Development of Environmental Tension in Zones of Extraction of Solid Minerals on Eastern Caucasus Slopes

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***Abstract*—The article contains a retrospective of the development of extraction of mineral resources in the mountain ecosystem of the Eastern Caucasus; the stages of environmental tension growth in various components of the biosphere of the region are also shown. It has been proved that in the areas of dislocation of existing mountain objects, landscapes and soils, which are an integral part of ecosystems, are distinguished by a pronounced zoning, each of which has certain components that influence the formation of ecological situation. The studies have shown that pollution of the soil horizon with heavy and toxic metals leads to depletion and degradation of the natural environment, a radical transformation of the landscape, leading fragmentarily to its steady destruction. It is shown that the ecological technical capacity of the territory depends on the volume of the air basin (in mountain canyons, gorges it reaches 200 meters height from the base), the totality of reservoirs of drains, land areas and soil reserves, the bulk of flora and fauna species; biochemical circulation flow rates (speed, mass of gas exchange, pure water increment, soil formation processes and biota productivity). The ecological situation formed under such conditions needs to be improved by adopting special scientifically grounded organizational, technical and technological measures to reduce the ecological load to the ecosystem of mountain landscapes and restore sustainable forms of its functioning. The results of the research given in the article can be useful for environmental agencies, design institutions and existing mining enterprises for taking necessary environmental measures to ensure sustainable development of the natural-technical system under the conditions of mountain landscapes of the Caucasus.**

Keywords—extraction of mineral resources; landscape degradation; heavy metals; soil horizon; ecological technical capacity of territories; region biosphere; components of the biosphere; landscape properties.

I. THE HISTORY OF THE MINING DEVELOPMENT OF NON-FERROUS METALS EXTRACTION IN MOUNTAIN LANDSCAPES OF THE NORTH CAUCASUS

The mineral wealth of the mountainous part of the Greater Caucasus was known in ancient times. The first information about Sadon silver ores refers to the 10th century. At the beginning of the 17th century the Russian government got interested in mineral resources of Ossetia and sent its mining experts to the Alagir gorge in 1628 in order to study ores of Sadon. A large deficit of lead for military needs forced the development of the Sadon deposit; in 1643 silver and lead smelting was carried out from the ores of the Sadon deposit, and all products were delivered to the treasury [1].

The construction of the Alagir-Sadon road and the lead-silver plant in Alagir (which began operating in 1853) started in 1847. Up to the beginning of the 20th century only lead and silver were extracted from the ore at the Alagir plant, and zinc ore was sent to the dumps and to fill the interstices in mines.

Production facilities of the Molybden mine of the Tyrnyauz tungsten-molybdenum complex were put into operation 1935, and facilities of the Urup mine were implemented even later in the 1960 of the 20th century.

Traditional technologies of mining and ore processing used in mines and quarries are characterized by the increased geo-destructive activity and high environmental pollution, leading to steady degradation of the natural ecological system and the loss of the basic properties of the biosphere. That is why the further activity of mountain enterprises in this mode can lead to unpredictable consequences for the environment.

II. PHYSIOGRAPHIC, GEOLOGICAL AND GEOCHEMICAL CHARACTERISTICS OF THE TERRITORIES OF NON-FERROUS METALS EXTRACTION. SADON ORE-BEARING REGION

The area of the Sadon mines is located in the mountainous part of North Ossetia and is characterized by medium-highland relief with absolute marks of 1800–2800 m above sea level and relative altitude up to 800–1600 m. The mountains are sharply divided by numerous rivers and their tributaries on a number of narrow and long gorges of various directions. The longest gorges have submeridional directions and are formed by the Ardon, Urukh, Fiagdon rivers, which are the main tributaries of the river Terek. The climatic regime and nature of vegetation in such gorges are very variable and closely related to the relief. The relief also determines the local distribution of the thermal regime, the moisture regime and the direction of the air flow.

The valleys of the rivers Ardon and Fiagdon belong to “Sunny valleys” with a specific microclimate. The average temperature of the warmest month (July) in the area of the villages of Unal and Fiagdon is +16 ° C, and the coldest one (January) is -2 ° C. The annual precipitation is 300–400 mm with the highest fall in summer and autumn. Winters with little snow with periodic snow cover of about 10 cm. The area is characterized by strong valley winds up the gorge during the day and down at night.

