The mapping results of the landscapes of the Upper and Middle Yenisei basin

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Abstract. The issues of displaying information about diversity, differentiation, integration, dynamics and evolution of conditionally-natural and anthropogenically-altered geosystems on medium-scale maps are considered. The mapping technique is based on the theory of geosystems and the principles of constructing the hierarchical structure of geosystems by integrating their indicators. To demonstrate the organization of low-steppe and forest-steppe topogeosystems in southern Siberia on a large scale, a classification was developed based on the principles of the theory of geosystems and the concept of the interdependence of geosystem organization with the differentiation of matter. When compiling maps of geosystems of a smaller scale, the methodological approaches of landscape analysis, synthesis and detailed landscape survey that are applied at the topological level are impossible. The main sources for medium-scale maps are remote sensing materials, topographic, thematic maps only partially controlled by the results of a wide-scale landscape survey and detailed mapping of key areas. The maps of parts of the south of Central Siberia are generalized to create a single medium-scale geosystem map (1: 1000000). When compiling it, the author's own ideas on the classification of geosystems obtained from the experience of landscape mapping of other regions are also used. In future information on geosystems obtained with landscape mapping will be interpreted from the positions of applied geography for the creation of landscape-evaluation maps in order to optimize nature management with the use of landscape planning. To adequately reflect the organization of the geographical envelope from the perspective of the theory of geosystems, it is necessary to develop a modern landscape classification based on correct quantitative data including three taxonomic series of geosystems: typological, horological and dynamic.

1. Introduction
Identification of the space-time organization of geosystems remains one of the most important areas of physical geography. Landscape mapping is designed to display and document the results of direct research and generalization of physical and geographical information on diversity, differentiation, integration, dynamics and evolution of conditionally-natural and anthropogenically-impacted geosystems. The scale and detail of the cartographic mapping of the structural and dynamic properties of the geographical envelope are determined by the objectives, research tasks and the hierarchical level of the main mapping units.

Currently some results of landscape mapping of the investigated territory have been summarized. For cartographic support, medium-scale landscape maps and schemes of physical and geographical
zoning of the Nazarovo and Minusinsk depressions, maps of administrative areas (soil, vegetation, agricultural and land fund), synthesized satellite imagery, topographic, general geographic, thematic maps of various scales, schemes and materials of route studies and key areas were used.

2. Models and methods
The methodology of landscape mapping is based on the basic principles of the theory of geosystems by V.B. Sochava [1]. The classification of geosystems and the creation of a landscape foundation legend are based on the system-hierarchical approach to the identification of subordination of landscape taxons and the evolutionary-dynamic interpretation of the charted units. The structure of the map legend is proposed taking into account the positioning of the territory and the typological spectrum of geosystems in the planetary system [2]. The group of facies was chosen as the lowest charted unit of geomers.

Maps of administrative areas (soil, vegetation, agricultural and land fund), synthesized satellite imagery, topographic, general geographic, thematic maps of various scales, route study materials, key site maps, and previously compiled medium-scale landscape maps and charts, physico-geographical zoning of the Nazarovo and Minusinsk depressions, which were generalized to create a geosystems small-scale maps, were used to map this territory. The results of preliminary decoding of space images were transferred to a cartographic basis, which was a preliminary map layout. Field surveys used profiling in combination with work on key areas selected in regions with the most complex spatial structure of geosystems.

3. Results and Discussion

3.1. Large-scale mapping
The development of the classification of lowland steppe and forest-steppe geosystems in the south of Siberia for their large-scale mapping was based on the principles proposed by V.B. Sochava [1] and the concept of the interdependence of geosystem organization with the differentiation of the matter of their components [3]. The method of compiling landscape maps with simultaneous display of geomers and geochors [4] allows us to represent typological and horological units of geosystems on one map, as well as their dynamic state. On these maps, the geohore mosaic includes geomeric parts. If geochors are shown in natural boundaries (taking into account, of course, the map scale capabilities), then the geomers are displayed depending on the scale and level of their generalization, i.e. on the rank.

