TECHNOGENIC LANDSCAPE – AS PARADYNAMIC SYSTEMS DETERMINING THE ECOLOGICAL CONDITION OF MINING IMPACT ZONES

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Abstract. *The present work concerns some landscape-geochemical peculiarities of Georgia. The exploitation of the fields has caused chemism modification of the environment. The dependence of the linear process of biologic recultivation on physiographic factors is obtained by means of multifactor regression analysis and the ways of effective optimization of the mining region environment, damaged under the influence of technogenesis, are distinguished. The influence of anthropogenic factors is spread even on the territories outside the field exploitation area (approximately twice exceeding its area) and causes regime changes of soil waters and migration of chemical elements, activation of erosive processes, falling of ground efficiency, etc. Besides the coefficient of every single opening roof layer (Tchiatura) i.e. Bever coefficient has been calculated and the optimum admissible parity has been determined that excludes the possibility of annual erosion.*

Theoretical and practical results of the research can be successfully applied in forecasting technogenic processes and in the field of solving environment optimization problems.

Key Words: *landscape recultivation, geochemical situation, physiographic factor, Ecological problems.*

Intoduction

Ecological problems of environment protection are mostly stipulated by geochemical functioning of geocomplexes, influenced by technogenesis, in particular, by the migration of mineral and biogenic substances in them. Resulting from the active anthropogenic influence, certain modification of landscape (technogenic) is formed, which in its turn, causes qualitatively new forms of element migration and situation formation, ecologically different from the previous one.

Peculiarities of spreading diffused elements and their areal in mining regions are, at some rate, determined by metalogenetic specificity of certain provinces and zones, distinguished by the set of typical (mining) metals, as well as by types of fields, mirroring the soil, areal and background waters, etc. on the background of metalogenetic peculiarities of the mining provinces some other air factors of the diffused metal formation are revealed: landscape-geochemical character of the region, mining formations, soil varieties and soil forming layer, their phisiochemical consistence, etc.

Landscape-geochemical conditions of Georgia, determining the region environment, where the processes of diffused metal area formation (in soil and waters) take place, are complex and miscellaneous. A wide range of mining regions is located in mountain forest and mountain meadow areas. The combination of high mountainous Alpine regions, characterized by cold and mildly continental climate, with the middle mountain ones, characterized by the mildly damp climate, creates the complexity of landscape-geochemical conditions, where the migration of the products of oxidizing mining fields takes place [3].

On the territory of quarries soil surface, natural and cultural vegetation and natural-anthropogenic complex, in general, having shaped during the centuries, are totally disappearing [1]. Quarry vicinities often appear to be the locus of erosive and sliding processes and the reason for soil, air, surface and underground water pollution [2]. Here sometimes harmful and even dangerous environments can be created, that complicates utilization of the territory from the agricultural point of view, reduces yielding ability and worsens living conditions of the population.

The main aim of the present research is the evaluation of recultivation time period of technogenic landscapes by means of mathematical statistics method and determines interdependence of natural factors influencing the process of optimal rehabilitation of the territory.

Objects and Methods

The object of the present research is the manganous mining region located in mountain forest and mountain meadow zones in western Georgia, administratively belonging to Tchiatura district. The region to be researched is known with its brown forest, humus-carbonate and mountain meadow soils. The above mentioned soils are characterized by original morphochemical and micromorphogenic parameters [4, 5].

Traditional methods of research together with the modern ones were applied for structural-dynamic research of modern, anthropogenic, particularly technogenic landscapes. The method of mathematical statistics has been used aimed at estimating recultivation time periods. With the account of the fact that technogenic landscapes are characterized by the migration of biogenic and mineral substances, specific geochemical methods of research have been applied.

Results and Their Discussion

Approximately 4000 hectares of agricultural lands have been practically made useless resulting from mineral mining in Georgia. If we take into consideration the fact that the price of 1 hectare is more than 20-25 thousand GEL (approx. 14 000-14 500 $), it will become clear, that the research of technogenic complexes and their optimization is of paramount importance.

