GIS TECHNOLOGY OF USING REMOTE SURVEYING MATERIALS IN COMPILATION OF GEOLOGICAL MAPS

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ABSTRACT:

Remote sensing methods are necessarily used in geological surveing on the territory of Russia and compilation of the geological maps. Use of remote surveying materials in the geological cartography is determined by their informativeness, which is interpreted as the possibility of revealing those elements of geological structure from images, which should be reflected in the map. The informativeness is affected by technical and natural factors.

Modern computer GIS technologies for integrated analysis of geological and remote sensing data and compilation of geological maps envisage: 1, Revealing of the structural framework based on initial geological maps and the lineament analysis of remote sensing materials; 2, Revealing the outlines of geological bodies.; 3, Revealing the specific features of composition and inner structure of geological bodies; 4, Overlapping of varios thematic layers, and additional joint analysis of the image pattern, of geological and geophysical materials for a more precise definition and confirmation of the geological nature of certain elements, recorded using the remote sensing materials; 4, Compilation of the final map.

A stage-by-stage integral analysis of remote sensing materials and geological evidence, their mutual comparison and correction of the obtained results at all stages of map compilation ensure a high quality of the latter.

1. APPLICATION OF RSM

Remote sensing methods occupy a highly important place in the general complex of methods used for geological surveying and compilation of maps of geological content. At present the most important type of geological mapping in Russia is compilation of State Geological Maps on 1:200,000 and 1:1,000,000 scales compiled sheet-by-sheet. Small-scale maps of the whole territory of Russia and its large geological-structural regions are compiled on their basis. Improvement of the informative character, quality and reliability of geological maps is one of primary tasks whose solution is possible at the expense of more comprehensive considering the information obtained while analysing the materials of remote surveying.

There are two approaches to using remote sensing materials (RSM) for compilation of geological maps. one of them is realised in the form of specialized aero- and cosmogeological maps, where the remote sensing information makes up the main contents. These maps can be assigned to the structural-formational type, since the main object of cartography is the structural-petrological complex, revealed using the image features.

In the second approach RSM are regarded as one of the types of initial cartographic materials on which basis the geological map is compiled. Use of RSM in this case is determined by their informative character which is interpreted as the possibility of revealing those elements of geological structure from images, which should be reflected in the map.

In compilation of the geological maps RSM are used for solution of following main tasks: 1, determination of areal stratified and non-stratified objects from peculiarities of their representation (hue, texture); 2, determination of linear objects (tracing the geological boundaries and faults, dikes, individual layers and reference horyzons within layers of homogenous composition); 3, revealing the petrological composition of mapping objects, including areals and zones of altered rocks.

2. IINFORMATIVENESS OF RSM

2.1 Natural factors

The informative character of RSM is affected by two groups of factors, natural and technical. The most important natural factor is the state of landscape. Therefore obtaining of the potentially informative image is associated with selection of the optimum season and time for surveying. The proper choice provides the most expressive representation of main indicators of geological objects from RSM.

2.2 Technical factors

Main technical factors are resolution of the images and their spectral characteristics.

Resolution. The resolution can be considered sufficient if the objects whose minimum dimensions correspond to the requirements of the scale of the compiling map are revealed from RSM. The immediate determination of the mapping objects is, however, possible only with good conditions of the interpreting. In the majority of cases, the mapping objects are revealed from a combination of natural indicators whose dimensions are an order less than the object itself. Therefore, the image resolution must provide the revealing of the indicators rather than the objects. The necessity of providing psycho-physiological comfort of the interpreting process which significantly affects its efficiency should be also taken into account. This comfort can be provided with the image resolution of 5 to 10 lines per mm, i.e. 20 to 40 m in conversion to the resolution in locality.

Spectral characteristics. It is advisable to consider the requirements for RSM spectral characteristics in groups of tasks.

To distinguish objects according to their tone characteristics and to solve structural-tectonic problems, it is necessary to use the materials covering the long-wavelength part of the visible optical range and the near infrared part of the spectrum. It is possible to gain supplementary information which mainly permits the problems of structural interpreting to be solved when using radar images.

To solve the problems of determination of petrological composition of geological bodies it is advisable to use the whole of the visible and infrared ranges.

Materials of surveying in the thermal range are most effective while revealing some specific objects (zones of recent volcanicity, solfataric-fumarol activity).

