Technogenesis and Geochemical Features of the Crimean Soils and Landscapes

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Abstract. The paper presents the results of field geo-environmental monitoring studies of the Crimean peninsula’s territory. The basis of the work lies in the results of the study of soil and lake bottom sediments conducted during the implementation of different-scale ecological, geochemical and hydrological studies in the period from 2003 to 2013. A large amount of factual material on the distribution of chemical elements in the soils and landscapes of the Crimea made it possible to analyze the current geochemical and ecological status of the territory for the first time. It is noted that technogenic pollution of soils and landscapes has increased in the Crimean Peninsula in recent years. Mining and agrogenic load on the soil are recognized as the most large-scale processes that transforms the peninsula’s landscapes.

1. Introduction

Intense anthropogenic impact on the natural landscapes of the peninsula has led to the forming of anthropogenic landscapes with specific ecological and geochemical conditions on the territories, which largely determine the pollution level and intensity of various environmental components, their ability to self-purification. Migration and accumulation of natural and man-made trace elements depend on the properties of the landscape. The main geochemical flows are concentrated in the soil and geological area due to the agricultural specialization of the territory and its physiographic features [1, 2]. Therefore, the purpose of our research is to identify modern ecological and soil geochemical relationships, considering the zonal-provincial and landscape features of the territory for the further development of the monitoring system for individual components of landscapes (primarily soil and geochemical). The relevance and timeliness of such studies are currently increasing, due to the possible restructuring of hydrogeochemical flows as a result of changes in the land use structure of the plain territory of the Crimea and as a result of cessation of water supply through the North Crimean Canal, which has been used for irrigation for a long time.

The soil cover and modern landscapes of the Crimean peninsula were formed mainly in the Neogene-Quaternary and Holocene time, i.e. in the period of neotectonic and modern tectonic movements [3].

The territory of the Crimean peninsula is characterized by a temperate mild climate with a significant number of sunshine hours, relatively mild winters, hot summers and a deficit of atmospheric moisture in almost the entire area [4].

Chernozems and Kastanozems are the zone soils in the Plain Crimea. Rendzic Leptosols soils are found on the Tarkhankut peninsula and in some places in the central part of the Plain Crimea.
Significant areas of the hydromorphic plains along the coast in the Prisivashye (on the Kerch Peninsula) are occupied by automorphic and hydromorphic Solonetz and Solonchak. Chernozem combination with Rendzic Leptosols are located in the lower zone of the northern part of the Crimean mountains. Mollic leptosol with limestone outcrops on ridges alternate on a mountain meadow [5]. Cambisols dominate in the upper belt of the southern macro slope of the Main Ridge. Phaeozems prevail in the soil cover lower on the Southern Coast of Crimea.

2. Material and research methods

The methodological basis for assessing the geochemical state of landscape components is the theory of landscape geochemistry — a science that reveals the patterns of migration of chemical elements in natural and anthropogenic systems. According to N.S. Kasimov the methodology of landscape geochemistry is also connected with the conjugated analysis of the flow of matter in the integral landscape-geochemical systems of mainly local and regional levels [6].

The basis of the actual material in the article and of basis the map is the data of field geo-environmental monitoring studies in the Crimea from 2003 to 2015. Analytical studies (spectral and chemical analyzes of soil and lake sediments) were performed in certified laboratories of the Crimea Department of the UKRDGRI (Ukrainian State Geological Prospecting Institute, Ukraine) and the Ministry of Environment of Crimea. Spectral analysis of the main rock-forming elements and chemical analysis of macro- and microelements, analysis of the distribution parameters of Cu, Zn, Cb, Co, Ni, Nb, Cr, V, Ti, Sn, Hg, B, Be, Nb, Ga, Ag, Wi, Ge, Sc, St, Li, P, F in mass fractions are presented. About 800 samples of soil and bottom sediments of rivers and lakes, proluvial and alluvial sediments, samples of vegetation, as well as raw materials of products and sludge from chemical enterprises, their solid and liquid effluents were taken into account. Based on the results of field and cameral works the parameters of the normal geochemical background of the soils and soil-forming rocks of the main natural geochemical landscapes, reflecting the landscape-geochemical and geo-ecological features of the territory of Crimea and adjacent territories, were determined [7].

The classification of the geochemical landscapes of the Crimea is based on the ideas of A.I. Perelman [8], B.B. Polynov [9]. Zones, subzones, classes, types and genera of landscapes are highlighted. Geochemical formulas of landscapes are determined.

3. Results of research and discussion

The geochemical diversity of landscapes and soils of the studied territory is explained by to the conditions of their formation and the direction of evolution.

A steppe zone is distinguished within the limits of the plain part of the Crimean peninsula in the legend of the landscape-geochemical map. This zone covers dissected elevations (Tarkhankut, Kerch) and Prisivashsky low-grade lowland.

