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# Applying the elements of GIS of designated conservation areas when designing opencast mining

**Igor A. Glebov[1]*, Vlada A. Shabanova[2]**
[1] Institute of Mining UB RAS, Ekaterinburg, Russia
[2] Ural State Mining University, Ekaterinburg, Russia
***e-mail: vladarudenko@mail.ru***

***Abstract***

***Introduction.*** *Prior to development, a potential subsoil user is to pass a number of mandatory procedures: reconciliation and geological data collection, processing and analysis. The subsoil user collects information on the geology, composition of rocks, tectonic features of the area, the presence of minerals, and other important characteristics obtained through geological surveys, aerial photography, well drilling, etc. It is at the initial stage of a mining enterprise that all the data obtained are to be thoroughly analyzed, since mistakes made when forming a license for the right to use subsurface mineral resources can result in serious economic problems that the enterprise might face. At present, the development of methods for express assessment of design solutions remains relevant.*

***Methods of research.*** *To develop methods for express assessment for open-pit design in GIS of conservation area assets of the Sverdlovsk region, regulatory and technical literature, as well as the experience of mining enterprises design using GIS was analyzed.*

***Results.*** *Based on the analysis, solutions were proposed to improve the existing GIS. The solutions make it possible to prepare documents that meet legal requirements and ensure the economic efficiency of mining enterprises.*

***Conclusions and application of research results.*** *The proposed solutions employed when forming a license for the right to use subsurface mineral resources will allow for a step-by-step update of data as well as initial technical solutions for mining and environmental restrictions at the stage of technical design assignment development, which has a significant impact on the future of an enterprise.*

***Keywords:*** *GIS data; license; subsoil user; subsoil assets manager; designated conservation areas; geographic information system; GIS.*

**Introduction.** Prior to development, a potential subsoil user is to pass a number of mandatory procedures: reconciliation and geological data collection, processing, and analysis. Geologic data, or geodata, is coordinated information about the geographic space, or geospace, and its elements that is presented in a digital computer-perceived form and is the source material for geospace modeling [1].

The main law governing this procedure is the Law of the Russian Federation No. 2395-1 of February 21, 1992 (latest revision), On Subsoil Resources. It states that "... the use of the certain areas of the subsoil may be limited or prohibited to support national defense and state security, sustainable use and protection of subsoil, and environmental protection", "the use of subsoil in the territories of populated areas and zones with designated conservation areas may be limited or prohibited in cases where such use may endanger life and health of the population, threaten environmental protection and the safety of buildings and structures, including the safety of mine workings, boreholes, and other structures involved in the subsoil use".

Some subsoil areas are located in designated conservation areas, (Federal Law No. 33-FZ of March, 1995 (latest revision), On Designated Conservation Areas), territories of the Ministry of Defense or Russia's Federal Security Service (FSB), local designated conservation areas, etc., therefore cannot be developed.

When developing design documentation for open-pit mining, inaccuracies made during the formation of the license scope (Table 1, stage 1) often limit the development of part of the deposit. Such inaccuracies include incorrect or insufficient geodata about the location of the asset. GIS data required at various stages of a mine's life are shown in Table 1.

**Table 1. Geodata required at different stages of life of a mining enterprise (by the example of the Sverdlovsk region)**

**Таблица 1. Геоинформация, необходимая на разных этапах жизни горного предприятия (на примере Свердловской области)**

| A stage of life of an enterprise | Required geodata |
|---|---|
| 1. Formation of a license scope of a deposit | Data from the Ministry of Natural Resources and Ecology of the Russian Federation |
| | Data from the Ministry of Natural Resources and Ecology of the Sverdlovsk Region |
| | Data from the Federal Security Service of the Russian Federation (FSB) |
| | Data from the Ministry of Internal Affairs of the Russian Federation |
| | Data from local Designated Conservation Areas |
| 2. Formation of design documentation | Technical design assignment |
| | Data on the presence of animal burial at the site of the deposit |
| | Data on the presence of burials |
| | Data on the presence/absence of designated conservation areas of local and federal significance |
| | Data on the indigenous peoples settlement |
| 3. Formation of a mine allotment | |
| 4. Mine development in accordance with the license agreement and the approved documentation | |

For example, when preparing the Technical Design Document for the Development of the Nikitinsky Carbonate Rock Deposit, it was established that part of the mineral reserves included in the license scope were located in the water protection zone. To solve this problem, the subsoil user additionally developed the Program for the Engineering and Environmental Survey to Assess the Impact the Opencasting of the Nikitinsky Carbonate Rock Deposit to the Horizon of +220 m (in the Conditional Height System) Has on the Natural Environment Elements. The Program's development is certainly an additional financial burden for the enterprise.

