ENVIRONMENTAL POLLUTION WITH TRACE TOXIC ELEMENTS IN THE TRANSCARPATHIAN ORE FIELDS

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The ecogeochemical sampling of soils and surface waters in the areas of gold and mercury deposits in the Transcarpathian was carried out. It was revealed that dumps of rocks are the main cause of pollution. Both soil and water within the gold deposits territories are polluted with As and Cd, soil (with Hg, As, Tl) and water (with As) within the mercury deposits areas are polluted in amounts exceeding the ***maximum allowable concentrations*** (MAC).
Deposit, environment, pollution, toxic elements.

There are both the mercury and gold-ore deposits in the Transcarpathian region of Ukraine. Their exploration and mining are the cause of environment pollution with trace toxic elements (MAC < 10 mg/kg).

In order to determine intensity and extent of the pollution as well as a possible threat to population, an ecogeochemical sampling of dumps, soils, and surface waters has been completed. This sampling has been accomplished according to [1]. A grid of sampling was chosen depending on the extension of deposits. Sampling of dumps, which remained in the area of deposits, has allowed finding potentially dangerous elements (table). In addition to the semi-quantitative spectral analysis of all samples of soils and dry residuals of water for finding the Tl content (the detection limit of 5 mg/kg), the atomic absorption analysis of the Hg content in dumps, soil samples (2.10^{-5} mg/kg) and water ($2{,}8.10^{-5}$ mg/dm^3) was completed. Also the following analyses were carried out: quantitative chemical-spectral analysis of the Sb content in soil samples (0,3 mg/kg) and water (3.10^{-4} mg/dm^3), the X-ray spectral analysis of the As content in soil samples (2 mg/kg), the spectrophotometer analysis of the As content in water (5.10^{-3} mg/dm^3), and the atomic absorption analysis of the Cd content in soils (1 mg/kg) and water (1.10^{-3} mg/dm^3).

The toxic elements content in samples was compared with the MAC for a soil and potable water accepted in according to State sanitary rules and norms [2].

There are the following three gold-bearing deposits: Muzhyeve gold – base metal deposit, Saulyak gold-quartz deposit, and Bigan' barite – base metal deposit (with increased content of Au and Ag). Ores of all deposits are characterised by an increased content of As, also Sb (due to the

presence of sulphosolts) and Cd in the gold – base metal deposits. The content of mercury is not high and is more typical for ores containing Pb and Zn sulphides and sulphosalts. The Hg content in soil does not reach the MAC, and Sb forms small aureoles (up to 2,2 MAC) around dumps at the gold – base metal deposits. The Hg and Sb contents in both surface and ground waters are also much lower than the sanitary norm.

The As aureoles in both soil and water are the most essential. At the Muzhyeve deposit the large pollution aureole (up to 60 MAC) spreads from the rock dumps and approaches the Muzhyeve village outskirts (fig. 1). The As aureole with the concentration exceeding the sanitary norm in both surface and ground waters covers the territory of the whole Big Beregove mountain and is not technogenic one caused by the presence of dumps; it is a native hydrogeochemical aureole of the Muzhieve deposit. Nevertheless, the As technogenic pollution aureole of both surface and ground waters (from 920 MAC in the brook flowing from under the dump to 10-40 MAC near the Muzhyeve village) spreads from the dumps.

Contamination of soil with As is also observed around the dumps of the Saulyak deposit (up to 80 MAC) and along roads near the Bigan' one (up to 14,5 MAC), where broken stones from the dumps were used for road construction. In these deposits the As anomalies (from 1 MAC in Saulyak to 3 MAC in Bigan') in surface and ground waters are also registered. The increased Cd content has been revealed in both soil and water in the Muzhyeve field only, where a high concentration of Cd in dumps has occurred (see table). In soil the local aureoles with the Cd concentration of 1.5 MAC was established. For a lot of samples of surface water, the Cd content does not reach the norm. The high content of Cd (12200 MAC) in water has been revealed in the spring from under the dump as well as in the brook originated from this spring to the west of the Muzhyeve village (6200 MAC). In underground water Cd occurs in two flows: the first one along the mentioned brook and the second one to the southeastern direction from the dumps (in the well at the northern border of Muzhyeve, 2 MAC of Cd).

Thus, according to the sanitary norms, in the areas near the gold-bearing deposits in the Trancarpathian, the greatest hazard may be caused by As and also by Cd (in the Muzhyeve deposit). There is necessity in more detailed test of both surface and underground waters as well as in developing of safety measures for population against toxic affection.