The exploitation of the fields has caused chemism modification of the environment. River waters have been enriched with acid products, migrating from far distances from the ore body (approx. 2-2,5 km). High concentration of metals and sulfate-ions can be observed not far from the ore body (primary area). Lower to the river flow the concentration is becoming higher, accordingly pH parameter is increasing. In comparatively longer distances (2-2,5 km from the ore body) the migration of sulfate-ions, zinc and molybdenum. As for the ore elements (copper, lead and iron) the radius of their migration doesn't exceed 800 m [6]. The most considerable geochemical situation is distinguished in the soils of ore-bearing regions. Resulting from the hydrochemical research of the lead-zinc field of Georgia it has been concluded that the lead consistency is ecologically of a very dangerous ingredient, reaching up to 50 mg/l and the area of its diffusion is 100-150 m.

The influence of anthropogenic factors is spread even on the territories outside the field exploitation area (approximately twice exceeding its area) and causes regime changes of soil waters and migration of chemical elements, activation of erosive processes, falling of ground efficiency, etc. Despite the above mentioned negative influence, in view of high profitability open quarry method is widely applied in many countries of the world.

In Georgia the open quarry method of minerals is applied in all the places with the appropriate geological conditions, in particular lithologic structure of the composing and optimum capacity of roof layer. In Tchiatura manganese field only the economy made by the application of this method, constitutes a rather solid sum. The coefficient of opening roof layer i.e. Bever coefficient, calculated by the interrelation of roof layer capacity and ore-bearing layer (Fig.1), is set according to optimum capacity of layer and enables to determine the possibility of open field elaboration. The optimum admissible parity is considered to be calculated 40:1 (Fig. 2).

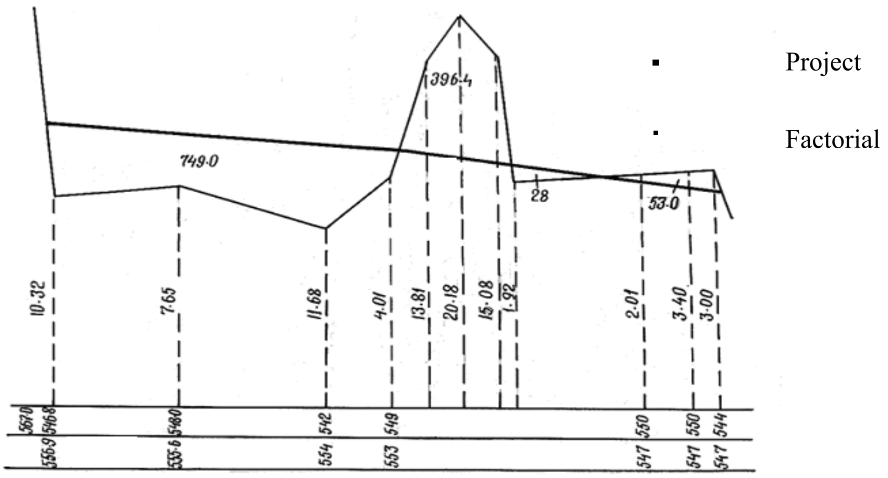

Fig. 1. Parity of project and factual level of Zodi quarry surface

Coefficient of opening roof layer (according to Bever)

