

CREATION OF THE WESTERN SIBERIA DIGITAL GEOECOLOGICAL MAP WITH GIS

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Abstract

The paper describes the experience of a digital geoecological map compiling of one of the largest geological and industrial areas of Russia. Western Siberia geoecological maps were compiled in 1990's using a traditional manual method on the regional ecological research results of 27 nomenclature sheets of a scale 1:1000000 of an international listing. The concept of the digital geoecological map content was designed, the general principles of the legend making were updated, and the methodical advises on the digital model structure and the attributive information databases were formulated. The unified digital map satisfying to all requirements of GIS is the digital theme map basis. The geoecological map is informational digital model consisting of four theme items, describing the geoecological condition of a region on definite set of mapped parameters. The complex estimation of geoecological condition of the region is given as an integral criterion defined with GIS ArcInfo. The offered technology of creating the Western Siberia geoecological map as a digital cartographic model on the basis of GIS-technology, will allow to receive sets of the new digital specialized theme maps, to provide their constant actualization, to estimate the geologic environment condition.

The introduction

The geologic maps are peculiar depths model and they are reflect in the generalized form the research results. Until recently the maps were made with traditional manual way. The process of map creation took some years sometimes. Appearance of computer technologies and, in particular, geoinformational systems (GIS), have allowed to reduce the compiling time of any theme maps, to increase their informational saturation, reliability and accuracy. The information database, the geographically coordinated observation points, the digital cartographical background are the basis of digital maps.

The world and Russian experience of using the GIS at a mapping demonstrates the advantages of the digital maps in comparison with the conventional "paper" the ones [Anokhin 1998, Konusova et al. 1992, Koshel and Musin 1991]. In case of using the GIS the map creation philosophy is change. It is possible to create a lot of theme maps using the methods of a geographic data analysis.

Present article considers the principles of developing the Western Siberia digital geoecological map (DGM). Western Siberia is large geological and industrial region of

Russia. Western Siberia Coordination Council on geoecology at the supporting of the Department on geology, hydrogeology and geophysics of the Russian Federation natural resources ministry made a resolve to develop the Western Siberia digital geoecological map of a scale 1:1000000.

The given project is unique in Russia. It fulfils for the first time within the framework of the ministry and it has experimental and methodical nature. The author groups of the joint stock company Geoteks (Tyumen), the state company Aerogeology (Moscow), the VSEGINGEO (Moscow), the state company Beryozovgeology (Novosibirsk) and the natural resources Committee on Omsk region are co-executives of the project. The state unitary company Territorial Center Tomskgeomonitoring (Tomsk) executes the general project management. The project is developed taking into account the general policy of the geologic mapping in Russia based on realization the modern generation of the geologic map as the geological and cartographical informational systems. These systems use GIS-technologies for the creation of different digital theme maps and the maintenance of their updating.

The necessity of geoecological map creation is connected with the intensive oil and gas, mineral resources mining, the industrial and agricultural developing the Western Siberia territory. In such conditions the man-caused activity negatively influences on the depth condition, results in a pollution of land, air, surface both underground waters and other components of an environment. The Western Siberia area takes the area more than 2,36 million. sq. km. It consists of Novosibirsk, Omsk, Tomsk and Tyumen regions, Yamalo-Nenets Autonomous Area.

The author's cartographical materials obtained as a result of regional ecological researches in 1990's use for creating the digital maps set. The geoecological maps on territory of the region in quantity 27 nomenclature sheets of a scale 1:1000000 of international listing was compounded on conventional "paper" technology for each administrative formation according to the present branch normative. The analysis of the paper maps content has shown, that during compiling the geoecological maps and the maps of an estimation of an ecological condition of geologic environment the groups of authors made some correctives to the content of the maps, connected with the volume and detail of the available geoecological information, the necessity its mapping and the others, frequently subjective, reasons. It has resulted that the geoecological maps developed for each subject of the Russian Federation, had different legends and were not adjusted on the administrative boundaries. Besides, topographical background used for developing the maps differed from each other. Therefore the resolution on developing new principles of formation of the geoecological map structure taking into account the computer development was accepted.

Western Siberia DGM is the map set made on the unified topographic background of 1:1000000 scale in standard international listing, and it includes:

- Digital map legend;
- Digital cartographic background (topographic map);
- Digital geoecological map (geologic environment and man-caused objects);
- Digital map of estimation of geologic environment state;
- Bank of the primary data of the geoecological information;

- Additional information (map and data format descriptions, etc).