Another example is the Technical Design Document for the Development of Limestone, Loam and Sand-Gravel-Clay Rocks of the Rogozinsky Open Pit. When preparing the document, it was revealed that the reserves specified in the license for the right to use subsurface mineral resources were outside the license scope. To resolve the issue, the subsoil user had to correct a technical error in the license agreement. Such circumstances might negatively affect the economy of enterprises with low capacities.

The situations described can be prevented at stage 1 and thus minimize the economic and labor costs of mining enterprises.

It should be taken into account that it takes from two to six months to develop design documentation for such enterprises and often requires urgent replenishment of the mineral resource base of the operating enterprise and fulfillment of the regulatory authorities' requirements. When developing the documentation, the following aspects are of particular importance: high quality of the project, high accuracy and reliability of the mining and geometric calculation results, diverse design solutions, terms of design documentation examination, and the terms of clarification of factors that impose restrictions on mining

**Relevance.** Considering the above, it is relevant to develop geodata express assessment methods that can shorten the decision-making process to guarantee the most efficient deposit development and ensure the generation of several mining options and their effective assessment.

**Methods of research.** To perform a high-quality express assessment, modern design technologies are to be used, including GIS modeling of mining facilities [2, 3]. Such GIS data analysis obtained at stage 1 can ensure the fullest development of the deposit as well as the preservation of the environment.

Technical and regulatory documentation for low-capacity enterprise design and literature on GIS were analyzed to develop the express assessment methods. The experience of working in existing GIS and in the sphere of design was also studied [4, 5].

Automating the routine and repetitive problem-solving process makes it possible to reduce the time of their implementation during the life of a mining enterprise, from the license scope formation to reporting documentation and mining reclamation and closure plans [6, 7]. Analysis of the practice of computer-aided design and work in administration shows that data automation tools allow to reduce labor costs by 20–30% keeping the quality of the end result [8, 9].

At present, the use of GIS in mining allows the in-depth study of huge amounts of data that impose restrictions, and these data determine the end result [10, 11]. Such data may include the following information: properties and quality characteristics of the claimed asset; technical-technological and environmental restrictions; economic restrictions; restrictions related to historical and cultural heritage; restrictions related to areas conservation [12, 13].

In 2023, the departmental information system Subsoil Use of the Sverdlovsk Region (hereinafter referred to as the System) was formed, which is "a set of interacting basic supporting and functional subsystems of subject areas, as well as a departmental segment, each designed to perform a given set of functional tasks" (*Resolution of the Government of the Sverdlovsk Region No. 977-PP of December 27, 2022, On the information system for socio-economic development monitoring in the Sverdlovsk Region; Resolution of the Government of the Sverdlovsk Region No. 699-PP of October 03, 2024, Amendments to the Resolution of the Government of the Sverdlovsk Region No. 977-PP of December 27, 2022, On the information system for socio-economic development monitoring in the Sverdlovsk Region*).

The structure of the System involves solving simple problems under given conditions:

– creating information about the applicant;
– creating an interdepartmental request;
– making a decision on the application;
– preparing a draft list of subsoil areas of local significance provided for use;

– making a decision on approving the draft list;
– generating an order to include the area in the list;
– generating a notification of refusal to consider the application.

The structure and procedure for its operation are outlined in Figure 1.

The System is based on cartographic data and coordinate data arrays characterizing the boundaries of the described assets and territories. It includes information on the presence/absence of information on the deposit of common minerals at given coordinates, as well as data on existing restrictions for the deposit development from the point of view of environmental legislation.

