UDC: 550.812.14:351.823.3

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MANAGEMENT AND LEGAL REGULATION OF MINERAL EXPLORATION: CHALLENGING ISSUES

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When carrying out exploration at the expense of subsoil user, the recommendation is to use the principle of least work proposed and applied in the 1920s in the USSR. The authors note that modern computer systems and methods for quantitative assessment of reserves reliability allow applying these principles to improve quality of exploration. They demonstrate impossibility of least-work principle application without changes in the requirements of current regulations

Ключевые слова: subsoil use; solid commercial minerals; exploration grid density; design; regulatory and methodological support; expert review of exploration program

In the first decade of the last century, P.K. Sobolevsky, Professor of the Tomsk Institute of Technology (today it is Tomsk Polytechnic University), according to his student V.F. Turchinsky [1], proposed to introduce the principle he called «principle of least work» (or least-work principle) into the system of exploration work management. According to P.K. Sobolevsky, specialists of the Mining Geometry Laboratory of the Ural Mining Institute and the Ural Research Institute of Applied Geophysics and Mining Geometry successfully applied this principle in 1920s in the Urals (Bakal, Kizel, Polovinka, Gubakha, Usva [2]). In 1926, the Resolution No. 176 [3] of the I-st Soviet Union Mining Research and Technology Congress noted its importance and encouraged mining specialists to use the least-work principle in the system of field investigations.

P.K. Sobolevsky proposed this principle from the following considerations: *«One of the very important consideration in field exploration work simplification lies in the distribution and selection of exploration units – the necessary and sufficient principle should naturally be governing in this matter»; and «A field explorer must work with the motto no extra borehole, no extra prospecting pit». «Each exploration unit must be accurately substantiated»*[2]. For transition from this obvious statement to practical implementation, it was proposed the following: first, making a small number or even individual drillholes or pits on the site; and second, process the data acquired and, basing on it, formulate first working hypothesis on subsurface behaviour of the studied parameter. This hypothesis should be visualized as a graphical model of the object (in contour lines). Next, based on the first hypothesis, it was necessary to design the second group of drillholes (a single drillhole), their position was selected with the purpose of clarification, validation or disproval of the hypothesis. After drilling holes, it was necessary to formulate a second working hypothesis, to design a third group of drillholes, etc. In such a way, *«the previous group of drillholes (pits) determines location of the following group of planned*

drillholes (pits)» [1]. It was suggested that not only the level of disagreement between the hypotheses, but also the smoothness of contour lines of the examined indicator should be used as the criteria for assessing validity of the hypotheses. In accordance with the geofield theory suggested by P.K. Sobolevsky [2], the contour lines should be smooth. In their works, P.K. Sobolevsky [2, 4] and his disciple V.F. Turchinsky [1] (who proposed to drill groups of preferably three holes in order to infill exploration grid) considered a certain procedure for formation of working hypotheses in the early stage of exploration activities.

The principle P.K. Sobolevsky proposed is in many respects similar to the principle of exploration activities staging, which was already widely used at the beginning of the last century. In essence, the idea of the least-work principle was to «split» the exploration stage into smaller «substages», and to carry out a set of mining geometry works in them, which was a completely new solution at the time.

The above-mentioned approach to managing the exploration process has disappeared from exploration practice. Technically significant reasons for this could be the high labor intensity of multiple geometrization works on the studied object and absence of clear-cut criteria for identifying the weakest points of working hypotheses about the nature of the indicator behaviour. It should, however, be recognized that the main reason for not using the least-work principle in practice is that it was completely outside the scope of the planned system of the economy introduced in the country. After all, applying the leas-work principle excludes the possibility of determining the necessary amount and cost of exploration work before it begins. That is, the principle proposed by P. K. Sobolevsky contradicted the fundamentals of the socialist planned economy management. The right to reserve small amounts of drilling work in exploration projects, as provided for in later regulations, did not ensure that this principle was applied in practice.

Much later, Prof. V.A. Bukrinsky, one of the last disciples of P.K. Sobolevsky, enlarged the idea of his teacher; he proposed a similar dynamic predictive method for identification of patterns of indicator behaviour in different field types [5]. However, understandably, this method also was not widely used, although it could be used for planning of appraisal works.

As of today, situation changed because of transition to market economy and changes in the content of a number of regulations related to the area of geological studies of subsurface, which formally allows reviving the idea of P. K. Sobolevsky for the following reasons:

– Works in the exploration stage are currently funded mainly by subsoil users having a flexible budgeting system, which are interested in obtaining the results of required quality at the lowest financial cost;

– Modern software systems designed for processing the data obtained as a result of geological exploration, enable quick and low-cost adjustments to be made in deliverables after information on new exploration units is added to the original dataset used;

– Paragraph 16 is introduced in the present Classification of Reserves and Possible Resources of Solid Commercial Minerals [6], which obliges the use of additional classification indicators for quantitative and probabilistic assessment of accuracy and reliability of determination of main variables used to estimate reserves, in the procedure of reserves categorization. This allows using these estimates to identify the weakest points in working hypotheses about the nature of the indicator behaviour without any non-routine works.