Two main types of soil are singled out within the valleys: wormwood-forb and slope mountain-forest-meadow; brown podzolized and humus-carbonate soils. The major agricultural direction in the area is fruit and vegetable production and livestock. A large area here is occupied by apple and pear orchards, which have not only local, but also industrial importance. Potato and corn have maximum distribution among vegetable and grain crops.

The valley of the river Ardon is asymmetrical in the transverse profile. The left bank is steep, bounded by rocky outcrops of middle crust and landslide deposits of the mount Kion-Khokh. The Transcam road which connects Transcaucasia with the North Caucasus passes on it. The right bank is represented by a series of multi-level accumulative basement river terraces. All terraces are composed of boulder-pebble deposits with gravel-sandy aggregate and are covered with a layer of loam, often loesslike. The topsoil layer in the area of the village Nizhniy Unal is represented by black soil with thickness of 0.2-0.3 to 0.4 m; Unal tailing dump, which was put into operation in 1984, is situated on the lower terrace near the bridge across the river Ardon. The tailing dump is located in the floodplain of the left bank of the river and is 0.5 km north of Nizhniy Unal, and 10–12 km north-east of the Mizur concentrating mill. The bed of the tailing dump consist of pebbles of the river Ardon, the right bank of which is separated from the river bed by a concrete dam. The absolute mark of the bottom of the floodplain is 873.3 m, and the absolute mark of the village Nizhniy Unal is 900 m above sea level. Mill tailings of the Mizur concentrating mill are transferred to the tailing dump by pipeline hydrotransport. The entire infrastructure of the Sadon Lead-Zinc Plant, including the residential zone, is located in the narrow valley of the river Ardon. The bedrock and geological exploration waste is simultaneously exported and stored in the flood plain of the river Ardon by motor transport. Fiagdon tailing dump has been functioning since 1970. It is located in a narrow, canyon-shaped gorge of the Hanikomdon river, a right tributary of the river Fiagdon at an altitude of 1250 m above sea level. It has a sharply elongated shape, bounded on the both sides by rocky sandy-rocky and limestone outcrops of the Jurassic and Cretaceous. Fiagdon tailing dump is separated from the valley of the river by a high rock dam; it is located downstream the river Khanykomdon at about 600 m from the village of Staryi Dzuarikau. The village is located in the floodplain of a narrow valley of the river; dirt road between Hanikom mine adit and Fiagdon dressing mill passes along the left slope of 400–500 m. Tailings were transferred by pipeline hydrotransport to the tailing dump in two lines.

III. CONTAMINATION OF THE LITHOSPHERE BY MICROELEMENTS

One of the main environmental problems is related to the amount of heavy metals accumulated in soils. Heavy metals enter the soil as a the result of the mining complex functioning. Metals get into the soil in the process of applying environmentally hazardous technological processes of production, low gas cleaning efficiency, open transportation of ore from mines to the processing complex, concentrate for metallurgical processing, removal of dust fractions from the surface of the tailings and landfills of substandard ores with incomplete cleaning of mine waste effluents of enrichment plants, air pollution due to exhaust air removed from mines, leaching of ore minerals on the surface rows, tailings, slimes and other. The most dangerous environmental pollutants are mercury, cadmium, lead, arsenic, chromium, copper, nickel, zinc, iron and sulfur. Among all chemical contaminations, microelements are considered to be of particular ecological, biological and health significance [2-8].

The behavior of microelements in the soil is very different, the residence time of polluting components in the soil is incomparably longer than in other parts of the biosphere, and the level of contamination especially with heavy metals remains almost unchanged for centuries. According to our data, the soils of the Sadon industrial region contain lead, zinc, copper, cobalt, strontium, molybdenum, cadmium, silver, bismuth, arsenic, selenium, manganese, chromium, nickel and thallium.