EMBED Equation.DSMT4

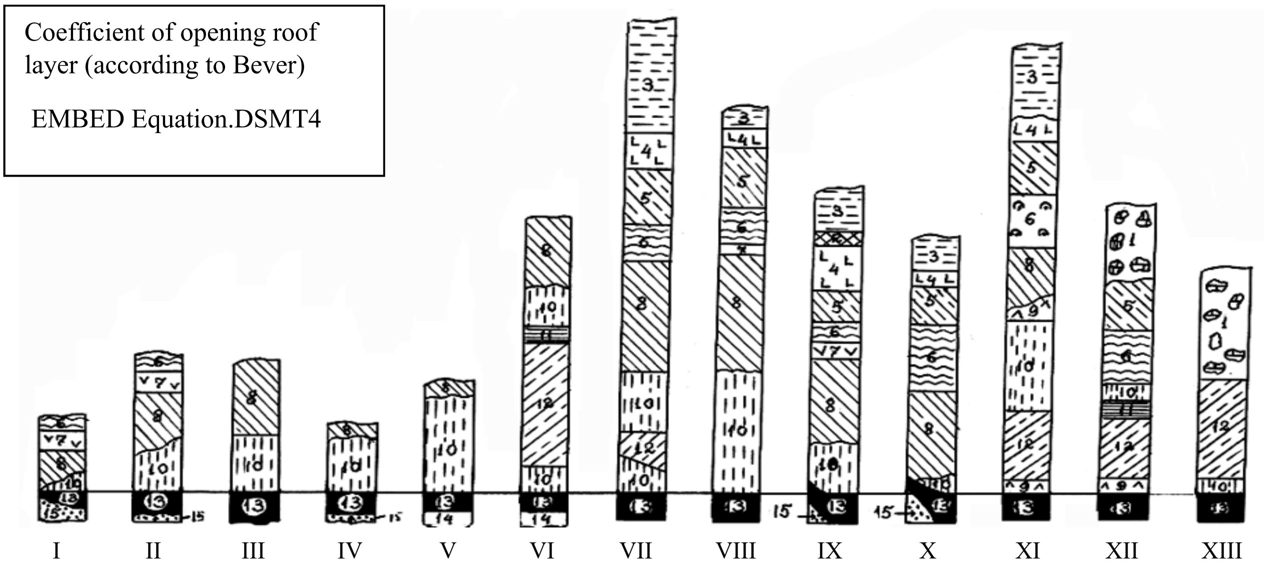

Fig. 2. Stratigraphic cut of separate plateaus manganese field of Tchiatura

I- Kveda Rgani; II-Rgani, III-Zeda Rgani, IV-Bunikauri, V-Tabagrevi, VI-Mgvimevi, VII-Itkhvisi, VIII-Shukruti, IX-Perevisa, X-Merevi, XI-Pastseti, XII-Darkveti, XIII-Sareki
1-diluvium; 2-basalt; 3-clays; 4-polite limestones; 5-sandy limestones; 6-clays, limestones; 7-limestones; 8-quartz, sands, sandstone; 9-shaly clays; 10-spongolitic sandstones; 11-manganese-bearing top horizon; 12- Maikop clays; 13- manganese-bearing bottom horizon; 14-low-ore sandstones; 15-limestones, sandstones.

First attempts to recultivate the landscapes, damaged by technogenesis in Georgia, were taken in the 60s of XX century. Despite the fact that practical works on landscape recultivation have been carried out for quite a long time, the elaboration of these issues from theoretical and scientific point of view began in Georgia only several years ago, though many scientific works by foreign authors have been dedicated to it [7, 8].

Judging from the fact that soil is one of the landscape content elements, the difference between the land recultivation and landscape recultivation can be traced in the fact, that during the landscape recultivation alongside with the soil, quasibalance and some other components (geological structure, relief, climate, flora, fauna, etc.) are taken into consideration.

Recultivation process is mostly defined by the following factors: phisiographic situation of the region, its hydrogeological character, soil and fauna and phisiochemical condition of the soil. From the social factors it is reasonable to take into account the demographic situation of the region, level of the economy development and its tendencies.

A bit more complex is the process of restoring technogenic complexes, emerged as a result of underground ore elaboration i.e. the result of quasibalance of phytocenosis through self-regulation.

In Georgia approximately 160 ha has been degraded because of the above mentioned reason and in Tchiatura only this figure reaches 91,6 ha. In the case when recultivation is carried out alongside with the works carried out through the open method, it is crucial to take into consideration the time factor, necessary for the completion of field elaboration. Besides, it must be taken into account that mineral alloys existing on the surface are represented by the masses of absolutely barren soils, consisting of ore element admixture, having a negative influence on the ecological condition of the environment. Eg.; on the territory of carboniferous fields (Tkibuli, Tkvarcheli) dumps and waste heaps consist of not only neutral admixture, but active substances (pyrite, coal, timber, etc) as well. At air penetration in the waste heap depth self-ignition takes place, what in its turn often causes flora extermination.

The aim of the research was to establish the approach of the recultivation (self-recovery) duration(y) for the following factors [9]:

where y is the reclamation time period (resultant factor). The explanatory factors are:

– the power of the roof layer (m), – x_1
– the horizontal section of the relief (km/km^2)- x_2 – the vertical section of the relief (m/km^2)-x_3
– the relief inclination (deg.) – x_4
– the soil humus layer thickness (sm)- x_5

– indicator of the soil acidity (pH) – x_6
– the maximal difference between project and surface indices of the dirt pile (m)- x_7
– the dirt pile area (m^2) and – x_8
– the dirt pile volume ($10^3 m^3$) – x_9

The table below (2) presents the respective surveillance data of the 9 recultivation objects of the research region.

