Method of Use GIS Technology in Compiling Passports of the State Cadastre of Deposits

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Abstract. This article discusses the problems of using GIS technologies in compiling passports of the state cadastre of deposits. Currently, modern GIS technologies are quite effectively used to make GIS projects of digital maps for placing forecast resources on solid minerals as cartographic applications for issuing the appropriate balances. Creating the state cadastre passports of deposits could also be automated using GIS technologies. In this regard, forming a methodology for the GIS technology use in compiling the state cadastre passports of deposits is of particular relevance, which determined the purpose of this article. The necessity to integrate the proposed information system with the existing data resources of the Federal Agency on Subsoil Usage and the Russian Geological Fund should also be taken into account. This work was financially supported by the grant of the President of the Russian Federation No. MD-2409.2020.5.

1. Introduction

The main accounting systems for mineral resources of Russia are maintaining the State balance of mineral reserves (hereinafter SBMR) and maintaining the State cadastre of deposits and occurrences of mineral resources (hereinafter SCD). In this case, only SCD contains information on the mineral raw material base (hereinafter MRMB).

The current SCD management instruction supposes to provide the geographical coordinates of the conditional centres of metering objects (deposits and occurrences) within the accuracy of minutes. Compiling the registration cards for SCD metering objects is carried out only in the territorial funds, on paper topographic maps on a scale of 1: 200000. Each sheet of the map should apply the conditional centres of all SCD metering objects identified within the boundaries of this topographic map on a scale of 1: 200000. When the state of development or knowledge of the object changes, the signs were accordingly made adjustments to. Paper registration cards are not normally provided to the Russian Geological Fund.

In the XXIst century, the indicated accuracy does not allow reliably placing objects on the map due to a large margin of error. The object on the map should be shown by an outline.
2. Theoretical part
The problems of applying GIS technologies for forecasting and modelling in geological exploration were studied by the authors in [1,2,3,4,5,8,10,13].

To determine the geographic outlines of the SCD metering objects it is proposed to develop the form “The sheet for updating the geographic coordinates of the SCD metering object” which is an appendix to the SCD passport and to draw up new “Methodological recommendations for determining the outlines and coordinates of the SCD metering objects”. The task of determining the contours of deposits and manifestations is solved jointly with the territorial geological information funds.

It is proposed to use GIS technologies for conducting SCD with the application of the ArcMap package (ArcGis) and to integrate it with existing software products. It is advisable to implement the GIS block of the SCD on the basis of ESRI and SQL software. The graphical server part should be realized on the basis of ArcSDE.

Selecting ArcGIS is, first and foremost, due to the fact that this geographic information system allows you to make single information space when working with GIS projects, using at the same time many maps, covers and database partitions, provides the ability to dynamically create maps based on undirected database queries and on the arbitrary combination of various vector covers, maps, and the results of attributive and spatial queries [7,11,12,15,19,20].

ArcGIS includes the following components:
- ArcMap application which is the main application for performing all cartographic tasks, such as map analysis and data editing, creating and publishing maps [25-27];
- ArcCatalog application which is designed to organize the storage structure of spatial data and manage them, to create databases and to record, view and manage metadata;
- ArcToolbox application which contains an extensive set of geoprocessing functions, including tools for managing and converting data, processing coatings, vector analysis, geocoding, statistical analysis [21-24];
- Maplex which adds ArcMap advanced labeling capabilities for high-quality cartography.

To date, the database of the SCD “Nedra” and the GIS block of the SCD contain information on almost 8,000 contours of SCD metering objects. Preparing digital maps of the deposit location and licensed areas for solid minerals is cartographic supplements to the issues of the State balance of solid mineral (SM) of the Russian Federation. Preparing and compiling GIS projects of the digital maps for issuing State register of mineral reserves (SRMR) is carried out at the Russian Geological Fund for 140 types of minerals [6,9,14,16,17,18].