Taking into account the fact that the considered ecosystem includes continuous industrial development of non-ferrous metals, the applied technology allows using only a small part (first percents) of the extracted mass of rocks. All the rest accumulates on the surface in the form of dumps and sludges, which are potential sources of environmental pollution by a wide range of chemical elements. The presence of residential areas located in the field of influence of the mining complex, as well as a plot of agricultural development with the cultivation of fruit and vegetable crops and occupation of the population by livestock creates a real danger of environmentally safe living in this area [4]. The qualitative characteristics of mill tailings are shown in table I.

TABLE I. COMPOSITION OF CONCENTRATION TAILINGS OF THE SADON MINES, % (AU AND AG IN GRAMS PER TON)

Chemical elements	Tailing dump	
	Fiagdon	*Mizur*
Pb	0.13	0.16
Zn	0.15	0.08
Au	0.008	0.01
Ag	3.55	5.13
Bi	0.002	0.002
Cd	0.003	0.001
Fe	3.78	4.52
S	-	2.09
Si	57.9	64.0
Ca	6.25	0.89
Mg	215	0.60
Al	10.24	5.36
K	-	2.49
Na	-	0.80
As	0.06	0.05
Mn	-	0.16
Ti	-	0.15
C	-	1.69

Let`s remind that the tailing dump in the floodplain of the Ardon river, near the village of Nizhniy Unal, has been operating since 1984, and its area is about 1.2 km^2. At the same time, up to 40–50% of its surface is covered with a layer of water; the dry part is a source of dusting of the environment. The dust content of the air at wind speeds of 5–7 m/s varies from 10 to 18 mg / m^3. The number of tailings of the Mizur tailing dump is 2593 thousand tons and Fiagdon tailing dump is 2382.3 thousand tons.

Investigations on the territory of the village Nizhniy Unal have established that the content of the main ore elements in soils was the following: lead - 0.15%, zinc - 0.4%, copper - 0.1% and all of them are confined to the humus horizon of the soil. Low levels of lead and zinc were found out in seasonal vegetables (potato tubers) and high, exceeding the maximal permissible concentration (MPC) were found out in perennial fruit crops (apples, pears) [9].

Area and intensity of soil contamination by ore elements exceeding MPC in the region of the village Nizhniy Unal are given in table. 2

The background of the ore elements correspond to the average values of the alluvio-deluvial formations in general for North Ossetia [10].

The deposits of polymetallic ores of North Ossetia are localized both in the basement rocks and in the Jurassic volcanic-sedimentary deposits [11-13]. The most significant reserves of polymetallic ores is Sadono-Unalskoe ore field, represented by the following deposits: Sadon, Zgid, Arkhon, Oktyabrskoe, Kholst and others. The deposits are of vein type, the main ore minerals are sphalerite, galena, pyrite, pyrrhotite, chalcopyrite, minor - arsenopyrite and marcasite. The main useful components of ores are lead and zinc and the associated ones are silver, copper, cadmium and indium. The distribution of the main ore elements is extremely uneven, the lead content in the ores varies from 0.42 to 12.8%, zinc from 1.87 to 26.2%.

The Fiagdon ore field is represented by the deposits Levoberezhnoe, Kadatskoe, Khanikamskoe, Kakadurskoe and others located in thick sandy shale strata of the Jurassic in the form of breccia and carbonatization zones. Brecciation zones contain galena, sphalerite, pyrite, arsenopyrite, holcopyrite; tin, silver, gold, cadmium and bismuth are noted among the companion elements.

IV. TYRNYAUZ TUNGSTEN-MOLYBDENUM DEPOSIT. MINE “MOLYBDEN”

Production facilities of the mine are located at various levels: the concentrating mill is located at 1350 m, the amenity complex and the main haulage adit - at 2004 m, the main skarn - at 2600 m, the Mukulansky quarry - at 2700 m. The town Tyrnyauz occupies the floodplains of the Baksan river and its tributaries Sakashili-Su and Kamyk -Su at elevations of 1250–1300 m above sea level. The area is characterized by a strong dissection, narrow deep gorges, rocky slopes, large amplitudes of relative heights. Also the features of the relief are clearly defined traces of glacier activity, which (during their movement) gave the river valleys a trough-shaped form, known as troughs. The result of the glaciers activity is rocky protrusions on the banks of the rivers. In areas of the river valleys, especially in the mouths of rivers flowing into the Baksan river, as well as in the Baksan gorge, there are powerful terraces composed of loose detrital material resulting from the erosion-accumulative activity of glaciers. The formation of friable-detrital material on the bottom and on the slopes of river valleys is explained by the weathering of the rocks. The reasons for the formation of terraces and cones of loose loose detrital material are debris flows in most of the watercourses of the region.

