Certain results of agrolandscape zoning in the south of Central Siberia

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Abstract. The article considers the results of landscape and agrolandscape mapping of the south of Central Siberia at a scale of 1: 1 000 000. Landscape mapping displays and records information on diversity, integration, dynamics and evolution of conditionally natural and anthropogenically modified geosystems. The mapping of natural landscapes is based on the theory of geosystems by V.B. Sochava and the principles of building a hierarchical structure of geomers. The study implements a unified classification, which is based on a system-hierarchical approach to identifying the landscape taxa subordination, taking into account the territory location in the system of physical and geographical zoning. We identified and characterized more than 200 groups of facies, combined into 42 classes of facies, 12 groups of geomes in the area under consideration. Agricultural landscape studies were carried out on the basis of landscape mapping data. The methodology was developed in accordance with the work specifics aimed at studying agricultural landscapes and analyzing the agro-natural potential of geosystems. Characteristics of agricultural landscapes include data related to both natural and agricultural blocks. The internal structure of natural components (relief and soil) and the features of the external environment (zonal-provincial geographical position, agro-climatic resources) have been investigated. Types of agricultural use (types of crop rotation and agrotechnical complex) and the average long-term yield for individual crops are taken into account. The relationship features between the differentiation of natural conditions and farming was established, and the territorial differentiation of agricultural landscapes was revealed.

1. Introduction
The research territory is the south of Central Siberia (the Republics of Khakassia and Tuva, the southern and central regions of Krasnoyarsk krai), covering the basin of the upper and middle Yenisei (Nazarovskaya, Kanskaya, Minusinskaya, Tuva depressions and their mountainous framing). The area under consideration is included in the territory of the complex investment project "Yenisei Siberia" for the joint economic development of Krasnoyarsk krai, the Republics of Khakassia and Tyva.

The study of functioning regularities and landscape changes is one of the main problems of environmental protection and rational use of natural resources under the anthropogenic impact. Nowadays, there are no longer natural-territorial complexes that were not impacted anthropogenically. The anthropogenic impact on modern landscapes violates the connections that characterized the natural landscape, while new ones that actually exist at present are being created. Consequently, anthropogenic landscapes are formed, wherein agricultural landscapes are the most common among the others.

By now we compiled a landscape map on a scale of 1: 1 000 000 for the entire area under consideration and fragments of agrolandscape maps. Now we continue the agrolandscape research.
2. Materials and methods

As previously noted, the methodological framework of this study was the principle of the theory of geosystems by V.B. Sochava [1]. Additionally, in compiling an assemblage of maps to display the research results we used a methodology based on the synthesis of methods for mapping natural geosystems and agricultural landscapes, described in a number of works [1-10]. On parity with the above-mentioned principles and methods of mapping generally accepted in Soviet and Russian landscape studies, we used a systemic-hierarchical approach to identifying the landscape taxa subordination and an evolutionary-dynamic interpretation of mapped units. Legends are built taking into account the territory location and the typological spectrum of regional geosystems in the planetary system [11]. Mapping of geosystems of the southern regions of Central Siberia was based both on the above-mentioned principles and on the author's own ideas about the classification of geosystems arising from the experience of landscape mapping of the regions of southern Siberia.

We used medium-scale landscape maps, schemes of physical and geographical zoning of the Nazarovskaya and Minusinskaya depressions [9, 12], maps of administrative regions (soil, vegetation, etc.), synthesized Landsat 7 ETM satellite images, and topographic maps as a cartographic support. The initial territorial assessment and analysis of landscape sections are possible in the cartographic method and study of the Earth's remote zoning (ERS) materials [13]. In the field studies, we used profiling in combination with key areas study in selected areas with the most complex spatial structure of geosystems. The results of the desk interpretation of space images were transferred to the cartographic base, which was a preliminary model of the map.

3. Results and discussion

As mentioned above, the landscape mapping technique was based on the basic principles of the V.B. Sochava's theory of geosystems [1], but had some peculiarities due to the specifics of our research aimed at the study of agricultural landscapes and analyzing the agro-natural potential of geosystems. Therefore, the landscape structure is shown on four maps: landscape typological, physical-geographical zoning scheme, agrolandscape (anthropogenic modifications of natural geosystems) and a map of agro-natural potential.

Landscape mapping gave rise to present various information at all territorial levels. As a result of landscape studies, we identified numerous natural complexes and mapped them on the territory. A group of facies, which is a single factorial-dynamic series of facies, reflecting changes in the degree of hydromorphism in this area, was chosen as the lowest mapped unit of geomers. The groups of facies were combined into classes of facies and geom. Geoms includes groups of facies that are similar in material and energy exchange, genesis, structural and dynamic features, and biological productivity. A class of facies serves as an intermediate step between a group of facies and a geome [6].

Totally, more than 200 groups of facies have been identified in the study area, which are combined into 42 classes of facies and 12 geom. The latter belong to three groups of geom: North Asian goiletz and taiga, North Asian forest-steppe and steppe, Central Asian mountain-tundra, tundra-steppe and steppe.

It is a common fact that a necessary prerequisite for the systematization of geosystems is the recognition of their dual origin, i.e. the existence of two series of taxonomic units: a) geochores, or heterogeneous wholes, allowing to take into account the discreteness of the geographic space and b) geomers, or homogeneous systems located inside geochores and reflecting the continuity of the natural environment. At the same time, the hierarchy of the landscape envelope is determined by the spatial integration of geosystems, where the geomers naturally fit into the variegated mosaic of geochores. Thereby, the two-row classification introduces a new beginning in solving the problem of the relationship between the two concepts of landscape typology and physical and geographical zoning [1].

