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Study and Mapping of Impact of Mining on State of Land in Economic Corridors "China–Mongolia–Russia"

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***Abstract*—The article presents materials on the assessment and mapping of the state of lands disturbed in the process of mining and processing of minerals in the areas of creating transport economic corridors between China, Mongolia and Russia, provided by the trilateral agreement of the leaders of these countries. The content of the research reveals the structural-logical scheme, in accordance with which the presentation of the material is given. The leading research method is cartographic modeling. A system of conventional signs, reflecting the processes and phenomena in the field of ecology of mining in the territory under consideration, has been developed. A system of indicators has been proposed, with the help of which the assessment and mapping of the environmental impact of mining in the mining areas has been carried out. The areas of economic corridors on the maps show the density and structure of disturbed land. The article presents materials and maps showing the effects of mining production on the social sphere.**

Keywords*: *transport economic corridors; mining complex; anthropogenic impact; cartographic modeling

I. Introduction

During the talks between the leaders of Russia, China and Mongolia, held in the framework of the Shanghai Cooperation Organization (SCO) Summit in Tashkent on June 24, 2016, a program to create a system of transport economic corridors "China–Mongolia–Russia" was signed, involving more than thirty promising projects.

Economic corridors solve the problem of increasing trade and development of transport infrastructure – railways and highways – connecting the countries participating in the agreement [1]. The implementation of the agreement will increase the flow of investment in cross-border regions. At the same time, environmental degradation can be expected due to increased man-made impact and population growth.

Transport routes pass through areas with high environmental restrictions – the Central Ecological Zone of the Baikal Natural Territory, near specially protected natural territories – the national parks of the Pribaikalsky and Gorkhi-Terelzh, nature reserves of the Baikalsky, Daursky, Goviyn Baga Darkhan Gazar, Khan Hentik, various reserves and numerous monuments of nature [2-4].

The mining industry in the region is the most important sector of the economy, but at the same time it is a powerful source of negative impacts on humans and the environment. Issues related to the assessment of this impact are the subject of a study of mountain ecology. The task of this science is to build models of human interaction with the environment in the field of mining; the summation of the results of the research and the development of the scientific foundations of technological processes ensure the optimal level of environmental impact [5]. Our study investigates theoretical and methodological issues of this scientific direction using the cartographic method [6, 7].

The assessment of technogenic impact is carried out at two levels – in the areas of mining and within the boundaries of municipalities – administrative regions of the Russian Federation and Mongolia, located in the sphere of influence of economic corridors. Numerous mineral deposits are identified and developed here. Improving transport accessibility will contribute to an increase in the extraction of raw materials and related industries. The study is based on a model based on the methods of cartographic representation of information. The article further develops our earlier studies on the above topics [8, 9]. Compiled maps provide a visual representation of the environmental impact of mining in the areas of mineral extraction – mineral deposits and the environmental situation in municipalities

II. Methods and Research Model

The work is based on a model that represents the basis for solving the tasks posed – assessing and mapping the anthropogenic impact of mining at mineral deposits and within the administrative districts, along which economic corridors pass (Fig. 1).

The research model algorithm is a sequence of steps in solving the problems of interaction between man-made, socio-economic and natural systems in the field of subsoil use. The model includes a number of blocks related to the environmental impact of mining. The subjects of anthropogenic impact are the enterprises of the mining industry. Objects of impact are natural and socio-economic areas. Violations are localized in the fields; in the districts their background characteristic is given. Estimated indicators are used to calculate the degree of anthropogenic impact.