Vegetation cover of the area is zonal. Floodplains of the valley of the Baksan river covered with grass and shrubs. Woody vegetation appears on the slopes of the Baksan gorge. Broadleaved species are first dominated; with a height they give way to a needle-leaved forest. The zones of alpine meadows with xerophytic vegetation (mosses, lichens, and alpine grasses) are located above the forest zone.

The Baksan river and its tributaries in the upper part of the basin are mountain-type watercourses. The main base of the water regime is the spring-summer flood, during which, even during rain floods, rivers carry suspended sediment and stream sediment. Detrital material (scree, debris, etc) is piled up in many places on the slopes of the gorges. Formation of the sources of air pollution is associated with the wind regime of the area and the thermal-moisture factor.

The wind regime of the region is determined by orographic conditions and temperature mode that is defined by the proximity of the location of perpetual snows – glaciers. Depending on these factors, local mountain-valley winds, characterized by diurnal variability, prevail. During the day, the wind blows from the bottom up - the valley wind; at night - in the opposite direction - the mountain wind.

In the area of the mine there are strong lateral winds blowing from the Main Caucasus Range, descending into the valley of the Baksan Gorge. Winds have the character of mountain fohns. The environment is polluted by dust particles from the places of their location - debris on the terraces, overburden dumps of the “Mukulansky” and “Vysotny” quarries; the accumulation of dumps of geological works and others. [10].

The wind regime is characterized by mean annual repeatability in the directions of table 3 and mean annual wind speeds in the directions of table 4.

TABLE II. THE AREA OF CONTAMINATION AND ORE CONTENT (MG / KG) IN SOILS IN THE REGION OF THE VILLAGE OF NIZHNIY UNAL

Chemical elements	**Background concentration, C_b**	**Maximal permissible concentration in soil, MPCs**	**Area of contamination %**	**Concentration on the area of contamination, C**	**Relative, MPCs**	**Maximal concentration of metal, C_{max}**	**Relative, MPCs**
Pb	47.5	200	45	460	2.3	1500	7.5
Zn	100	400	50	1200	3.0	2000	5.0
Cu	27	100	isolated	100	1.0	100	1.0
Ag	0.05	5	isolated	2	1.0	2	1.0

TABLE III. THE MEAN ANNUAL REPEATABILITY OF WINDS IN THE DIRECTIONS, %

N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
22.8	43.8	2.2	1.7	12.2	15.5	1.0	0.8

TABLE IV. THE MEAN ANNUAL WIND SPEEDS IN THE DIRECTIONS, M/SEC

N	NE	E	SE	S	SW	W	NW
4.7	4.8	2.0	2.1	6.7	4.7	1.1	0.9

TABLE V. ZONALITY OF LANDSCAPES

Zones	**Belts**	**The height of the floodplain from sea level, m**	**Remark**
Glacial-nival		Over 3500	Mine
Mountain-meadow	Subnival-alpine	3000 -3500	“Molybden”
	alpine	2400 - 3000	
	subalpine	1000 - 2500	Sadon
Mountain-steppe		800 - 2000	Sadon
Mountain-forest	Pine and birch forests	1600 – 2400	Sadon
	Deciduous forests	750 - 1600	Urup

V. CHARACTERISTICS OF MINING ENTERPRISES

Mountainous provinces are ecosystems specific for mountainous areas, characterized by their significant isolation in terms of the distribution of water and air flows by concentration of slope slides in thalwegs by the mosaic microclimatic setting. The anthropogenic load of mountain valleys determines the degree and nature of pollution not only of the valley, but also of flat landscapes in their estuarine parts. The current level of anthropogenic load on the mountain valleys is very high: the distribution of load across different valleys of the North Caucasus is extremely uneven. The most stressed ecological situation is in the valleys of the Ardon, Baksan and Urup rivers, where mining complexes with developed infrastructure are functioning.

