Mining production and status of geomorphological environment of the platform denudation plains (Central Kazakhstan)

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Abstract. Study of environmental management and mining production, detecting main types and characteristics of their manifestations is based on studying numerous literature and cartographical sources, results of field research and social survey data. This work for the first gives a general interrelated analytical summary of types of economic activities and degree of economic disturbance of geomorphological environment of platform-denudation plains of Kazakhstan caused by them. In accordance with the purpose and objectives of the research, general analysis was made of geographic maps with scale 1:500000 published in various years and of geological maps with the same scale, as well as three-years-long field research, during which population was questioned about presence of geomorphological disturbances, their causes and dynamics of development. The comparative assessment of geomorphological environment disturbances shown in the table was built on identification of all kinds of relief disturbances, including technogeneous forms (including buildings and engineering structures) per area unit (km2).
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Introduction

At present, in fact, the process is going on of transforming natural systems, including geomorphological ones, into natural-anthropogenic systems. Degrees of anthropogenic transformation of geomorphological systems are different and, depending on it, geomorphological systems can be grouped into three subgroups: weakly transformed, greatly transformed and anthropogenic.

Deteriorations of natural functioning of natural environment, their scope and nature of manifestations depend on the type of economic activity - economic and engineering, mining and processing, agricultural, urban planning, etc. Type of exposure or nature management involves complex of events being a result of human economic activity through a variety of types and sizes of structures, buildings, structures, equipment, tools and material.

Virtually all types of society's impacts on the nature belong to the category of motivated. Urban and industrial agglomeration create thermal, gravitational, radioactive and electromagnetic fields, and are also major sources of deterioration of, and, in particular, leveling of terrain, concentration of technogeneous deposits, pollution of land cover, atmospheric air, natural water resources. Changes in the environment, natural physical fields in cities are complicating factors for human habitation, and, therefore, for effective functioning of the entire city economy. Virtually all economic activities, anyway, lead to (wide range) chemical contamination Environment, including relief environment.

Central Kazakhstan is one of the regions of the country that is experiencing strong anthropogenic pressing. High rates of developing mineral raw materials, fuel and energy agricultural resources have led to emergence of major urban and industrial agglomerations (Karaganda, Zhezkazgan, Balkhash) and many urban settlements (Aksuat, Konyrat, Satpayev, Kayrauty, Zhezdy, Topar and many others). Central Kazakhstan features extremely unfavorable natural conditions, but has significant resources of solid minerals, most of which is being developed. The latter resulted in the fact that in large areas in Central Kazakhstan substantial transformation of environment components occurs: natural terrain and terrain-forming processes, soil and vegetation, pollution of water and air and geosystems in general.

Methods and Materials

Study of anthropogenic activities and types of wildlife associated with it, including the main - mining production, within the framework of shaping modern landscape and dynamics of exomorphogenesis for the area of Central Kazakhstan has been performed for the first time. Being the main goal of our work, this study determined the direction of bibliographic search and analysis of literature sources [1,2,3, ..., 11], contents of a three-year field study (2011-2014), and choice of key sites in the context of human activities,

the list of essential cartographic materials and the nature of scientific inquiry.

The work was performed basing on the use of comparative geomorphological and cartographic analyses, system terrain analysis and study of data of field observations, analysis of topical (geological and geomorphological) and geographic maps with large scale - 1:500 000 and 1:100 000 from different years of publication (1972, 2010), materials of stock reports and statistical data of a sociological survey. Materials of stock reports were the basis for identifying key areas and the scope of field work.

Main part

Featuring arid climate, poor productivity of land cover, serious scarcity of water resources, at the same time Central Kazakhstan has unique mineral deposits in composition and reserves, which, like other components of natural resource environment, is being intensively developed. In addition, due to complexity of development of the region in the context of the natural resource base, associated types of nature management or types of anthropogenic production are being developed with associated types of land transformation and the degree of broken condition of geomorphological environment [1] (Table 1).