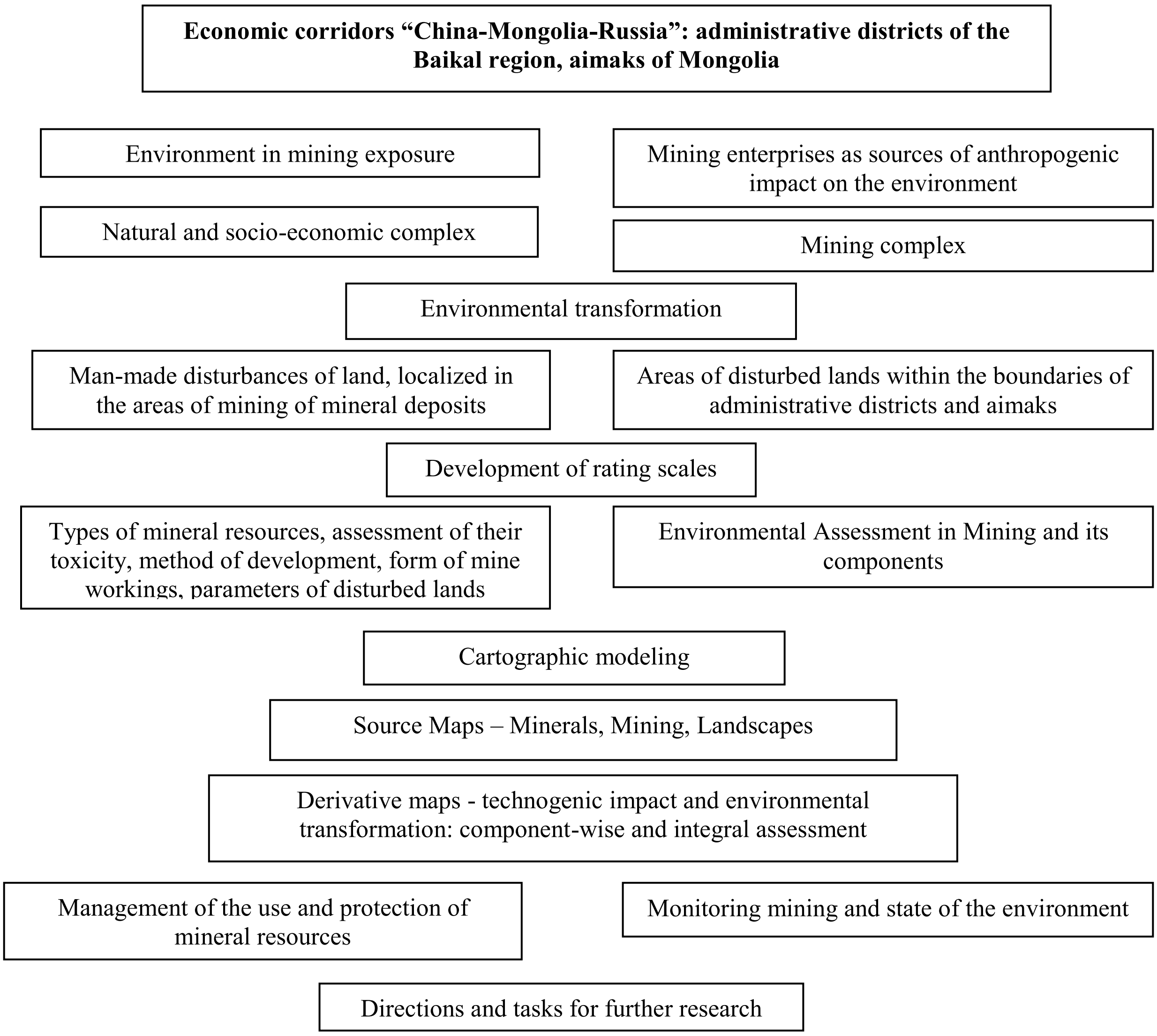

Fig. 1. Model of research.

The leading method of research is cartographic. To create maps, we use the program ArcMap. The detail, accuracy and efficiency of the maps is achieved by the interpretation of high-resolution satellite images (Landsat 2012-2018).

Maps of minerals and mining industry were used as initial ones [10-13].

The icon method of the cartographic image is used to indicate the location of objects, localized point by point and not expressed at the scale of the map. The nature and extent of violations associated with mining production are displayed on the sites for the extraction of raw materials with cartographic signs of different colors, shapes and sizes. To show the ecological state of lands within the boundaries of the regions, the method of color quantitative background is used. Evaluation is carried out in points, which allows for a comparative analysis of various indicators and calculate their total values. The structure of indicators having an areal character is displayed by means of bar and stack diagrams. They are informative and improve the visual perception of the data.