Landscapes and soils, which are an integral part of the considered ecosystems, have a wide variety. In the areas where existing mountain objects (Sadon mines, mines “Molybden” and “Urupsky”) are located, the high altitude zonality of landscapes is strongly marked. Each of these zones has certain components (Table 5), which significantly affects the formation of the ecological situation.

The glacial-nival zone is located above the snow line and it is an area of snow accumulation, which turns into firn and glacier ice. Intense physical weathering is developed in this zone, in a result of which detrital material is formed.

In the subnival zone, the soils are thin, chirping, representing the stage of formation of mountain-meadow soils.

In the alpine and subalpine belts, erosion processes and especially chemical weathering play an important role [14–16]. The slopes of the ridges here are dissected by deep valleys whose bottoms are located at an altitude of 1800–2000 m. The bottom of the depressions and the lower parts of the slopes are the accumulation of detrital material, with mountain-long winds its dusty fractions serve as a steady source of atmospheric dusting.

VI. Impact of Geophysical Parameters of the Landscape on the Quality of the Environment

The North Caucasus has various key strategic resources for the economy of the Russian Federation: polymetallic, hydro-mineral, hydropower, resort and recreational, touristic, recreational, natural forage lands, etc. The period of predominantly extensive development of the region caused irreparable damage to the natural recreational and ecological potential, especially in mountainous territories. The lack of development strategy of mountain areas, especially in the European part of Russia, impedes the large-scale involvement of the natural potential of mountain ecosystems in order to improve the general well-being of the population living in these places. Various symposia, international conferences, numerous articles and publications in the periodical press and in special scientific journals were devoted to the solution of these problems of mountain territories. However, to date, the environmental conditions and the ecological situation in the mountainous zone of the North Caucasus do not meet the requirements of the time. The state of the ecosystems of the mountain zone, especially in the zones of economic activity, does not meet the requirements for the sustainable development of the natural and technical environment. The area of degraded land continues to grow, despite the lack of mining, due to the continued activities of dilapidated orphan infrastructure in the past developed mining and processing complex. Performance of work in the mountain zone is carried out with serious violations of current regulatory construction requirements.

Analyzing the current environmental regulatory documents, it should be noted that they do not reflect and, consequently, regulate environmental requirements that must be met in mountain ecosystems when carrying out various economic activities: capital construction, laying of transport communications, creation of energy facilities, and gas communications, blasting, etc. Absence to date, of the regulatory and legal framework for taking into account the specific conditions in ecosystems leads to serious violations and distortions of the true value of the resources of mountain areas, undermines the aesthetic and moral attractiveness of the pristine natural environment. Under current conditions, it is extremely important to stop the destructive use of mountain territories, mountain resources, and take scientifically based measures to preserve potential natural resources, with a view to subsequent involvement in coordinated interaction with humans and ensuring the sustainable development of mountain territories. The fact is that the biosphere performs regulatory functions and the removal (introduction) by a human of any components inevitably leads to the transformation or degradation of ecosystems. A unified methodology for assessing the elementary units of the biosphere has not yet been developed, although a fee for environmental management, pollution charges, fines, etc., is envisaged. There are only attempts by individual researchers to characterize the negative impact of production and economic activity of enterprises on the well-being of ecosystem components. For example, according to the authors [17, 18], the investigation of the impact of the objects of the technosphere on the biosphere, in general, should be carried out by evaluating all its components: the hydrosphere, atmosphere and geological environment (with soils). Initially, it is advisable to study the following components:

- the existing characteristic of the environment state in the area where the mining enterprise is operating;

- types, volumes and intensity of the existing environmental pollution in the area of direct and indirect activity of the mining enterprise;

- change of environmental parameters under the influence of the mining industry; environmental and social consequences of the functioning of the mining facility. The authors of this paper adhere to the concept put forward to ensure environmental well-being in the area of mining enterprises activity. At the same time, in order to more fully characterize the ecological well-being of the territories where the technosphere objects are active a new approaches are proposed, the use of which will allow making a comprehensive assessment of the ecological well-being of the ecosystem, including human health. Geophysical and geochemical environmental factors that are involved in the formation of the ecological well-being of a local ecosystem are recognized as being considered [19, 20].