Type of nature management or type of economic impact has different dimensions - areal, linear and local-point one. In all cases, the area of direct influence usually coincides with the area of load objects, while the area of indirect influence is much larger. Analysis of nature management and, accordingly, of impact and, consequently, of disturbance of geomorphological environment in the Central Kazakhstan is shown in the table below (Table 1). It shows 5 types and 11 subtypes of nature management and types of land conversion associated with them, as well as various degree of geomorphological environment broken state. Selected taxonomic units of nature management consider the following criteria: type - reflects genetically homogeneous nature management; subtype reflects the character of nature management (anthropogenic production); kind - specific forms of nature management and land conversion. K.M. Baymyrzaev [1, p. 148-153] is absolutely right when he says that almost all kinds of influence on natural (including geomorphological environment as well - R.B.) in the region are intensive by nature. The dominating types are mining and hydraulic engineering represented by ore mining, metallurgical and hydraulic subtypes of anthropogenous production. Ore mining subtype is associated with mining coal, ferrous, non-ferrous polymetallic and rare metals ores, their enrichment, and is the leading subtype in development of Karaganda region natural resources potential.

Anthropogenous activity that goes before mining is exploration work, including studying the area for construction and operation of transportation routes and industrial sites of geological parties. In course of this work, deformation of the structure and deterioration of soil occurs, as well as destruction of grass cover and shrubs, deterioration of fertile soil, compaction, soil contamination by fuels and lubricants, flushing fluids, and cutting slurry. Area of disturbed soil and vegetation at production sites for mining and exploration activities vary widely from hundreds of square meters in course of drilling shallow pits, to several thousand square meters and more in course of making a network of exploration ditches or a complex of underground exploration mines. Similar deteriorations are observed on plots (sections) adjacent to the roadway, from which rock is taken for road construction, creating new micro-landscape in separate sections of the roadway in relation to excavations and making embankments, making dikes, etc. Elimination of grass cover and shrubs in connection with preparatory work on the road bed and development of reserves has a particularly negative influence in the areas with unfavorable geographical conditions - dry steppes, semi-deserts and deserts.

Table 1. Types of nature use and degree of disturbance of the geomorphological environment

Types of use the nature	Subtypes of use the nature	Types of land conversion	Disturbance of geomorphological environment		
			small	middle	high
Mining and hydraulic engineering	Mining(mining and milling of ores)	- Career -Underground voids - Blades -Tailing	+	+ +	+
	Mining	-Manufacturing Enterprises industry -Enterprises processing industry		+ +	+
	Hydrotechnical	-Reservoirs, including storage of household and commercial waste - Channels -Reservoirs, including storage of domestic waste water		+ + +	
Urbano-residential	Urban	- Large urban agglomerations - Cities		+ +	+
	Rural	-Townships -Agriculture type - Objects recreation	+ +	+	
Agricultural	Agrotechnical	- Rain fed agriculture -Irrigated agriculture		+	+
	Pasturable	-Pastures		+	
Transport - Communications	Transport	- Roads Railways - Roads road			+ +
	Communication	-Power Lines -Products Pipeline	+ +		
Military, scientific - strategic	Test -range	- Test range			+
	Rocket -Space	- Spaceport			+

Deterioration of terrain where exploration is performed due to formation of bowls as a result of open pits development, and hills formed by rock mass dispensed from dumps. Rock dumps formed during exploratory excavations are divided into temporary and permanent. Temporary dumps include

accumulations of rock mass delivered to the surface in course of excavation of exploratory ditches and shallow pits, and subsequently used for filling these excavations after sampling and registration of geological documentation. Rock mass from other exploratory excavations is stored on the surface in permanent dumps (which are virtually no different from dumps of mining companies). Their dimensions are not considerable, but they occupy large areas. Such dumps are observed almost everywhere in the research area.

The greatest deterioration of terrain is associated with drilling of open-cut mines, overburden mining and mining in quarries; in underground mines - with mineral mining followed by caving of overlying rocks and deformation of day surface damaged by underground operations; in open-pit and underground development - with placing rock dumps from the excavations on the surface. Moreover, each plot of land disturbed during open-pit mining affects an adjacent plot with approximately the same area. Changes caused by deterioration of the surface have negative effect on its biological, erosional and aesthetic characteristics of the area.