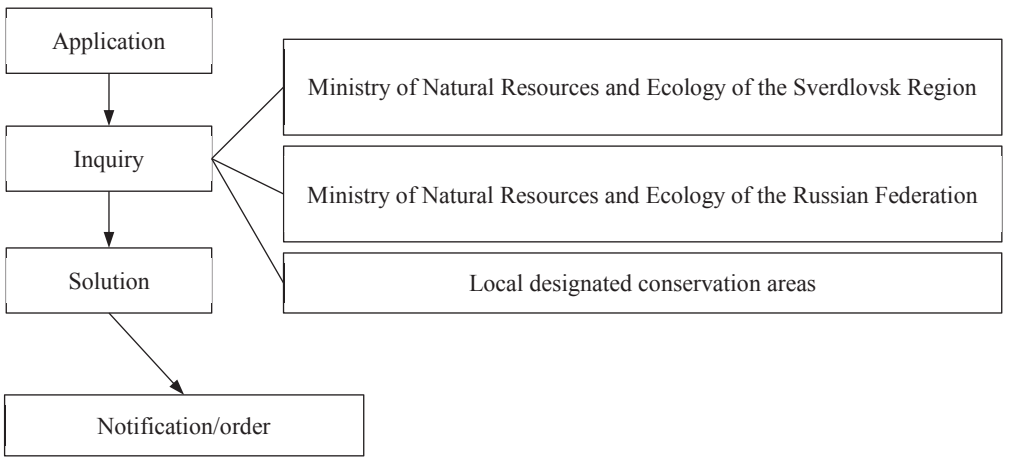


Figure 1. The structure of inquiry processing in the system Subsoil Use of the Sverdlovsk Region
Рисунок 1. Структура отработки запроса в системе «Недропользование Свердловской области»

Based on the request and analysis, a decision is formed, which specifies information about the claimed asset, as well as the contour of the proposed deposit to include in the list, taking into account the analyzed restrictions provided by the departments.

Based on the formed decision, an Order to include the site in the list of subsoil sites is created, or a justified refusal based on the identified restrictions is created.

At the moment, the System does not include GIS data from all departments affecting the formation of the license scope; it also does not include all the main terms of the license for the right to use subsurface mineral resource. For example, information on the presence/absence of deposits of federal significance, information on restrictions from the Ministry of Defense and FSB, information on cultural heritage sites, etc. is not included.

The above mentioned may be the reason for delayed deadlines for making decisions in the field of subsoil use, which can be critical for enterprises with low capacities.

**Results.** Based on the analysis of regulatory and technical literature, as well as the experience of designing mining enterprises, solutions have been developed that make it possible to develop methods for express assessment in the open-pit design and improve GIS of conservation area assets of the Sverdlovsk region. This will allow, when forming a license for the right to use subsoil, a step-by-step update of data as well as initial technical solutions for mining and environmental restrictions at the stage of technical design assignment development.

To improve the current situation in designing enterprises with low capacities, GIS data from various departments should be added to the System to provide an integrated presentation of information and restrictions on cartographic material.

Firstly, layers and departments should be added to the System, whose data and decisions significantly affect the final decision, such as FSB and the Ministry of Defense.

Secondly, it is essential to add information on the presence or absence of:

– designated conservation areas of regional significance within the licensed area;
– designated conservation areas of local significance within the licensed area;
– cultural heritage sites of local significance within the licensed area;
– cultural heritage sites within the licensed area.

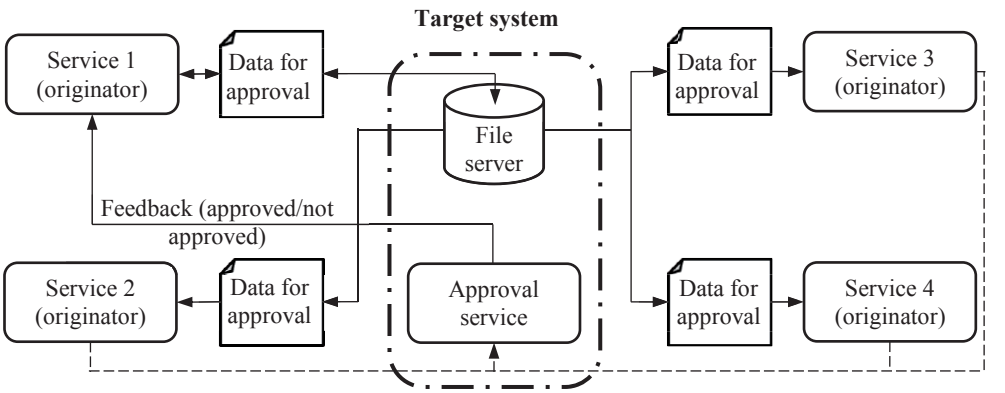


Figure 2. The scheme for the formation and interrelation of departments when using the system Subsoil Use of the Sverdlovsk Region

Рисунок 2. Схема формирования и взаимосвязи ведомств при использовании системы «Недропользование Свердловской области»

Thirdly, the System interface is to be supplemented with the appropriate layers and legend, coordinates in the State Coordinate System of 2011 (the GSK-2011) and in the local coordinate system.