III. RESULTS AND DISCUSSION

The results of the research show the following cartographic materials.

Map "Technogenic impact of the mining industry on the environment" (Fig. 2). Sources of impact on the environment: 1 – quarries, cuts, dumps (open mining method), 2 –dredge and hydraulic fields (open mining method), 3 – mines, adits, dumps (underground mining method), 4 – wells (underground method mining), 5 – mines, tunnels, quarries, dumps (combined mining method), 6 – dumps, ditches, excavations (no data on the development method). The area of disturbed land, km2:7 – more than 10, 8 – 1-10, 9 – 0.1-1.0, 10 – less than 0.1. Density of disturbed lands within the municipal districts (aimaks), km^2/thousand km^2: 11 – more than 5, 12 – 1-5, 13 – 0.5-1.0, 14 – 0.005-0.5, 15 – violations are not identified. The type of the extracted raw materials: 16 – coal and brown, 17 – ferrous metals, 18 - non-ferrous metals, 19 – rare metals, 20 – gold, 21 – non-metallic minerals, 22 – fluorite. Borders: 23 – state, 24 – subjects of the Russian Federation, aimaks, 25 – municipal areas.

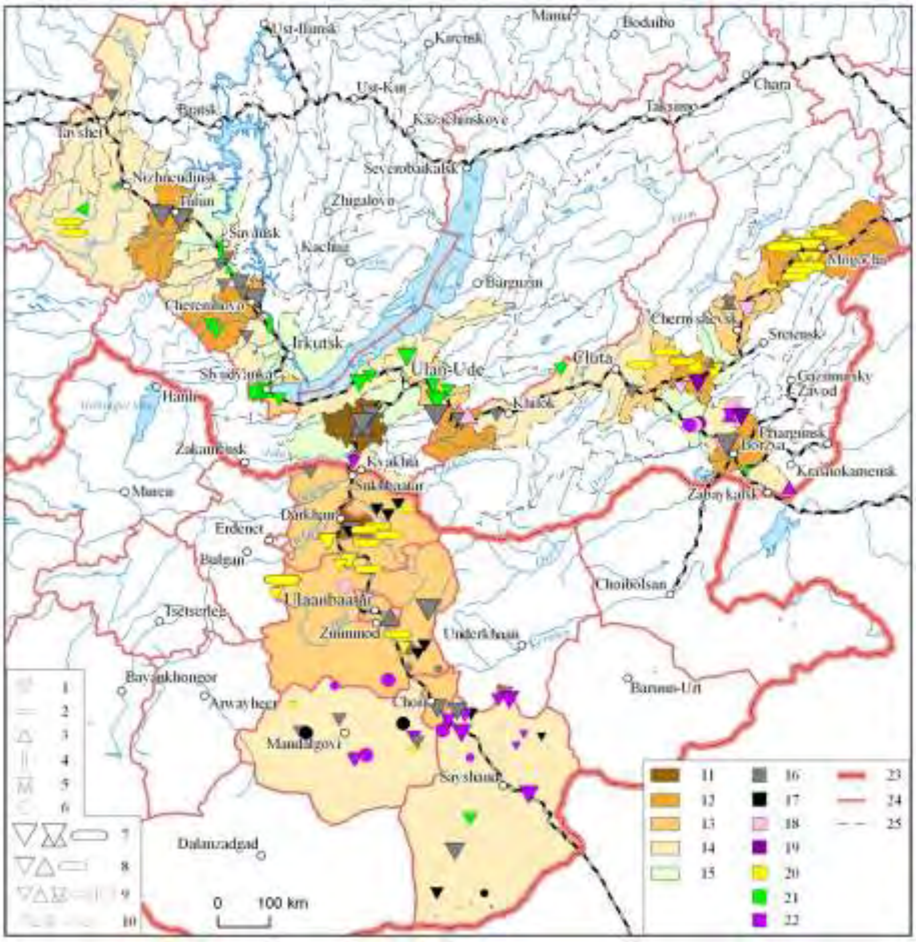

Fig. 2. Technogenic impact of the mining industry on the environment.