The differentiation of geosystems is determined by the radial differentiation of matter, with each hierarchical level of geomers of topological level corresponds to certain amplitudes of matter reserve in soils and phytomass, increasing with the rank of the taxon. This enables classification of geomers using the results of landscape-geochemical analysis of geosystems by taking into account the absolute quantities of matter in their components, especially since geomers within geosciences differ in absolute amounts of these or other elements or their radial differentiation [5]. The main mapping unit for large-scale mapping of geosystems is usually the facies. A facies combined biogeocenoses with one plant association and one soil variety within the limits of similar locations. By the principle of homogeneity, the facies are combined into subtypes, types and groups of facies. The basic criterion for combining facies into types (eluvial, translevuvial, transaccumulative and superaquial) is the landscape-geochemical conditions for the formation and functioning of typed geosystems, reflected in the classification of locations [6]. Within the facies types subtypes (para-eluvial, ortho-eluvial, neo-eluvial, trans-eluvial steep, very steep, steep and gentle slopes, transaccumulative acclivious and gentle slopes, accumulative aligned surfaces), in which the nature and degree of migration of the substance are reflected [4, 7].

Integration of geosystems is caused by lateral flows of matter, and for lower levels of geochoras, unidirectional migration and a single balance of substance differentiation are typical, with all ranks of geochoras topological dimension, corresponding to specific ranks of geomers with certain limits of variability of absolute quantities of matter in components of subordinate geomers whose distribution
areas are limited by data frames of geochoras [3]. Therefore, it is advisable to carry out geochoric integration stepwise on the basis of landscape-geochemical synthesis of geosystems by taking into account absolute quantities of matter and revealing the balance of migration flows in subordinate geochoras [5].

Introduction of two additional taxa of topological order into the taxonomic system of geomers by V.B. Sochava [1] – a type and subtype of facies - allowed to observe a more complete correspondence between taxa of typological and chorological series. If, with the traditional generalization of the landscape map and zoning schemes, it is possible to intersect geomers areas by the borders of geochoras, then the conjugate mapping of geomers and geochoras makes it possible to generalize geomers in stages, consistent with generalization of geochoras, and therefore on such maps the intersection of geomers contours with the horological borders is absent [5].

Unfortunately, the approaches to landscape synthesis described above are applicable only at the topological level. One example of a medium-scale map constructed in this way is a map of the geosystems of the Nazarovo depression [3]. First, the indices of differentiation of the phytomass substance do not work here due to the large reserves of matter in woody plants, against anthropogenic transformation of native forest vegetation (felling, fires) and succession (spontaneous and regenerative) changes. Secondly, the absolute indices of the differentiation of matter in forest soils do not reflect the specificity of the geosystems: the presence of processes of podzolization, leavage, gleying, etc., which are of decisive importance in determining the classification affiliation of the geosystems of taiga and subtaiga, are not indicated by the total indices of substance differentiation. Besides, with the expansion of the research area in the steppe and forest-steppe regions, serious difficulties were found in interpreting the relationships of substance differentiation and the organization of geosystems. Therefore, in the following years our research was aimed at understanding the role of not the substance as a whole in the formation of the geosystem structure, but in identifying the role of natural and anthropogenic flows of specific chemical elements and their associations in the formation of typological diversity, regional and topological patterns of integration of geosystems in mountain taiga and subtaiga.

3.2. Medium-scale mapping
In medium-scale landscape mapping a direct survey with subsequent control of the correctness of the boundaries of all selected contours is, of course, impossible. Therefore, topographic and thematic maps, remote sensing materials, a multi-scale landscape survey and detailed mapping of key areas are used in the mapping of medium-sized geosystems. The mapping of the geosystems of various areas of the Minusinsk depression included the compilation of large-scale maps of the nearest environment of physicogeographical field stations (Berezovskii forest-steppe in the Nazarovo depression, Lena mountain taiga in the foothills of the Western Sayan, and Novonikolaevskii steppe in the Minusinsk depression), and analysis of long-term observations of behavior conditionally-natural and anthropogenically-modified geosystems, the definition of dynamic and evolutionary trends in the development of geosciences and the extrapolation of the results obtained in the course of long-term field investigations, on the adjacent field model. Considerable attention was paid to the problems of determining the landscape-geochemical, landscape-geophysical and biogeocenological indicators of anthropogenic transformation of geosystems under the influence of urbanization, emissions of industrial enterprises, agriculture, and forestry for cartographic mapping of anthropogenic changes in natural formations [5].