Digital maps (GIS projects) of placing the deposits and licensed areas for solid minerals as cartographic supplements to the issues of the SRMR of the Russian Federation as of 01.01.2019 on a scale of 1: 1,000,000 - 1: 200,000 (hereinafter - GIS map projects for SRMR issues) were performed on the territory of eight federal districts (in the constituent entities of the Russian Federation).

3. Practical part
When forming the methodology for creating digital maps of the SCD passports, one should proceed from the structure of a typical request for providing the information on a subsoil plot:

1. Determining the boundaries of the subsoil plot (proposals for the boundaries of the subsoil plot indicating the geographical coordinates of the corner points of the subsoil plot contour and the calculated area, proposals for limiting the depth of the subsoil area, the availability of valid licenses and objects of an unallocated subsoil fund in the subsoil plot indicating their boundaries).

2. Information on the reserves and / or resources in the subsoil plot indicating documents which approved the reserves and / or resources.

3. Graphical applications including a scheme of the subsoil plot made on a topographic basis indicating plotted corner points and their numbers, as well as valid licenses (if any); a geological map indicating plotted blocks of the reserves (or resources); a geological cross-sectional map indicating the boundaries of the subsoil plot in depth (at the absolute mark).
4. A copy of the SCD passport, a copy of the protocol of the state reserve commission, territorial reserve commission (or another department) on approving the feasibility study of exploration conditions in the field, a copy of the protocol of the state reserve commission, territorial reserve commission (or another department) on the reserve approval, a copy of the protocol of the scientific and technical council (or another agency) on testing (adopting) the forecast resources, a copy of the State balance sheet for all types of minerals contained in the subsoil plot.

Often when assessing the spatial distribution of a subsoil plot, a discrepancy between the plot contour and the constructed ore bodies is revealed. In this regard, proposals are being made to change the boundary of the subsoil plot for the complete contouring of ore bodies of the deposit.

The methodology for creating digital maps of the SCD passports should be carried out in stages and meet the principles of geological cartography. One of the main principles is phasing the exploration:

1. Analyzing, systematizing and structuring the source data.
2. Inputting initial data from the cards, circuits, notes into a computer, i.e. creating a primary digital database (primary information space).
3. Verifying data entry.
4. Creating GIS projects of individual maps.
5. Making legends for each thematic layer to display specialized information in the project within the system of conventional signs adopted during geological mapping, for the convenience of working with the project and generating analog maps.
6. Creating a GIS project containing a map, diagram.
7. Thus, the created GIS projects provide the solution to the following tasks:
8. Comprehensive analysis of the database in the automatic sampling mode at the user’s request to allocate space and facilities in various sectors of the national economic activity;
9. Generating new maps having a variety of geological data based on the selection made;
10. Visualizing the constructed maps in the usual way for perception (generating analog maps).
11. Linking the scanned graphical applications from the geological reports to a topographic base, on which principle a diagram of the subsoil plot is constructed with the removal of ore bodies, contours of reserves and resources, boundaries of the subsoil plot, existing licensed areas.

The database of geological and economic indicators accumulated over a period of time within the framework of the State Cadastre of Deposits will automatically prepare data and generate reports:

- at the request of federal and other authorities and organizations on the mineral resource base and subsoil use at the state level;
- on the presence / absence of deposits and occurrences of mineral resources in a certain territory, as well as subsoil plots of federal significance which are located within the boundaries of the subsoil plots proposed for using in geological exploration (mining and evaluating) at the subsoil users’ expense;
- on the presence / absence of deposits and mineral manifestations within the territories planned for constructing infrastructure facilities;
- on the expert assessment of the spatial location of the MRMB objects having disputed boundaries of the licensed areas, with constructing the contours of the requested objects, ore bodies (deposits), removing blocks for calculating reserves.

4. Conclusion

Thus, on the basis of the study, we can conclude that the methodology for using GIS technologies in compiling passports of the state cadastre of deposits will cope with the following problems:

- compiling effectively geographic information;
- creating and managing geographic databases;
- solving issues using spatial analysis;
carrying out automated exchange of geological and economic information.

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