Landscapes of the Crimean mountains and foothills are characterized by significant diversity caused by changes in geomorphological, lithological and climatic conditions (Figure 1).
Legend:
Landscapes of dry steppes, stony steppes, low and high plains:
1. Sivash landscapes of chloride-sulphate class with hydrogen sulfide contamination within the limits of the Prisivash lowland. Solonetz, meadow solonchaks on loesslike light loamy sediments.
2. Tarkhankut landscapes of calcium, calcium-sodium class. Tipchakov-feather grass steppe in combination with feather grass, forbs grass-fescue-feather grass vegetation on Chernozems loamy and clay sediments and eluvium of carbonate rocks.
3. Kerch landscapes of calcium-sodium class. Motley grass-fescue-feather grass steppe on Kastanozems, Solonetz and Solonchak on clay eluvial-diluvial sediments.
4. Landscapes of the Central Crimean and South-Western Crimean low-elevated plains. Forbatching-feather grass steppe on Chernozems, formed on eolian-diluvial soil-forming rocks.
5. Crimean foothill landscapes of acid and calcium class. Agrolandscapes at the site of meadows in combination with forest-steppe vegetation and low-growing forests on gravelly chernozems, formed on gravitational-proluvial-diluvial and eluvial sediments.
6. Crimean mountain landscapes of calcium class. Forest-meadow vegetation on Cambisol sand Mollic Leptosols eluvium of carbonate karst rocks.
7. Crimean South Coast landscapes of the Southern Macro Slope of the Main Ridge. Shibliak Mediterranean, marine groups on the Phaeozems of the southern coast of Crimea.
8. Lowland dissected denudation-accumulative plains (groundwater level 2-8 m)
Many modern flows of chemical elements that are not identified on the territory of the Crimea. Agricultural landscapes of the Mountain and Foothill Crimea are characterized by a significant agrogenic chemical load on the soil. 

The main technogenic sources of pollution on the territory of the Crimean peninsula are concentrated in the Armenian-Krasnoperekopsk industrial hub; Sevastopol industrial-urban agglomeration with a developed port and military-industrial infrastructure; in Saki, Theodosia, Kerch and Simferopol industrial hubs; agrolandscapes of the Flat Crimea and Kerch Peninsula (including irrigation and modern postirrigation); agricultural landscapes of the Mountain and Foothill Crimea. Pollutants are deposited in soils and bottom sediments of ponds, lakes, reservoirs and seas, serving as various geochemical barriers. Ponds-accumulators of the waste of the Armenian-Krasnoperekopsky industrial hub and Saki lakes of the Saki industrial hub are especially characteristic of these processes of toxicants accumulation.

In recent years the impact of technogenic and agrogenic factors on the content of many elements in soils has increased dramatically. Within the steppe zone of the Crimean peninsula, agrolands dominate almost the entire territory, for example, the cultivation of agricultural land in some administrative districts of the Flat Crimea reaches 90% [10]. Many modern flows of chemical elements that are not typical for zonal ecosystems enter the soil as a result of the use of pesticides, herbicides and mineral fertilizers. Thus, in recent years, facts of soil contamination with heavy metals and pesticides have been established on a total area of 1079.5 hectares. Including on the area of 566.2 hectares, an elevated copper content was found, on 115 hectares - an elevated lead content [11]. The increased copper content is associated with the use of copper-containing preparations in previous years in the cultivation of perennial plantations. Similar data (for the territory of Moldova, Ukraine and the southern regions of Russia) fully reflect the modern geochemical environment, which is characterized by a significant agrogenic chemical load on the soil [12-15].

A significant negative impact on the landscape environment of the flat Crimea is exercised by the mining industry, widely represented by numerous quarries. Ecological consequences of the development of deposits are caused by changes in the engineering-geological and hydrogeological conditions and mechanical disturbances of the components of natural landscapes. Erosion and landslide processes arise and develop in the pit walls. Explosions result in the decompression of rocks, a network of microcracks arises, which activates the karst. Often, quarries are used as dumping sites for domestic and industrial waste, which is an additional source of environmental pollution. Such an active anthropogenic activity over the course of historical time led to the formation of transformed...
landscapes on the peninsula, with completely or partially missing soil cover. These are territories where large areas are occupied by dumps, excavations of rocks formed during the extraction of minerals, during intensive land-reclamation construction, industrial and residential construction, and so on, requiring recultivation. Existing State Standarts of reclamation of disturbed lands provide for a standard approach to all man-made landscapes of the country and do not take into account the specifics of each type of landscape. This fact can lead to an unreasonable increase in the cost of rehabilitation projects, a decrease in their economic efficiency and, as a consequence, an increase in abandoned non-reclaimed sites. We believe that in modern conditions on disturbed lands it will be expedient to take measures that stimulate the process of gradual soil formation through the realization of the soil-forming potential of the environment, which will lead to the restoration of landscapes. The results of mathematical modeling of the formation of humus soil horizon showed that with the reclamation of disturbed lands dumps of open-cast mines for mining in Crimea, the rate of formation of humus soil horizon varies, depending on the starting conditions, from 2.77 mm/year to 1.31 mm/year [16-18]. For 20 years, humus horizon is formed on such plots with a capacity of more than 2 cm. Considering that the zonal hydrothermal features of soil formation conditions are quite fully reflected by the amount of energy expenditure (according to Volobuev VR, [19]), it is possible to stimulate the formation of humus soil horizon in the reclaimed areas by increasing the energy component, for example, by irrigation and/or by applying mineral and organic fertilizers [20].

4. Conclusions
As a result of complex landscape-geochemical studies, a map of the geochemical landscapes of the Crimea was compiled. Intensive development of industry, transport, chemicalization of agriculture, the expansion of urbanized areas led to the predominance of natural and man-made elements migration. The distribution of technogenic load across the peninsula is uneven. Industrial enterprises are permanent sources of local pollution. Currently, the most dangerous are the processes of intensive pollution of atmospheric air, soils and waters in the zone of the Armenian-Krasnoperekopinsky industrial hub.

Irrational use of mineral fertilizers and toxic chemical sin agriculture, the increase of disturbed lands in the area as a result of open mining of minerals is the cause of pollution in a large area.

In the current economic conditions on disturbed lands during the reclamation, it is necessary to carry out additional measures to stimulate the processes of soil formation, aimed at increasing the energy costs of soil formation.

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