The main types of deterioration in geomorphological environment during development of mineral deposits are shown in Table 2. In recent years, in course of mass development of solid minerals (SM) dramatic negative changes to the state of environment occurred. Set of works for SM development leads to changes in geological, geomorphological, hydrological, hydrogeological and meteorological conditions in mining areas and in bordering land. Excavation and accumulation of rock mass changes geological and geomorphological conditions; protection mining sites from flooding (pumping pit and mine water) changes hydrological and hydrogeological conditions. Simultaneously with the hydrogeological conditions (delivery, draining, unloading, leveling, pressures, speeds, temperatures and chemical composition of groundwater), thermal, gas and geochemical functions in the upper lithosphere change as well. Springs disappear, rivers and lakes become shallow, and karst erosion is developed as well as many other processes that cause rapid transformation and deformation of earth's crust upper layer and terrain-forming elements. It was found that lowering of underground water piezometric level by every 10 m of the aquifer stratum increases the load on the overlying rock mass in average by 1 kg/cm2.[2] Gas and dust blowing from mine hollows occurs, and they are delivered to the surface, causing changes in meteorological conditions.

As a rule, deteriorations of the earth's surface do not disappear and become permanent technogeneous formations. Basing on said above, "disturbed" is called the land that has lost its value, or that is the source of negative impact on the environment as a result of industrial activity.

The structure of all mining companies usually includes mining plants, waste rock and oxidized ore dumps concentrating mills, industrial waste storage, metallurgical and chemical plants, water intake facilities, population centers, underground roads, power lines, etc. Compact arrangement of these facilities is geographically related to development of one or a group of deposits. Mining operations in the fields of ferrous and non-ferrous metallurgy in Central Kazakhstan have gained a large scale. The developed here open-pit and underground deposits of iron ore (West Karazhal, Zhezdy, Kentobe), copper ore (Zhezkazgan, Kounrat, Sayan group), lead and zinc ores (Zhairem, Ushkatyn, Karagaily, Alaigyr, Akzhal, Zheskazgan), rare metals (Koktemkol, Upper Kairakty, Akchatau) are constant factors of both direct and indirect negative impacts on geomorphological environment. One of significant consequences of open-pit, surface-underground and underground mining are dumps, i.e., waste products that have been accumulated to 7 billion tons in the studied area that not only occupy significant agriculturally used areas, but also increase tangible negative environmental and social influence. According to estimates, in 2009, accumulation of all types of solid wastes amounted to about 24 billion tons. Mostly this accumulated waste is located in the Karaganda region (29.4%). The extent of recycling such waste in Kazakhstan is still insufficient. Most of the copper ore waste is located near Zhezkazgan and Balkhash, being the source of significant pollution of terrain as a result of exogenous agents, surface and underground water and soil.

Open-pit mining has direct negative impact on terrain, topography, hydrology, soil-and-vegetation cover and wildlife, leads to development of a number of dangerous geomorphological processes: linear and planar erosion, landslides, avalanches, deflation, etc. manifested in sides and bottoms of quarries and on the surface of overburden mining dumps. Besides, excavation and accumulation of huge masses of rock is accompanied by appearance of large areas of newly formed soils without topsoil and vegetation cover that completely changes the natural conditions of exomorphodynamics. Artificial soils, i.e., disintegrated rock masses, stocks of finished product along with deep-laid cuts of open-pit mining that form positive (terricone type) and negative (quarry type) landforms.

Underground and open-pit-and-underground methods have both direct and, to a greater extent, indirect impact on the landscape and components of environment. Underground mining is related to

deformation coating stratum and forming cauldrons, layers sagging under their own weight, shifting rock along formation lines, fall of roof above exhausted layers (which takes place above old exhausted pits within the ore field in Satpayev), formation of a zone of cracks and intense rock breaking leading to changes in land drainage, flooding and swamping of sagged areas above underground mines. With increasing the depth of ore bodies development that occurs, for example, in the Akchi-Spassky and Annensky ore fields (featuring very complex tectonics) in the Zhezkazgan deposit, overburden pressure increases, the processes of roof peeling in mine voids become more intense [3]. Displacement of rock mass and the earth's surface under intensive development of the mining industry are very dangerous to surface structures. In order to avoid dangerous consequences, safety pillars are preserved under structures and natural objects.