According to their reserves, mercury deposits in the Transcarpathian are arranged in the following order: Borkut, Shayan, and Kam`yanyy Kar'er. All of them were earlier developed and have dumps of rocks. The largest deposits are located within the Vyshkovo ore field while the small Kam`yanyy Kar'er deposit is situated in the Carpathian Flysch zone. The dumps of all mercury deposits a whole are characterised by the increased Hg content while the Sb content are low. The As

contents in ores and rocks of the deposits are very low and Cd is absent. At the same time, increased TL concentrations in ores of the Borkcut and Shayan deposits are typical.

Soil and surface water (streams) were sampled in the square of 40 km^2 according to the grid of 1x1 km within the Vyshkovo ore field which covers the south part of the Oash mountain ridge near the Romanian border as well as some part of the Tysa river floodplain. The Vyshkovo village is located near the central part of the Vyshkovo ore field, whereas the Shayan village and the sanatorium of the same name are located in the northwest part of the area. The purpose of the study was to obtain a degree of possible threat for these villages from toxic elements (Hg, Sb, As, Tl), that usually pollute environment during mercury ore mining and processing. More detailed sampling was carried out in the Borkut (200x200 m) and Shayan (200x50 m) deposits.

At the most part of the Vyshkovo ore field the level of Hg-pollution is permissible, the Hg content around the dumps of the Shayan deposit complies with the level up to 3.2 MAC (medium level). Taking into consideration the presence of the human settlements in this area, the *geochemical background* (GB=0,2 mg/kg) of mercury was calculated as the average of the content value for the territory apart from the mercury deposits. There are 3 aureoles of the mercury pollution of soil relatively to the GB: 1) at the south-western side of the Big Shayan mountain (up to 33.6 GB, the dangerous degree of pollution); 2) at the northern side of the Varged' mountain (the Borkut deposit, up to 26.1 GB, the moderately dangerous degree); 3) at the southern slope of the Grendesh mountain (up to 33,3 GB, the dangerous degree) (fig.2).

The GB for As is 15 mg/kg. The whole area of the ore field complies with the admissible degree of pollution for human settlements, and soil pollution can be apply to the low level (up to 12 MAC). As a whole the toxic elements contents in soil of the Vyshkovo ore field correlate to their low concentrations in surface water (see table).

A detailed sampling of the soil in the area of the Shayan, Borkut, and Kam`yanyy Kar'er deposits has shown an almost identical pollution of soil with Hg (the dangerous and extremely dangerous degrees of pollution) and As (8-12 MAC, that corresponds to the low level of soil pollution). The hazard grows stronger due to the presence of the Tl concentrations, which reaches 5 mg/kg in soil of the Shayan deposit area.

In the Kam`yanyy Kar'er deposit, the Hg aureole (the dangerous degree of pollution) spreads down along the slope from the dumps, reaches the water stream and extends along it in the direction of the Olenevo village.

Nevertheless, the immediate threat of the toxic elements concentrations in soil and dumps of the mercury deposits only exists for workers of the titanium powder plant (in the Borckut deposit

area) and the mineral water factory (the Shayan deposit), whereas the Shayan, Vyshkovo, and Olenevo villages are located within limits of the admissible extent of contamination.

1. A temporal methodical guide for conducting complex ecological and geological studies (in the territory of Ukraine). - Kyiv. - 1994. – 325 p. (Rus.).
2. The hygiene requirements on treatment of industrial wastes and identification of their class of danger for public health. State Sanitary Rules and Standards N 2.2.7.029.99.-Kyiv.- 1999. (Ukr.).