Nevertheless, there are currently a number of legal and regulatory problems that prevent the use of the least-work principle when managing and carrying out exploration of solid commercial minerals at the expense of the subsoil user (consideration of its possible use in exploration at the expense of the State budget, as well as in the earlier stages of subsurface exploration is beyond the scope of this work; the authors took the examples presented here from the experience of coal deposit exploration, so that they may not fully comply with the practice of other mineral exploration).

Main elements of exploration management in the mentioned circumstances are as follows [7]:

– A subsoil user prepares and approves Terms of Reference (or Geological Assignment) for exploration within the subsoil area, which define goals, geological objectives, and key methods to solve them, expected results and schedule time;

– A subsoil user or engaged legal or natural person prepare project documentation for exploration work performance, which contains substantiation of methodological approaches, technical and engineering solutions ensuring achievement of the exploration goal and solution of geological tasks while meeting the compulsory requirements of mining legislation and subsoil use conditions stipulated by license;

– Positive findings of FGKU Rosgeolekspertiza should be obtained on the result of the state expert review of project documentation (Art. 36.1 of the RF Subsoil Law), which provides for the following: analysis and assessment of compliance with the subsoil legislation, subsoil use conditions stipulated by license, validity of the accepted methodology, technique, technology, scope and content of exploration activities and their sufficiency for solution of geological problems while ensuring the sustainable use and protection of mineral resources [8];

– A subsoil user approves the exploration program that has received a positive state expert opinion, and then starts working on its implementation.

In accordance with Paragraph 26 of the Regulations [7], substantiation of design solutions on types and scope of geological exploration activities is based on the expected geological model of the exploration target, which is created on the basis of consolidation and analysis of available geological information – i.e., on the first working hypothesis according to of P. K. Sobolevsky terminology. At the same time, Regulations [7] stipulate that the full scope of work, information about borehole locations for entire project network and drilling sequence must be listed in the project, which is impossible when the least-work principle is applied.

When a subsoil user funds exploration, Regulations [7] allow specifying in the project the allowable variation of the scope of work from the planned amount. However, for solid commercial mineral exploration programs, these variations are limited to a very modest 20%. This level of allowable variation not only eliminates the possibility of using the least-work principle, but also does not ensure the possibility of in-process decision-making based on the analysis of information obtained for known methodological purposes on the sites of detailed evaluation. It was probably one of the reasons for refusal to meet regulatory requirements [9] to creation of sites of detailed evaluation in exploration of most coal fields.

It should be noted that exploration drilling networks are currently being planned without the necessary methodological support. For example, the approximate well spacing mentioned in the Guidelines [10] in the context of exploration work planning, are exactly the same as in the recommendations of 1982 Reserves Classification, which was based on a different understanding of the reserve categories [11]. Ten years ago, tendering and bidding conditions for subsoil areas (at least coal-bearing) subsequently included in the license, contained the direct statements of minimum amount of exploration drilling required. For instance, the Istoksky area: in the second year of license validity, at least 3000 m of boreholes must be drilled; in the third year – at least 5000 m; similar requirements for Kyrgaisky Middle and Mincherepsky Middle were similar: in the second year – at least 5000 m, and in the third year – at least 5000 m. It is clear that it was no thorough substantiation behind these values since they were specified even before preparing of exploration projects began. In this regard, there were some cases where state subsoil authorities refused to send exploration results for state expert review because license requirements to drilling were not met, and subsoil user had to drill excess boreholes having no sense. Such restrictive practices no longer exist.

However, it is still possible to find geological assignments of subsoil users containing specific reference to the amount of drilling work to be taken as a target in the exploration project. For example, the exploration project for one of the coal bearing areas, which passed a state expert review in November 2019, contained a geological assignment stating that «total drilling metreage should be 25630 line metres». Naturally, this metreage of drilling was exactly the same as the numbers substantiated in the project.

Similar assignments can also be found on the official website of the Public Procurement Portal. It is no secret that in negotiating exploration contracts, subsoil users often independently determine the allowable cost of the work, the achievement of which is a mandatory requirement in the project documentation. There is no doubt that the requirements to design solutions for exploration network density defined by subsoil users are subjective and do not always rely only on the experience and wishes of the subsoil users' geological service specialists. The lack of clear requirements for the procedure of well density and location pattern designing for the exploration network does not allow carrying out a real expert appraisal of this most important methodological part of exploration projects, and forcing them to be limited to a statement of some components presence in the project. Applying the least-work principle eliminates this problem.