1. Developing the legend and the model of digital geoecological maps

The main conceptual principles of the Western Siberia DGM content based on creating the cartographic models of the large areas for mapping a geological environment state in natural conditions and under men-caused effect. The cartographic model forms on the basis of the territory zoning on a natural and man-caused components of geologic environment condition with selection of the corresponding taxones. The zoning allows to dedicate a geologic environment as a whole, as a component of an environment, to present its internal structure and to estimate a role of its components in the formation of living environment of the people, and also to define the territorial boundaries of mutability of the natural and men-caused ecological and geological situations.

Taking into account the main nature and geologic parameters and the processes determining the geologic environment stability, are developed:

- Main conceptual principles of the geoecological map content;
- General principles of digital legend construction according to the requirements of GIS-technologies;
- Methodic advices on the structure of the information database and digital theme maps;
- Criteria and parameters of an estimating the geochemical condition and the stability of geologic environment to men-caused effects.

According to the concept, the map is two-sheet model including the factual map (a geologic environment and men-caused objects) and the map of an estimation of an ecological condition of a geologic environment.

Factual map is the information and digital model consisting of subject items, describing a region geoecological situation on a certain set of mapped parameters. Factual map separates on subject items, because one cartographical composition can not contain such large number of mapped objects. The theme blocks and their components are:

The landscape and geochemical conditions:

- Geological environment typification (types, subtypes, morphogenetic kinds and type of lithogenous fundamental of landscapes, genotype of soils);
- Geochemical characteristic of landscape components (geochemical anomalies, their shape, genesis, structure and intensity in soils, vegetation, bottom sediments, snow).

The underground and surface waters:

- Underground and surface waters mineralization (dry rest);
- Water quality values on classes according to the Russian State Standard 2761-84;
- Dominant power of the aeration zone, protectability of underground water from pollution, average yearly module of a underground flow.

The geologic and the engineering and geological processes:

- Lithogenous basis;
- Permafrost;
- Geological processes and phenomena, engineering and geological processes;
- Intensity of the developing the geologic, engineering and geologic processes.

Men-caused objects and systems (complexes):

- Locality;

- Mining objects;
- Industrial, agricultural, power, transport objects, i.e. oil and gas pipelines, the railways, the motor roads, the burial places of household rubbish, industrial and radioactive waste, the cones of influence, the filtration and irrigation fields, the protected natural territories etc.;
- Glades, territories damaged from forest fires, agricultural grounds, melioration objects, explored mineral resources deposits, oil and gas production objects.

The estimation map is developed on the basis of selection of the categories of the ecological condition of geologic environment. These are: favourable, conditionally favourable, unfavorable and rather unfavorable. The values of evaluation balls assigns to each category by expert way. The evaluation parameters are:

- Provision with underground waters;
- Underground waters protectability from pollution;
- Geochemical pollution of the geologic environment components such as underground waters, soils, bottom sediments;
- Surface waters pollution;
- Icy measure of rocks;
- Exogenic geologic and engineering processes hazard;
- Radiation hazard;
- Seismic hazard.

According to the concept of the geoecological map content, the principles of developing the legend and criteria of an estimation ecological and geochemical condition and stability of geologic environment to man-caused effects, TC Tomskgeomonitoring developed a model and unified legend for Western Siberia digital geoecological maps.

2. Digital topographic background

The problem of the digital topographic maps quality as a background for the theme maps is not new and it is discussed in detail by Russian and foreign authors [Du Daosheng 1995, Giovachino 1992, Kirillov 1997].

Technical, organizational, economical and other Russian problems have resulted the using the different topographical background by the regions. Discrepancy of the ones is in issue year, scale, contents, projection, accuracy, generalization parameters, subjective author's approaches.

There are the differences between the topographic maps on boundaries of neighboring maps, therefore developing the Western Siberia DGM was started with preparing the unified digital topographic backgrounds, which one should be modern, have a unified projection, scale, set of mapped elements.

TC Tomskgeomonitoring has the some experience on the formulating the requirements to the digital topographic background content and the quality controlling the one. These requirements are about the accompanied documentation of a digital map, the digital background content, the topology, the attributive data, the neighboring maps coherence, the digitization rules.

The digital topographic background for developing the geoecological map on Western Siberia territory was prepared by the company "Kartsistema" (Noginsk, Russia)

according to the technical requirements developed by TC Tomskgeomonitoring including the above mentioned requirements. Topographic map is licenced.