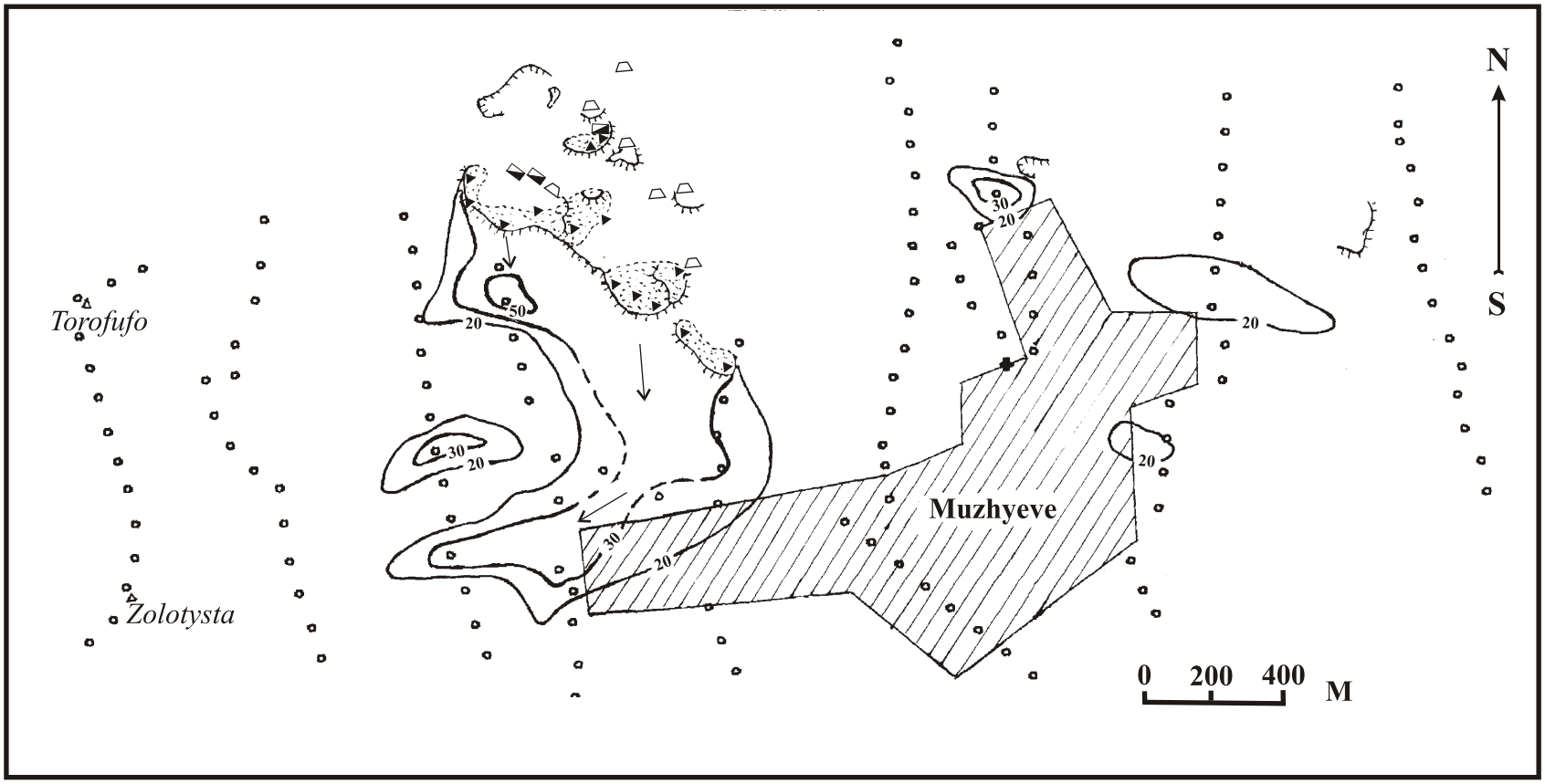
Table 1 The toxic elements content in the ore deposits environment in Trancarpathian.

Name of the field, deposit	Sampled item	Toxic element content in soil, dumps (mg/kg) and surface water (mg/dm^3)				
		Hg	Sb	As	Cd	Tl
Muzhyeve	Dump	0,22-11,99	20-1000	1000-8000	0,0-400	0,0
	Soil	0,034-1,522	2,1-9,9	12,0-120,0	up to 1,5	0,0-4,5
	Water	0,0-0,00015	0,0005-0,0017	0,0025-4,6	0,0-12,2	0,0
Bigan’	Dump	5,4-6,1	150-300	1000-1500	0,0	0,0
	Soil	0,069-0,243	2,8-6,9	8,0-29,0	<1.0	0.0
	Water	0,0-0,0001	<0.0003	0.0025-0.030	0.0005	0.0
Saulyak	Dump	0.179-0.580	0.0	90-150	0.0	0.0
	Soil	0.088-0.228	0.0	8-165	0.0	0.0
	Water	0.0-0.00016	0.0016	0.0	0.0	
Vyshkovo Ore Field	Soil	0.02-6.7	Not determined	5.0-85.0	Not determined	0.0
	Water	0.00002-0.000054	0.001-0.0024	0.005-0.06	<0.001	0.0
Borkut	Dump	4.4-40.3	0.0-20.0	0.0-90.0	0.0	0.0-30.0
	Soil	0.28-24.25	0.2-5.2	6,0-23,0	Not determined	Not determined
Shayan	Dump	2,9-39,6	0,0-20,0	0,0	0,0	0,0-40,0
	Soil	0,10-38,8	0,2-4,1	9,0-16,0	Not determined	0,0-5,0
Kam’yanyy Kar’er	Dump	44,0-49,35	0,0	0,0	0,0	0,0
	Soil	0,13-25,96	Not determined	8,0-18,0	Not determined	0,0-4,5
	Water	0,0-0,000024	0,0-0,00085	0,004-0,010	0,0-0,0005	0,0
MAC, mg/kg	Soil	2,1	4,5	2,0	1,0	-
MAC, mg/dm^3	Water	0,0005	0,005	0,01	0,001	0,0001

Fig. 1. The map of pollution of soil with arsenic in the Muzhyeve deposit area.
1 – the direction of As migration; 2 - adit; 3 - mine; 4 - dumps with the As content in the range of 0,1 - 0,8 % (500 -4000 MAC); 5 - isoline of the level of pollution of soil with arsenic: 1-20

MAC, low level; 20-30 MAC, medium level; 30-50 MAC, high level; > 50 MAC, very high level; 6 - sample from the dump; 7 - sample of soil; 8 - town.