The particular importance of the exploration stage in the industry is obvious: its task is to obtain a «final» picture («hypothesis») of the deposit, the accuracy of which allows using it to design a mining enterprise. The final version of the vision should not have «white spots» of critical size and significance, which allow for future situations that could not be resolved within the framework of design decisions already made. This is a fundamental difference between the exploration stage and the earlier stages, the results of which are, in Sobolevsky's terminology, only draft working hypotheses and their «white spots» are of no fundamental importance.

Therefore, the main expected result of the exploration project implementation cannot be reduced to preparing a geological report with reserves estimation in the specified categories of exploration maturity (as is usually formulated in projects). The current Classification of reserves [6] actually implies obtaining the reserves in two categories only – C1 and/or C2, depending on the complexity of geological structure of the deposit. After all, reserves of A and B categories are the reserves allocated only within the boundaries of specially created areas of detailed evaluation [6],

which serve the purposes of determining the existing errors in estimates of average parameters and minerals reserves, geometrization errors, etc. [7]. Thus, from the point of view of their subsequent use in an enterprise design, Category A and B reserves are over-explored, and reliability of their exploration is mainly of methodological rather than practical importance. Moreover, sites of detailed evaluation may not be present within the exploration area, since fragments of fields-analogues and/or previously exhausted fields can be used with this purpose.

Therefore, geometrization errors (i.e., models describing behaviour of mineral bodies, host rocks and their properties in the subsurface) that describe both the accuracy of reserve estimations and categories would be more logical to accept as the expected outcome of exploration instead of exploration maturity categories.

In contrast to the categories, errors may be more differentiated and more adequately reflecting the requirements of the subsoil user. A certain acceptable range of errors objectively corresponds to each of the categories. For example, from the point of view of the current Classification [6], areas of priority development in the fields of groups 1-3 (according to geological structure complexity) should belong to C1 category together with the main part of the deposit's reserves. Their location within the boundaries of detailed evaluation sites with high-category reserves is also possible, of course; but under current requirements is the exception rather than the rule. After all, areas of detailed evaluation should be allocated within the most complicated and «problematic» parts of the field, while areas of priority development tend to be located within the simplest parts. Speaking in terms of geometrization errors, a subsoil user can formulate a problem of exploration management in more nuanced way and control the process of its solution with the use of appropriate quantitative methods (criteria of exploration maturity) giving single-valued results.

Therefore, application of the least-work principle is fully consistent with the nature of current market relations in subsoil use, and does not result in violation of the interests of the state as a subsoil user.

Implementation of the least-work principle is impossible without the respective correction of Guidelines for Preparation of Project Documentation: Geological Studies of Subsurface and Mineral Exploration [7].

In accordance with the current procedures, exploration projects carried out at the subsoil user's expense are subject to state expertise under the existing regulatory mechanism. At the beginning of work, the subsoil user prepares a geological assignment, which makes a basis for exploration company or the subsoil user itself in developing the exploration project. The project is then submitted for state expert review and approved by the subsoil user (only after a positive opinion is received).

The first obvious task of the expert opinion is to confirm the existence of an exploration program, the preparation of which within a certain period of time is set out in subsoil use conditions stipulated by license. In other words, Rosgeolexpertiza that reports to the Ministry of Natural Resources of the Russian Federation, essentially provides another entity, Rosprirodnadzor, with legally documented information on the subsoil user's compliance with the terms of the license.

The second task is to ensure compliance of the project documentation with the state legislative and regulatory requirements and licensing conditions of subsoil use. However, one should bear in mind that once exploration is completed, the results, including the methodological decisions taken, will be subject to review by a third entity, Federal State-Funded Institution State Commission on Mineral Resources. It is well known that the use of efficient exploration methodology is the most important condition for obtaining reliable geological information and correctly assessing the quantity and quality of mineral reserves in the subsurface. However, by the time exploration begins, the subsoil user is no longer responsible for its selection, as the methodology is part of a mandatory project, the eligibility of which was determined by the results of the state expert review. In such a system, the opinion of Rosgeolexpertiza acquires a force of an «indulgence», the existence of which puts FBU GKZ in a mixed position, as all claims to the approved exploration methodology become claims to another state agency and should not apply to the subsoil user. In case a subsoil user is not sure in the design solutions proposed by him, he can always contact the relevant consulting organizations, without shifting the responsibility for the solutions onto the state agencies.

This seems to suggest that an expert review of exploration programs at the subsoil user's expense is not appropriate and reduces rather than increases the quality of exploration activities. It is clear, that other topics such as occupational health and safety, wildlife protection, EIA, etc., are also considered in the exploration program. However, most decisions on them are already set out in existing regulations (the list of which can be expanded if necessary) and clearly do not require additional approval.

In order to increase the efficiency of exploration work carried out at the expense of the subsoil user and to remove administrative barriers, it is reasonable to make changes in the procedure of their design in order to create the possibility of applying the least-work principle in exploration, as well as to renounce the state e[pert review of such projects. XXI