The list of the layers included in the topographic map for developing the geoecological map, are:

- Polygonal and linear hydrography objects, including the rivers, lakes, water storages, bogs;
- Isolines (horizontal) of a relief,
- Elevations;
- Motor roads and railways;
- The polygonal and point settlements with division on types and quantity of the inhabitants (uninhabited and separately costing buildings do not actuate),
- Degree grid;
- Framework (boundary of nomenclature sheets of an international listing);
- Administrative boundaries of the territorial formations.

Total number of coverages is 22.

The quality control of digital topographic maps was carried out according to branch standards of Russian Map Company on the digital topographic maps [Kaminsky 1995, Serov 1999]. The digital map models were checked up on conformity to the specification requirement, the instruction and methodical materials used for creating the cartographical products of the given type. The quality of the cartographical materials was checked up sequentially in some phases.

At the first phase the presence of the map passport and legend, the complete set of the layers, the conformity of their titles to the standard, the conformity of the coverages within the bounds of the one nomenclature sheet was checked up. The conformity of the neighboring nomenclature sheets of the digital models was checked by simultaneous review of the ones on joint boundary at large image scale.

Comparison between the digital model and the image is second control phase. The images registration was realized using GIS MapInfo 5.01 in the Gauss-Kruger projection, in degrees.

3. Developing the theme maps

The paper theme maps within the bounds of the mapped regions were corrected by the author groups on main layers according to the developed legend and the digital topographic map. Editing and coordinating the theme maps on administrative boundaries of adjacent administrative regions is important and time-taking work, for that the special technology was developed.

The realizing the Western Siberia DGM is made in following sequence:

- Printing on a paper and a film the digital topographic maps as cartographical backgrounds for the co-executives;
- Editing the author theme maps to the unified digital topographic basis according to the designed legend on the main layers (morphogenetic landscape types, lithogenous structure, soil types, aeration zone power, geochemical anomalies, men-caused objects);

- Editing the separate theme layers of the neighboring sheets made by different groups of authors to avoid the logical mistakes of the polygonal and linear objects boundaries, their conformity to each other;
- Digitizing the theme maps as the coverages in the topological format ArcInfo, preparing the initial factual databases.

The updating the author map information is carrying out using the automated computer methods of an interpreting and processing the high-resolution false-color space image. The integrated estimation of geologic environment state is given in the form of an integral criterion determined with GIS ArcInfo on 10 estimating parameters.

For compiling the map of an estimation of geologic environment state the new coverage creates with synthesizing the layers with evaluation parameters using GIS-technologies. For this purpose the layers was reduced to the polygonal type. The point and linear coverages was converted to the polygonal type using the buffering procedure. The minimum size of a buffer of each layer is determined by a map scale, the maximum size is determined by expert method taking into account the influence zone of an object. Each polygonal object obtains the attributive information. Then the prepared polygonal layers are sum up to the one intermediate layer using the cartographical analysis of GIS ArcInfo. The reclassification of the quality and quantitative characteristics of the intermediate layer objects in the ball values and the calculation of an average value of a ball for each object of intermediate layer according to the estimation map legend is the next phase of the work. The final layer of an estimation map of geologic environment state forms using the join of all intermediate layer objects of one category and deleting the temporary boundaries.

Developing the Western Siberia geocological map as a digital model let duplicating the one on the paper. The preparation of the cartographical composition sheets carries out using GIS MapInfo 5.01, the printing on a paper makes using the printer Epson Stylus Color 3000 (format A2) and plotter Mutoh RJ-800 (format A1 for N sheets of the nomenclature listing). Before printing it is necessary to take into account the types of the printer and the paper (or film).

Conclusions

The above mentioned technology allows to create the summary Western Siberia geocological map of a scale 1:1000000 as a digital cartographical model. This map realised as a cartographical informational system on the GIS-technology basis, will allow to create and update sets of the new digital specialized theme maps, to estimate a geologic environment condition, to choose the regions, unfavorable for the man life and the mining in the Western Siberia region. The digital map is for usage by the federal and territorial authorities, the nature protection and research companies interested in the analysis, usage and conservation of mineral resources.

As a whole this system should include a base set of digital maps, computer databases on the geological structure, the lithology, the geochemical, hydro-geological state of the region, the man-caused condition nature and intensity, text, tables and statistical information.

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