Four physical and geographical regions are distinguished on this territory according to the characteristics of the landscape structure; each has its own special landscapes: Ob-Irtysh (OI), Central Siberian (CS), South Siberian (SS) and Central Asian (CA). The latter, in our opinion, covers the southernmost part of the studied region [14].
The variety and specificity of natural conditions of this area and backlash of economic activity determine the implementation of landscape approach when justifying the optimization of agricultural landscapes in this region. A landscape map, as a basis for compiling agricultural landscape maps, enables taking into account the reserves of agricultural lands not only quantitatively but also qualitatively, as well as to outline the ways of optimal land transformation depending on the natural conditions of the areas.

The landscape map for the south of Central Siberia was compiled using a synthesis of two approaches to classification of geosystems: both conditionally natural and anthropogenically modified geosystems are shown as separate families. Agrolandscapes that develop inseparably from the surrounding geosystems and are closely related to them, are overlapped on natural landscape structures, classified in accordance with the theory of geosystems [1]. Therefore, the identification of the natural basis is an indispensable condition for the study of agricultural landscapes, but the principles of compiling a medium-scale typological landscape map result from the goals and objectives of the agrolandscape assessment of the territory.

The choice of ways of rational land use should be based on agrolandscape zoning, reflecting the specialization and technology of agricultural production in connection with the differentiation of natural conditions of the region. Zoning is an essential element of agrolandscape research. V.A. Nikolaev [15] reported that despite the partial transformation of natural properties of the original natural landscape as a result of agricultural development, they significantly affect the structure, dynamics and functioning of the agrolandscape system. The production components of an agricultural landscape, namely agricultural technology, land composition, system of a farming, land reclamation, etc. interact with the natural environment and determine the system stability as a whole. Otherwise, the natural potential of lands may decrease and even undergo degradation. At the same time, the production component of the agricultural landscape allows, to some extent, exercising control over natural processes on cultivated lands. The agricultural landscape is an open system, depending on the influences of the external environment (mainly climatic factors), scientific and technological progress, social and economic conditions [12, 15].

The agrolandscape map was compiled according to the method of V.A. Nikolayev [15]: landscape types were correlated with the land use types, crop composition in crop rotation, agricultural technology that is used, the yield of agricultural crops, climatic indicators, etc. This map presents the existing natural-agricultural systems. Their characteristics include information on both natural and agricultural blocks: component properties of geosystems; features of the external environment; current agricultural uses; average long-term crop yield.

The relationship between agricultural indicators of administrative districts and their landscape structure, determined in the study, made it possible to single out the lower natural economic units, i.e. agricultural landscapes. They were differentiated geographically by overlaying the boundaries of administrative regions on the boundaries of natural zones. The identified agricultural landscapes are parts of the territory of the administrative region within the boundaries of various landscapes or parts of the landscape within the administrative regions. This approach determined the contours of arable agricultural landscapes and their indicators. Separately, on the map, we identified taiga-subtaiga landscapes, agricultural landscapes of natural forage lands, and ranked arable lands.

Agrolandscape studies were intended to analyze and assess the agro-natural potential of the geosystems of the area. Each natural landscape has a certain agro-potential, which is determined in the process of consistent study of the qualities and properties of natural components and also is able to identify factors that are favorable, limiting, or restricting for farming, on the basis of multivariate analysis. The peculiarities of agricultural potential determine the possibilities of land use systems in specific regions, as well as those changes in natural geosystems that arise after their rational development.

The agro-natural potential of geosystems was calculated based on the integration of assessments of bioclimatic parameters, agricultural production characteristics of soils and limiting factors of agricultural land use. Considering the agro-natural potential of land, all analyzed landscapes were
divided into groups: from arable landscapes with high agro-natural potential to landscapes without agro-natural potential (geosystems of goletz and subgoletz, mountain taiga and taiga geoms).

We identified the contours of arable land and assessed the possibility of using the agro-natural potential of geosystems in terms of climatic indicators, prevailing production groups of soils, land erodibility, irrigation, etc. After aggregation the estimates of main components of the agro-potential, the arable agricultural landscapes, highlighted on the agrolandscape map, were combined into groups depending on their agro-natural potential: high, medium and below average. The assessment of the agro-potential of geosystems confirmed that natural factors significantly complicating or limiting farming in certain areas of the region are lack of heat (in steppe and dry-steppe regions), water saturation and high erosion hazard associated mainly with the mountainous nature of the relief. Current assessments of land resources, analysis of factors, dynamics and potential possibilities of their agricultural use have shown that the territory of the south of Central Siberia as a whole has a large land potential, which is used nonoptimal and very unevenly.

Prospects for agricultural output expansion in the region are associated with the preservation and improvement of soil fertility of already developed lands and restoration of lost lands.

4. Conclusion
Thus, the main task of agricultural landscape research is the study, analysis and assessment of the current state of natural and anthropogenically modified landscapes and forecasting the transformation of geosystems under the influence of agricultural activities. Based on the study of geosystems, we have compiled a landscape map of the south of Central Siberia using two approaches to geosystem classification. Agrolandscape mapping will be continued for the area under consideration.

The results of agrolandscape studies using landscape analysis of the agro-natural potential of the geosystems here will enable identifying priority areas for agrolandscape use, determining the ways of their optimization and organization of sustainable agroecosystems. Rationalization of land use should be based on an agrolandscape map, reflecting specialization and technology of agricultural production, depending on the natural conditions of the region. To preserve agricultural potential and develop measures to improve soil fertility, it is necessary to plan land use in order to achieve economic efficiency, environmental feasibility and social friendliness of agricultural production simultaneously. At the same time, each specific agricultural landscape can and should have an optimal variant of land use with a certain ratio of transformative organizational-economic and adaptive landscape-ecological measures that would sharply increase the potential of their self-regulation.

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