium).

Additional tools for implementing the projects are provided by the status of regional investment project according to Chapter 3.3, Part 1 of the Tax Code of the Russian Federation²³.

These investment projects have been selected for the purposes of calculations taking into account the fact that today there is a legislative initiative on cutting the precious metals MET rate from 6% to 3.5%. Now, taxation of precious metals is effected in line with Clause 5, Article 340 of the Tax Code of the Russian Federation²², which stipulates that the value of precious metals extracted from primary (ore) deposits, placer and technogenic deposits, should be estimated based on the current sales prices for chemically pure metals effective for this particular taxpayer within the period of taxation (or, if such prices are not available, effective within the nearest preceding period of taxation) without value added tax and decreased by the costs incurred by the taxpayer for refining and for delivery (transportation) to the customer.

Given the fact that the format of the abovementioned projects does not contain any information on the content of the useful component or on its amount to be extracted into prime product, to solve the set task, assume the industry average data: gold content is 4 grams per ton of ore, silver content is 8 grams per ton of ore, platinum content is 5 grams per ton, palladium content is 6 grams per ton, average extraction ratio is 75 % and this takes into

account the ore dilution factor. For the purposes of determining MET potential, the stocks and the resources are summed in this case.

The forecasted prices for the finished products (gold, silver, platinum) are sourced from Bloomberg²¹.

Calculations are based on the assumed price of US Dollars 670 per ounce, adjusted by up to 10% inflation for the years of the project implementation period.

Calculations according to the method described in this section (formula 1.2) show that optimal ad valorem MET rate for gold amounts to 10%; it makes 8% for silver; and it is 8% for platinum, and 8% for palladium.

Comparing the effective MET rates with the calculated rates, it should be noted that the Tax Code of the Russian Federation stipulates MET rate of 6% for gold and 8% for multi-component raw materials.

According to this example, the forecasted MET potential amounts to USD 2.7 mln, or RUB 170 mln at the US Dollar exchange rate of 63 Rubles for one US Dollar as adopted in 2016 budget.

It is still disputable whether MET rate should be set for the period of the field development or some other intervals should be specified for its revision.

Solving the problem of taxation in extracting and complex reprocessing of mineral materials in both natural and technogenic deposits will make it possible to forecast MET potential, to make informed decisions in the course of investment project implementation, to improve taxation methods at particular deposit fields and to develop preferential taxation principles.

Developing technogenic fields with a view to the best interests of the state and of the investors should also be focused on mitigating the scale of environmental impact, which is a priority in Russian state policy.

3. Results

The methods of establishing the tax base for mineral extraction tax have been suggested based on mining and geological differentiation criteria and on stock exchange prices for the finished products (chemically pure metals) for different types of mineral resources extracted from natural deposits.

A need has been justified to improve the investment attractiveness of the technogenic fields developed under special license.

Conceptual areas have been identified for developing the taxation policy of the state in the sphere of extracting

mineral resources from technogenic fields under special licensing procedures based on determining MET rates in the course of implementing investment projects and based on determining MET potential for technogenic deposit fields in Russia, including the following:

- Scientifically justified methods for determining ad valorem MET rates for commercial components, extracted from technogenic raw materials based on stock exchange prices for the finished products and based on MET differentiating criteria (content of useful component in mineral materials and the amounts of extraction into the prime product).
- Scientifically justified methods for determining ad valorem MET rates for commercial components extracted from secondary mineral materials based on imputed value of the extracted mineral resources and based on MET differentiating criteria.

4. Conclusions

Russia possesses the world largest mineral resource complex that is the basis of guaranteed economic and energy security of the country meeting the current and the prospective needs of Russian economy.

Russia holds leading positions in terms of availability and mining of basic types of mineral resources, including solid commercial minerals.

Over recent years, the growth of available mineral resources has been ensured by implementing measures aimed at searching for and estimating the deposits of the most important types of mineral raw materials.

Russia still belongs to the group of the states which, having considerable amounts of mineral resources at their disposal, export large volumes of the extracted minerals in raw condition.

Specific characteristics of the natural resource potential in Russia are its large-scale and complexity. Among the great variety of natural resources, there are large reserves, mining operations and other applications of particular types of mineral raw materials.

Considering the complex use of raw materials, it should be noted that the thoroughness (the level of throughout extraction of all commercial components from mineral materials into salable products) is not a criterion to be used for evaluating either economic effect or the efficiency of the field development.

However, the state and the agents of the economy should be interested in thorough extraction of all commercial components from the raw materials.

Major part of the current problems has been stipulated not just by the drawbacks of taxes and fees legislation, but also, and largely, by the imperfect subsoil regulations, including, for example, the problems of construing the fundamental ideas applied to subsurface resources taxation, the issues of licensing minerals mining operations and technogenic field developments.

In this study, the solution to the problem of complex use of mineral materials is based on the improvements to the existing taxation system.

Over a long term of years of mining industry development in Russia, huge technological losses resulting from mining and complex processing of mineral materials have been accumulated across the territory of the country.

Earlier technological processes that were applied to extract commercial components could not ensure the levels of utilizing mineral components that became possible nowadays.

At this stage of developing modern technological processes, technogenic deposits represent potential economic interest in terms of the possibility to make useful products out of these materials. Moreover, the contents of commercial components in such deposits can be even higher than those in the presently developed natural fields.

Increased complexity of mineral resources utilization achieved by means of introducing economic measures of state control, aimed at encouraging subsoil sector, calls for determining optimal ad valorem rates of minerals extraction tax, at which the feasibility of the investment projects and of the businesses focused on developing technogenic fields is ensured.

To this end, the study provides scientifically justified methods based on such ideas as mining rent where, within its structure, mining and geological factors (content of useful component in basic mineral material) and technological (amount of throughout extraction of components into finished products) have been identified as the criteria prerequisite for establishing economically justified levels of the imposed mineral extraction tax:

- Method for establishing ad valorem MET rates for commercial components, extracted from technogenic deposit fields based on stock exchange prices, on the contents of commercial components and on the amounts extracted into the finished product;

- Method for determining optimal ad valorem MET rates for the commercial components extracted in the course of developing technogenic fields within the framework of the investment projects in reprocessing such raw materials based on imputed value of the extracted mineral resources, on the contents of commercial components in minerals and on the amount extracted into the finished product.

Suggested methods can be applied to the areas of improvement of the taxation system in the Russian Federation and to the regional investment project management focused primarily on developing technogenic fields under special license.

Solving the issues of taxation in extraction and complex reprocessing of mineral raw materials, including the development of technogenic deposits, will make it possible not only to increase the tax revenues of the budgets at all levels, but also to reduce the scale of environmental impact.

As prospects of the further development of this theme, in particular, concerning methods for determining the optimal MET rates, of the extracted technogenic deposits, the collection and processing the following information is suggested:

- Capital and operating costs for the implementation of investment projects to develop every technogenic deposits;
- Annual extraction of each commercial component in case of realization of the investment project, when the NPV at the anticipated rate of return is above zero;
- Price forecast for all kinds of components in technological fields for the period of the investment project implementation;
- A software product development, which is based on information contained in the inventory of technogenic deposits and methods for determining the optimal ad valorem rates of mineral extraction tax, taking into account possible changes in task setting;
- Analysis of deposit outline in prospect for the issuance of licenses for subsoil use to determine the MET potential;
- Carrying out statistical analysis of the information on all technogenic deposits in Russia.

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