On the landscape map of the Nazarovo depression [3] geomers and geochoras are simultaneously displayed, and on the map of the Minusinsk depression [8] - only the geosystems of the typological classification series. The main mapping units on both maps were geomers of the rank of groups of facies, united in the map legend into facies classes and geomes. The map of the geosystems of the Minusinsk depression was compiled using the synthesis of two approaches to the classification of geosystems: as separate families, it shows both conditionally-natural and anthropogenically-modified
geosystems - agrolandscapes [8]. At present, these maps of the parts of the Minusinsk depression [3, 8] are being generalized to create a single map of the geosystems of the south of Central Siberia.

Sometimes, the reverse approach is also used, i.e. the detailing of maps of a smaller scale. It is known that when the scale is enlarged, the mosaic and the pattern of contours usually change, and the appearance of additional taxa requires a radical processing of the legend's content. This approach was used in drawing up the basis for landscape planning of the northern regions of the Altai Republic [9], when the map of the Altai landscapes [10] was interpreted taking into account the author's experience in mapping geosystems of adjacent regions and refined based on the own materials of field studies and detailed mapping of key areas.

In recent years the Sochava Institute of Geography is working on the compilation of a landscape-assessment map of the Asian part of Russia for the purposes of territorial planning and the ecological and geographical justification for the creation of large economic facilities. When compiling its sheets, a system-hierarchical approach is used to identify the subordination of landscape taxa and the evolutionary-dynamic interpretation of the charted units, and map legends are constructed taking into account the positioning of the territory and the typological spectrum of regional geosystems in the planetary system [2, 11].

Up-to-date, some results of landscape mapping of the basin of the upper and middle Yenisey (Nazarovo, Kansk, Minusinsk and Tuva basins, and their mountain frames) have been summarized [12-14]. Medium-scale landscape maps and schemes for physiographic division of the Nazarovo and Minusinsk depressions [3, 8], maps of administrative areas, synthesized satellite imagery, topographic, general geographic, thematic maps of various scales, charts and materials of field studies and key sections were used to map this territory. The group of facies was chosen as the lowest mapping unit of geometers. In general, about 200 groups of facies have been allocated on the territory of the region which are united in classes of facies, geomes and groups of geomes. On the small-scale landscape map of the region the differences in the complexity of the horizontal structures of the plain and mountain territories, in their landscape patterns, are first clearly revealed. Plains are characterized by a great homogeneity of the structure, and large areas of landscape contours. The landscape structure of mountainous areas is characterized by considerable complexity and contrast, so the regional specificity of high altitude zoning was especially carefully taken into account.

4. Conclusion

Cognition and mapping of the organization of geosystems require the identification of patterns of their differentiation, integration and development, and all these patterns can be obtained only as a result of analysis and interpretation of certain data on properties, both individual components and geosystems in general. Empirical data in geography are obtained in expeditions, at field stations, key areas and profiles. The expedition method allows to collect only a small range of data on the landscape structure and properties of geosystems, and to obtain information on the dynamics and functioning of geosystems, studies at field stations and key sites are needed using seasonal or other periodic semistationary studies. In key areas of reference landscapes, it is necessary to study typological units that determine the overall epifaunal structuring of knowledge. An analysis of all modifications of the indigenous geosystems should be aimed at identifying the backbone of the studied geochores. It is also necessary to develop and unify the methods of description, indicators of the structure and dynamics of geosystems, create inventories of signs, including physognomic and deciphering for analysis and interpretation of space imagery.

Further development of the theory of geosystems requires the creation of a modern landscape classification that adequately reflects the organization of the geographical envelope, which should include three taxonomic series: typological, horological and dynamic. The classification should be based on correct quantitative data. Hence a task of improving the methodology for collecting, mapping, analyzing and thematic interpretation of geographic information appears. New, geosystem-based, standardized methods of thematic mapping, GIS creation, and aerospace applications are
needed here. At the same time, everything should be balanced and work out precisely for the purpose of mapping geosystems.

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