For the revelation of interdependence character between various parameters, scientists often apply the method of mathematical statistics [10], mostly the method of multifactor regressional analysis. The practice of studying the parameter (factor) interdependence proves the possibility of linear model application:

1) $y = a_1x_1 + a_2x_2 + \ldots + a_nx_n + b$

By using the relevant statistical computer program have been adopted the following multiple regressive linear equation:

2) $y = 0{,}0044x_1 + 0{,}00392x_2 + 0{,}006x_3 + 0{,}0601x_4 - 0{,}2702x_5 + 0{,}5587x_6 - 0{,}1406x_7 + 0{,}0003x_8 + 0{,}0028x_9 + 0{,}035$,

Elasticity coefficient of i-th explanatory factor is one of the important statistical characteristics that are used for the analysis of regression relationship:

$$E_i = a_i \frac{\overline{x_i}}{\overline{y}}$$

where $\overline{x_i}$ and $\overline{y}$ are average values of i-th and output factors. These factors show the amount of percent of change of the dependent factors at 1% change of i-th factor when the others may stay constant. In particular, for the physical and geographical factors that were selected by us, the following values of elasticity were obtained: E_1=0,0915, E_2=0,0034, E_3=0,1674, E_4=0,1527,
E_5=0,1351, E_6=0,8957, E_7=0,4958, E_8=0,2450, E_9=0,1170.

As one can see, the influence of x_6, x_7 and x_8 factors are important in the region under the study.

The accuracy of the obtained statistical dependence is determined by the volume and objectivity of the empiric information. Due to shortage of necessary materials and some other reasons, the maximum needed information was not obtained. So, we have no claim to high accuracy of our results, although prognosis on the mining region optimization with satisfactory correctness is feasible by means of generalization of the obtained dependence and reasonable conclusions about the ecological quality of separate reclamation zones can be made.

The practical acceptance of our method is proved by the fact that in 2006 parameters of Shukruti, one of the sites of Tchiatura manganese field was: x_1=134,0 m; x_2=3,6 sm/km^2; x_3=75,0 m/km^2; x_4=13,9^o; x_5=2,4 sm; x_6=6,5; x_7=12,5 m; x_8=2700 m^3; x_9=68,5 th.m^3.

Recultivation process on this site was completed in summer, 2010. The factual reclamation time period of the process was 4,5 years. If we set the same values of regression, we'll get:

$$0{,}0044 \times 134{,}0 + 0{,}00392 \times 3{,}6 + 0{,}006 \times 75{,}0 + 0{,}0601 \times 13{,}9 - 0{,}2702 \times 2{,}4 + 0{,}5587 \times 6{,}5 - 0{,}1406 \times 12{,}5 + 0{,}0003 \times 2700 + 0{,}0028 \times 68{,}5 + 0{,}035 \approx 4{,}15 \text{ (year)}.$$

The availability of the necessary amount of valid statistical information will enable the scientists to make accurate prognosis of the reclamation time period and to set the way of efficient soil optimization in mountain-ore regions.

Conclusion

1. Complexes and their components under the long technogenesis influence have become coordinated to external conditions, that's why their restoration is so complex and is practically impossible.
2. Resulting from the geochemical analysis of underground and surface waters, soil and atmosphere of the vicinities of the objects under study the conclusions have been made that separate components, as well as the natural territorial complexes in general, undergo the transformation and the landscape-ecological situa-

tion is becoming even worse. High concentration of chemical elements is traced at the zone of mineral extraction, at 2-2,5 radiuses from the ore bodies. The surrounding territories are quite impoverished from ingredients, because of abatement of active chemical elements.

3. The analytical formula of reclamation time dependency on phisiographic factors has been obtained for Tchiatura mountain ore region through the method of multifactor regression analysis.

4. indicator of the soil acidity (pH)- (x_6), the maximal difference between project and surface indices of the dirt pile (m)-x_7, the dirt pile area (m^2) and – x_8 have great influence on the reclamation time period.

5.The availability of the necessary amount of valid statistical information gives the opportunity to make accurate prognosis of the reclamation time period. The presented approach may serve to be the methodological base for the research of dependency between any factors, particularly for studying interrelations between technogenic landscapes and their separate components, representing the object of scientific research.

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