According to a series of samples taken in the Fiagdon river (downstream one kilometer from the confluence of Khanikomdon) in the low-flow period (September 2015) the zinc content in water was 7 MPC, copper - 3.5 MPC, manganese - 2 MPC, iron - 4 MPC, cadmium - 0.8 MPC and lead - 0.5 MPC.

In the atmospheric basin in the zone of activity of the Unal tailing in dry weather, the dust content of the air in residential areas (Unal village, Zintsar village) reaches (1.8–3.6) mg/m^3, and just 15–30 meters from the dam, it exceeds 15–50 times the maximum permissible concentration in the air of populated areas with mountain-valley winds caused by periodic gusty winds, with almost 15-day frequency. Such a picture of the development of air dust content with up to 30% free silica in the composition of dust samples was established by the authors as a result of chemical analyzes of air samples taken in this zone.

For environmental assessment of the soil in the area of the Unal tailings storage facility of the Sadon Lead-Zinc Plant, special studies of the soil horizon were carried out. For this purpose, pits were made, with soil sampling in 20 cm vertically. The gross content of the main ore elements along the vertical section of the soil to a depth of 100 cm with a sampling interval of 0.2 m showed stable (Fig. 1), sometimes a sharp drop in the content of heavy metals with depth, which unequivocally confirms the anthropogenic nature of the anomaly detected. It was established that the maximum content of lead and zinc is confined to the upper layers of the soil section [7, 8], which confirms the anthropogenic origin of soil pollution by these elements. The accumulation of heavy metals in the top layer of soil contributes to the transition of mobile forms in biological diversity, including cultivated plants: annuals - potatoes, cabbage and perennial, pears and apples [11].

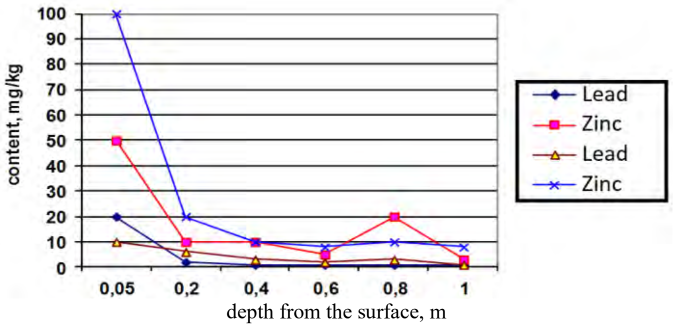

Fig. 1. Changes in the content of heavy metals in the soil profile in the area of activity of Sadon Lead Zinc Group of Enterprises

The prolonged indefinite functioning of ecologically negative objects causes certain direct and indirect disturbances in the natural environment. In the environment, there is a continuous process of partial transformation of pollutants into less harmful, and vice versa, into even more toxic substances, at the same time there is a process of their distribution, i. e. dilution in the natural environment [21]. In all cases, the technogenic load on the biosphere of a single region is characterized by a combination of individual indicators of the negative impact of the objects of the technosphere and the background load, which falls on a single territory. The total component of all loads should not exceed the eco-anthropogenic capacity of the biosphere of the local ecosystem, quantitatively equal to the maximum (maximum allowable) load that the ecosystem can withstand and endure for a long time without affecting the structural and functional properties.

Taking into account that the negative impact of the operating object on the biosphere consists mainly of the cumulative negative impact of its components: the impact on the air, on the aquatic environment and on the soil, the overall level of pollution of the local ecosystem can be determined by the indicator of environmental pollution. In fact, there is a transformation of the natural landscape into an industrialized landscape. Depending on the value of this indicator, environmental risk can be four levels [22, 23]. At the same time, every ecosystem has a certain ecological resource potential, in the form of perception of various forms of disturbances without losing its basic properties, while maintaining stability.

Theoretically, the ecological capacity of a single territory TE depends on the following indicators: the volume of the air basin (in mountain canyons (gorges) up to 200 meters in height from the base), the totality of water bodies of drains, land areas and soil reserves, the mass of flora and fauna; biochemical circulation flow rates (speed, mass of gas exchange, replenishment of pure water volumes, soil formation processes and biota productivity):

$$TE = \Sigma\, Ei\, Xi\, Ai \qquad (1)$$

where Ei is the ecological capacity of the i-th environment, tons/year; Xi is the coefficient of variation for natural vibrations of the substance content in the environment; Ai is the relative hazard coefficient of the impurity.