Fig. 2. The map of pollution of soil with mercury in the Vyshkovo ore field
1 – the direction of Hg migration; 2 – worked out deposit; 3 – explored deposit; 4 - adit; 5 - boundary between the mountain-wood (in the south) and backwater-plain landscapes; 6 - isolines of the extent of pollution with Hg: moderately dangerous (16-32 GB); dangerous (32-128 GB). The geochemical background of Hg is 0,2 mg/kg; 7 - sample of soil; 8 - town. The



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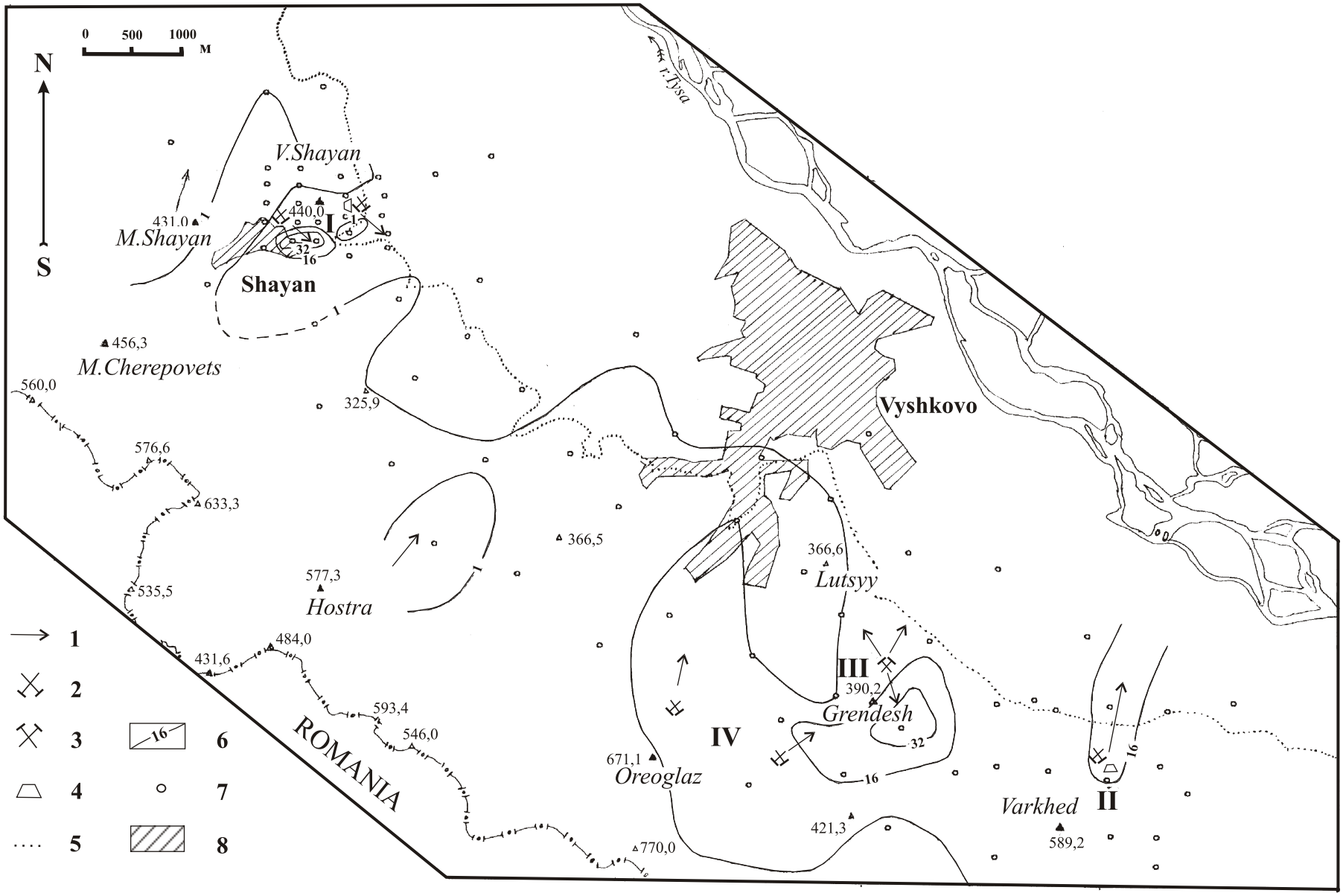
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