Extracted rock are the area of intensive development of chemical and physical weathering, as well as the source of soil, groundwater and surface water, air and biota pollution. Exposure to atmospheric agents leads to development of various kinds of destructive gravitational and erosional processes on sides of artificial structures, both positive and negative.

Thus, the extent of changes in geomorphological environment is due to specifics of mining operations. The largest scale of development and intensity of anthropogenic processes and phenomena are functionally related to overburden mining and open-pit mining, sometimes leading to drastic changes in the geomorphological environment. Changes of the latter from weak to significant occur in course of underground mining as well.

Load on the natural environment, including geomorphological, caused by coal mining industry is manifested in the entire Karaganda basin with total area over 4 thousand square kilometers. The basin consists of 4-carboniferous areas: Verhnesokursk, Karaganda, Sherubayev-Nura and Tentek. In case of underground mining great environmental risk is associated with sudden outbursts of coal and gas-dynamic phenomena. According to A.S.Saginov, sudden outbursts of coal in the Karaganda basin can be from few meters to 550 meters Especially dangerous is sour sulfur gas, significant amount of which is released during coal breakage and transportation [4]. Sudden explosions of gas lead to sagging of treatment facilities, which in turn leads to significant ground deformation.

The terricone material accumulated over the long history (over 60 years) of ore and coal deposits development is a permanent factor that has string impact on the environment. The dispersive part of terricone sediments is carried away by wind and water erosion over many miles, being a source of pollution and destruction of land cover and further strengthening of the erosion and deflation processes. Underground horizontal and inclined mining of coal-beds in some areas the city limit caused the earth's surface sagging, sometimes with formation of sinkholes. Thus, within the redevelopment area of the "Old Town", Maikuduk and Mikhailovka, deformation of rock mass around exhausted beds has reached earth surface. The sagged areas here are accumulators of various waters. The resulting artificial ponds by waterlogging built-up parts of the urban area increase the level of groundwater and are sources of both their pollution and of swamping of the most flooded areas. Dangerous situation with underground voids roof sagging has developed in some areas of the Zhezkazgan industrial zone, thereby the problem of resettlement of entire industrial communities is being solved (village Rudnik, village. ChKM, etc.) in cities Zhezkazgan and Satpayev.

Peculiarities of hydrogeological changes, deterioration of terrain and natural development of modern exogenous processes, issues of stability of shelves and sides of quarries are considered in works of V.P. Bochkarev et al. [5], K. M. Baymyrzaev [1] et al. According to these authors, the cumulative impact of the processes accompanying extraction of minerals on natural geomorphological environment for decades lead to a series of adverse events. Radical reorganization of the surface and subsurface part of lithogenous base occurs especially in open pit ore extraction, which in conjunction with technological processing dumps at ore mills in the conditions of semi-desert stimulates formation of lifeless areas - technological badlands. Virtually on sides of all open pits gravitational processes develop, which are represented by talus, rock falls, collapses. Large gravitational shifts of rock mass can be traced in weakened areas, where structures of strata, broken by tectonic fractures and breakages coincide with quarries slopes (Zlatoust-Belovsk, Annensky and Zhezdinsk quarry).

Disintegrated rock mass in dumps and quarries are areas of erosion and deflation processes. Stable conservation of dumps is achieved by artificial flattening and terracing of slopes and their phytomelioration. Nevertheless, modern rate and scale of dump formation, by capturing and contaminating large areas of land, lead to negative processes that deteriorate environmental condition of geosystems. Surrounding countryside, valleys of temporary streams and ground water in mining areas are polluted by dust carried out with air and water flows from quarries and dumps and by toxic waste products from mining machinery. Artificial - positive and negative