The listed updates will ensure the display of more accurate information on the existing restrictions for the land use in the requested area when forming an application, which will have a significant economic, environmental and technical impact. With the addition of more information, it will be possible to use the System in other areas, for example, tourism development and landscape parks formation in the Sverdlovsk region [14, 15].

The proposed scheme for the formation and interrelation of departments when using the System is shown in Figure 2.

**Conclusions and application of the results.** Solutions are proposed to improve the environment of GIS of conservation area assets of Sverdlovsk region, which make it possible to prepare documentation that meets the legal requirements and economic efficiency of mining enterprises.

The information system Subsoil Use of the Sverdlovsk Region updated based on the proposed solutions will allow for a step-by-step update of data, initial technical solutions for development, and environmental restrictions at the stage of technical design assignment development, which has a significant impact on the future of the enterprise.

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**Information about the authors:**

**Igor A. Glebov** – researcher, Institute of Mining UB RAS. E-mail: i.glebov@igduran.ru; https://orcid.org/0000-0003-4436-3594
**Vlada A. Shabanova** – senior lecturer, Department of Opencast Mining, Ural State Mining University. E-mail: vladarudenko@mail.ru; https://orcid.org/0009-0003-2697-1235

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## Опыт применения элементов геоинформационной системы охраняемых территорий при проектировании открытой разработки

**Глебов И. А.[1], Шабанова В. А.[2]**
[1] Институт горного дела УрО РАН, Екатеринбург, Россия.
[2] Уральский государственный горный университет, Екатеринбург, Россия.

***Реферат***

***Введение.*** *Прежде чем приступить к освоению месторождения, потенциальный недропользователь обязан пройти через ряд обязательных процедур: согласование, сбор, обработку и анализ геологических данных. Недропользователь собирает сведения о*

*геологическом строении, составе горных пород, тектонических особенностях местности, наличии полезных ископаемых и других важных характеристиках, которые могут быть получены в результате геологических исследований, аэрофотосъемки, бурения скважин и другими методами. Именно на начальном этапе работы горнодобывающего предприятия необходимо провести тщательный анализ всех полученных данных, так как ошибки, допущенные при формировании лицензии на право пользования недрами, могут привести к серьезным экономическим проблемам для предприятия. В настоящее время остается актуальным вопрос о разработке методик, позволяющих производить экспресс-оценку проектных решений.*

***Методы исследования.*** *Для разработки методики экспресс-оценки при проектировании карьеров в среде геоинформационной системы охраняемых объектов Свердловской области проведен анализ нормативной и технической литературы, а также опыта проектирования горных предприятий с помощью геоинформационных систем.*

***Результаты.*** *На базе проведенного анализа предлагаются решения по улучшению существующей геоинформационной системы, позволяющие составлять документацию, удовлетворяющую требованиям законодательства, а также обеспечивать экономическую эффективность горных предприятий.*

***Выводы и область применения.*** *Использование предлагаемых решений при формировании лицензии на право пользования недрами позволит поэтапно уточнять данные, предварительные технические решения по отработке месторождения и природоохранные ограничения на стадии разработки технического задания на проектирование, что оказывает значительное влияние на дальнейшую судьбу предприятия.*

***Ключевые слова:*** *геоинформационные данные; лицензия; недропользователь; распорядитель недр; особо охраняемые территории; геоинформационная система; ГИС.*

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**Сведения об авторах:**

**Глебов Игорь Андреевич** – научный сотрудник Института горного дела УрО РАН. E-mail: i.glebov@igduran.ru; https://orcid.org/0000-0003-4436-3594

**Шабанова Влада Александровна** – старший преподаватель кафедры разработки месторождений открытым способом Уральского государственного горного университета. E-mail: vladarudenko@mail.ru; https://orcid.org/0009-0003-2697-1235

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