Ecological capacity of environmental components is calculated by the formula:

$$E = V\, c\, Fob, \qquad (2)$$

where V is an extensive parameter determined by the size of the territories (area or volume, km^2, km^3); c is the content of the main ecological values of the substances in the environment, $tons/km^2$ or $tons/km^3$; Fob - the rate of multiple updates of the volume or mass of the medium, year.

TABLE VI. SCHEME OF THE DESTRUCTION OF THE LANDSCAPE UNDER THE INFLUENCE OF THE TECHNOSPHERE

Stage of degradation	**Total load level, times exceeded**	**Type of qualitative changes in the ecosystem**
The first stage (moderate)	1.5-2	Loss of sensitive species of lichen
The second stage (stressed)	2.7-4	Deterioration of the sanitary condition of trees, reduction of biodiversity
The third stage (catastrophic)	6.0-7.0	The woody layer is depressed, changed, some tree species are dying. Ornito-population density decreases
The fourth stage (collapse)	10 and more	The woody layer is completely destroyed. Gap of nutrients circulation. Loss of stability as an ecosystem restoration ability

The cumulative impact of the objects of the technosphere on the geological environment is accompanied by the development of deviations in the geospheres of the earth and when this load is exceeded on the environment, it enters a stressful state and then passes into a critical stable phase of degradation, with different periods of partial rehabilitation. In all cases of destruction of a local ecosystem, the transition from one stage of development to another is characterized by qualitative changes depending on the load taken. Correct assessment of the state of the ecosystem will allow to take preventive measures to preserve or slow down the negative transformations of the natural environment. Only scientifically based proposals can be used both fragmentary and large-scale on the territory of degraded ecological systems, with obtaining the expected results.

The process of transformation of the ecosystem as a whole under the action of the technosphere can be schematically represented as a sequence of certain stages (Table VI).

VII. Conclusions

1. It has been established that the ecological state of the environment depends on the interaction and location of pollution sources and objects of destruction.

2. It is shown that the pollution of the soil layer in the zone of activity of mining facilities with heavy and toxic trace elements have mineralization of mine origin.

3. It is shown that in the areas where existing mountain objects are located landscapes and soils, which are an integral part of the considered ecosystems have a strongly marked zonality. Each of these zones has certain components which significantly affects the formation of the ecological situation.

4. It was established that on the territory of the village of Nizhny Unal the content of the main ore elements in the soil was: lead - 0.15%, zinc - 0.4%, copper - 0.1% and they are confined to the humus horizon of the soil.

5. Low levels of lead and zinc in seasonal vegetables (potato tubers) and high, exceeding MPC - in perennial fruit crops (apples, pears) were defined.

6. In the mountainous part of the North Caucasus region, there are concentrated multimillion volumes of non-ferrous metal processing waste, leaching products of radioactive ores, including overburden rocks and hollow rocks of mining exploration and mining works. They are represented by overburden in the amount of more than 180 million tons in the Side gorge of the Baksan river valley; sheelite ore processing tailings in the amount of 150 million tons near the village of Bylym on the terraced section of the Baksan river valley; 130 thousand m^3 of bedrock and substandard ores and about 6.5 million tons of enrichment tailings of lead-zinc ores in the Ardon and Fiagdon river valleys, 700 thousand tons in the Elbrus Gorge at the gorge of the Kuban and Teberda rivers and 18 million tons of radioactive ore enrichment waste of the Bykogorsky uranium ore deposit (Lermontov) of the Stavropol Territory.

7. The geological and geophysical situation in the local areas where ores processing waste of non-ferrous metals and radioactive ores of the North Caucasus are located is in a stressed ecological state.

8. Contamination of the soil horizon with heavy and toxic metals leads to depletion and degradation of the natural environment i.e. fundamental transformation of the landscape, fragmentary leading to a steady destruction.

9. Formed ecological situation needs to be improved by taking special scientifically grounded: organizational, technical and technological measures to reduce the ecological load on the ecosystem of mountain landscapes and restore sustainable forms of its functioning.

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