land forms create additional conditions for development of modern exogenous processes. An example would be one of the largest deposits in Kazakhstan - West Karazhal deposit (Atasusk pool) of hematite and magnetite-hematite ores. Here the ore is developed using open-pit and underground methods. Deterioration of lithomorphic landscape base is manifested by formation of artificial form of terrain - a large quarry 236 m deep, 840 m long and 640 m wide. On sides of the quarry, same as of all other careers, rock mass is fragmented, in certain places slip planes are opened, the slopes are dampened. The area of depression cone around quarries reaches several dozens of square kilometers. To a large extent this contributes to development of gravitational and erosion processes. The quarry serves as drainage for fissure-stratal water from limestone. In the areas of underground water discharge, funneled pits are formed with diameter of 8-10 m [6].

Table 2. Basic shapes of geomorphological violations

Mining	Type of violation earthly surface	Landforms	Processes that determine the occurrence of anthropogenic relief
1	2	3	4
Uncovered	Channels	Elongated horizontal or inclined recesses rectangular, trapezoidal or stepped section	Drainage works, fencing industrial sites from flooding
	Trenches	Elongated, horizontal or inclined trapezoidal recess or stepped section	Excavation preparatory workings
	Burrow	Triangular shafts, trapezoidal shaped segment	Excavation support workings and stacking when driving workings scrapers and bulldozers, backhoes and excavators
Uncovered		Undulating	Filling the one-tier rock piles during transport
		Plateau-like	Handling of overburden excavators, spreaders
		Comb, plateau-like, terraced	Multilevel dumping overburden dumps during transport
Subterranean	Dimples and dips	Such troughs(trough subsidence trough)	Driving workings
		Terraced trough(trough subsidence)	Penetration inclined workings
		Tape, semi-ring	Dumping rocks in sinking boreholes drilling
		Tape straight	Dumping of rock pits and other ancillary workings simplest means of stacking
		Serrated	Dumping rocks bulldozer
		Tapered	Dumping rocks using skips and trolleys
		Comb, plateau-like	One-tier dumping dumps using road and rail transport

In the conditions of desert and semi-desert of the Central Kazakhstan changes in the hydrogeological conditions at active mines belong to particularly negative consequences of minerals development. Formation of depression funnels was caused by mines, area of which reaches hundreds of square kilometers. With increasing depth and area of mining, the depression funnel grows and water quality is simultaneously deteriorated. So, in the early years of Zhezkazgan mine development, at mining depth of up to 100 m, mine water was fresh and slightly salty and had hydrocarbon-and bicarbonate-sulfate composition. As the deposit development lowered to 200-300 m, the active water exchange area began to receive sulfate-chloride water with high content of minerals about 2.5-3.5 g/l. After uncovering tectonic disturbance areas (300-400 m) in course of mining, chloride water appeared with quantity of dry residue about 10-15 g/l. At the same time mine water often contain considerable amount of harmful micro-elements, such as lead, zinc, copper, iron, mercury, arsenic, etc., which make them unsuitable for use. Disposal of mine water is a big problem for many mining sites. In the areas of mining they contaminate ground water, swamp settlements, withdraw significant areas from use, have an impact on flooding of tailing dumps of coal-preparation plant, become the cause of soil swamping and salinization (Zhezkazgan, Karaganda, urban village Zhairem, village Aksu, etc.), and finally - to anthropogenous land desertification in Central Kazakhstan.

Conclusion

Thus, operation of mining companies in Central Kazakhstan causes intensive groundwater depletion under the influence of the powerful mine drainage effect. This, in turn, affects depletion of vegetation species composition, deterioration of soil cover, leads to increased wind and water erosion. Changes in environment components are directly manifested by direct deterioration of terrain and activation of natural-and-anthropogenic processes, including development of gravitational and erosional processes on slopes of quarries and various dumps. Furthermore, indirect impact is also observed of mining on the nature and intensity of the terrain-forming processes through changes in structural components of geosystems (through air pollution, pollution and increasing aggressiveness of surface, ground and underground water, changing soil structure and transformation of the species composition of vegetation). The land disturbed in course of exploration and mining enterprises has vast areas, dramatically reducing the area well-developed living space for the population of Central Kazakhstan.

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