This map is the basis for a series of subsequent maps. On it, to characterize the local anthropogenic impact, off-scale conventional signs are used, reflecting the type of the extracted raw material (the color of the icon), the way of development (the form of the icon) and the area of the technogenic transformation (the size of the icon). Currently, in this area, mining is carried out mainly by the open method. This method is the most cost-effective, but it has a strong negative impact on the natural and social spheres [14]. With the open method, the stripping works extend to a considerable depth; quarries and dumps are formed with the movement of huge volumes of rocks; dangerous engineering and geological processes are developing. In this regard, the area of land disturbed during the development of deposits has been taken as the leading indicator in our work. For areal characteristics within the boundaries of municipal districts and aimaks, the quantitative background shows the density of violations, determined by the ratio of the total area of disturbed land in the area (aimak) to the area of this place (aimak).

The most extensive violations in the region are related to coal mining. Such destructions have been identified in the Azei, Kharanorsk, Gusinoozersk and other fields. Large quarries and dumps of overburden and host rocks of considerable volume were formed here, reaching more than 200 million cubic meters.

Linear areas of disturbed land arise in river valleys as a result of placer gold mining. These areas are characterized by considerable length with small volumes of overburden being moved. In the zone of passage of economic corridors, more than twenty such sites were found, mainly in the Mogochinsky district of the Trans-Baikal Territory, the Selenge and Tuv Mongolia aimaks. Maximum disturbance, reaching about 40 square kilometers, is identified in the valleys of the river Tuul and its tributaries. The most negative consequences occur when developing alluvial deposits in riverbeds by dredge and hydraulic methods. At the same time, dirty water flows into the rivers, as a result of which irreversible changes occur in aquatic and riparian communities of organisms. In the arid regions of Mongolia that suffer from water shortages, mining increases the shortage of water resources. The aeolian processes are activated; desertification is intensified [15].

According to the map (Fig. 3), the average density of technogenic disturbances in the areas of passage of transport corridors is 0.662 km^2 per thousand km^2, the largest installed in the Selenginsky district of the Republic of Buryatia, Darkhan-Uul aimak in Mongolia. In Tulunsky, Alarsky, Cheremkhovsky districts of the Irkutsk region; in Borzinsky, Petrovsk-Zabaykalsky, Mogochinsky, Shilkinsky areas of Zabaykalsky Krai this indicator is lower. The map "Structure of disturbed lands" is in Fig. 3.