3. CHOICE OF RMS

3.1 Rules

Basic tasks of geological mapping from RSM are to be solved following two rules: 1, objects of minimum size to be mapped or their indicators are to be revealed using RSM; 2, images must cover a territory as fully as possible and represent the position of the mapped territory in general structure of region. This necessitates using the materials of higher level of generalization (on 3 to 5 times smaller scale than basic materials)

3.2 Basic and supplementary materials

The requirements given above dictate the choice of RSM for the purposes of mapping. For compilation of maps on 1:200,000 and 1:1,000,000 scales, materials of the native surveying system MK-4 correspond most closely to these requirements. They are both detail and review . As supplementary materials it is advisable to use data of KATE-200 for the review level and data of KFA-1000 for the detail level. Materials of visible and near infrared ranges of the LANDSAT TM are used as additional ones to reveal peculiar features of petrological composition. Data of the thermal channel LANDSAT are used for the mapping of zones of recent active volcanicity. Materials of the thermal channel of NOAA system give important information on deep structure in the small-scale mapping (on scales smaller than 1:1,000,000).

4. STAGES OF MAP COMPILATION

4.1 Preliminary stage

Necessary RSM are gleaned at the preliminary stage of map compiling process. Conversion of analogue materials of surveying to the digital form, necessary transformations and reduction of RSM to the necessary cartographic projection are carried out at this stage. It is implied that geological and geophysical materials are also presented in the digital form.

4.2 Compilatory stage

The compilation of a geological map is a multi-aspect process of integration of diverse information, its complex analysis, and representation of final results in the cartographic form. It is at this stage when basic problems of RSM use are solved.

Modern computer GIS technologies for the integrated analysis of geological and remote sensing data envisage the fulfilment of a series of successive operations.

Revealing of the structural framework.Structural frame of the map is compiled at the first stage. This work begins with RSM interpretation together with the analysis of cartographic materials. Visual and automated determination of lineaments is carried out using RSM. A software package designed at VNIIKAM is used for these purposes.

The lineament analysis involves construction of rose-diagrams, estimation of lineament density, determination of field gradients. The final result is a sketch of the lineaments. This information is checked by data of geological observations and geophysical data. The control over results of the RSM analysis materials is exerted in ERDAS and ARC/INFO enviroment. In so doing we can reveal new information which is lacking in source maps. Faults selected in the process of the combined analysis of the maps and the images are subjected to ranging and generalization taking into account the results of interpretation of the images on smaller scales.

Revealing the outlines of geological bodies. After mapping the rupture dislocations we can turn to compilation a contour basis. The analysis of initial geological materials is the main procedure used for revealing the contours of geological geological bodies. RSM only help us to make a pattern of geological boundaries more precise, for which purpose different methods of interchannel image transformations are used with subsequent visual analysis of synthesized images. An additional criterion of more accurate drawing the boundaries is the results of the automated processing of sketches of the lineaments. For this purpose areal gradients, i.e. gradients with equal parameters and characteristic features of lineament density are distinguished on their basis. Boundaries of such areal elements are considered as boundaries of structural-petrological complexes. A programme distinguishing the areas with predetermined parameters of brightness may be also used.

Refinement of the pattern of geological boundaries is carried out taking into account the phenomenon of natural generalization of the image in transition to smaller scales. This phenomenon manifests itself in two ways. In the first case an area of development of formations overlapped by a cover of loose deposits seen in the images is increasing. This increase apparently results from the fact that in the transition to the smaller scales thin loose deposits do not serve already as a screen for the manifestation of typical interpreting features of buried formations. In the second case several contours are integrated into a single contour which corresponds to the really mapped geological body of definite composition.

Revealing the peculiar features of petrological composition and inner structure of mapping objects is an important moment of the employment of RSM in geological cartography. At this stage of great significance is the analysis of spectral characteristics of the bodies distinguished using RSM as well as specific features of the structure of the lineament field. It should be borne in mined, however, that the determination of petrological composition from the results of interchannel transformations is possible only under favourable conditios, i.e. in arid well-exposed regions. Such conditions are not characteristic of the territory of Russia. In this connection expert systems for the determination of petrological composition developed at VNIIKAM (LITHO software package) are increasing in importance. Under conditions of insufficient exposure these systems provide interpolation of data of field observations on reference outcrops and key areas for the rest mapping territory.

Combination of geological-geophysical data and data of remote sensing methods at every stage of map compilation and their integrated analysis are carried out by ERDAS and ARC/INFO software.

4.3 Compilation of the final map

The completing operation is compilation of the final map. All the objects first distinguished using RSM and confirmed by geological and geophysical materials can be treated as reliable. They are represented in the map by established symbols. Ambiguously interpreted objects can be shown as assumed ones.

5. CONCLUSION

This technological scheme which incorporates the integrated analysis of RSM and geological data, their mutual correlation and correction of the obtained results at all stages of map compilation provides informative character and high quality of the map.