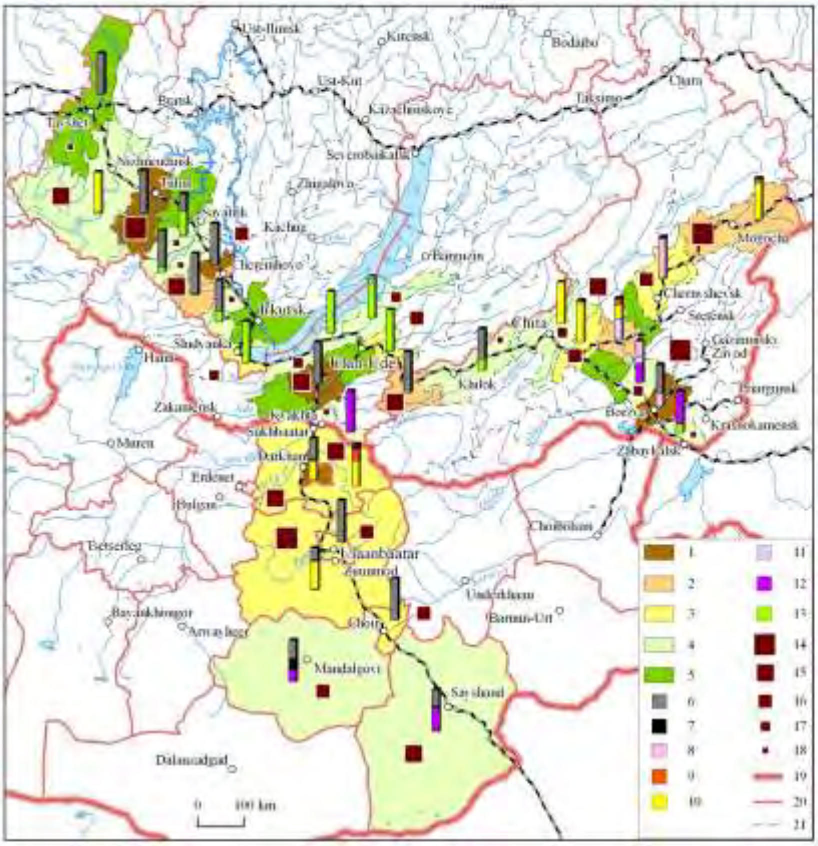

Fig. 3. Structure of disturbed lands.

Technogenic disturbance in the regions (aimaks) relative to the average along the corridor: 1 – very high (more than 5), 2 – high (1.5-5.0), 3 – medium (0.5-1.5), 4 –low (0.006-0.5), 5 – no violations revealed. The type of the extracted raw materials: 6 – coal and brown, 7 – ferrous metals, 8 – non-ferrous metals, 9 – gold ore, 10 – alluvial gold, 11 – rare metals, 12 – fluorite, 13 – non-metallic raw materials. The total area of disturbed land in municipal areas (aimaks), km^2: 14 – more than 30, 15 – 10-30, 16 – 3-10, 17 – 1-3, 18 – less than 1. Borders: 19 – state, 20 – subjects of the Russian Federation, aimaks, 21 – municipal areas.

The map shows the level of violations within the boundaries of municipal districts relative to their average value for all districts using the color quantitative background method. The highest values of this indicator were found in the Tulunsky district of the Irkutsk Region and Mogochinsky, Trans-Baikal Territory, as well as the Tuw Mongolia aimak. As the structure of disturbed lands, we have taken the ratio of the areas affected in the process of extracting certain types of minerals to the total area of disturbed lands in the development of all types of minerals within the municipal area. This indicator is demonstrated by stack diagrams (histograms with accumulation), normalized by the value of total violations indicators, which allows one to display the whole range of them by the estimated areas (Table I). The color of the elements of the diagrams corresponds to the type of extracted raw materials. The total area of disturbed land is displayed with special square-shaped icons of various sizes.

The greatest violations due to the extraction of various minerals were found in the following areas: Mogochinsk (placer and ore gold), Tulun (brown coal), Borzinsky (now brown coal and tin) in municipal areas, as well as Tuv aimak (brown coal, iron ore, ore and placer gold, tungsten).

TABLE I. THE SHARE OF LAND DISTURBED IN THE PROCESS OF MINING IN ECONOMIC CORRIDORS WITHIN REGIONS, %

Regions / Type of extracted raw materials	Mongolia	Trans-Baikal Territory	Republic of Buryatia	Irkutsk Region	For all regions
Coal and brown	32	30	78	83	46
Ferrous metals	3	–	–	–	1
Non-ferrous metals	–	14	–	–	5
Rare Metals	–	4	–	–	2
Gold ore	7	5	–	–	4
Placer gold	50	46	–	13	36
Non-metallic raw materials	–	–	21	4	3
Fluorite	8	1	1	–	3

In general, in the study area, 46% of violations are related to coal mining (Mugunsky, Cheremkhovsky, Azeisky, Tugnuysky, Kharanorsky, Baganuur and other cuts). The second place is occupied by man-made landscapes that have arisen during the development of gold-bearing placers (valleys of the Ithaca, Kiya, Kruchina, Davenda, Tuul, Sharyn-Gol, etc.).

IV. Conclusion

The conducted studies are carried out in accordance with a specially developed program presented in the form of a structural-logical scheme. To visualize the results obtained, a cartographic method is used. From the general series of thematic maps in this article, two maps are considered that reflect the disturbance of land as a result of the development of mineral deposits in areas where economic corridors pass. For mapping, a special cartographic language has been developed, the use of which makes it possible to show the placement of man-made objects with an indication of the nature of their impact on the environment. The following article focuses on issues related to the negative environmental consequences of mining for the population.

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