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ESTIMATION OF THE INFLUENCE OF MUD VOLCANOES TO THE FORMATION AND ECOLOGICAL CONDITIONS OF LANDSCAPES (ON THE PATTERN OF SOUTH-EASTERN PART OF THE MAJOR CAUCASUS)

Abstract: *The article is devoted to the study of the characteristics of landscapes formed in territories of wide spread of mud volcanoes in Azerbaijan. It was found that mud volcanoes are mainly distributed in mountain-semidesert and desert landscapes, complicating their internal differentiation. Various structural and functional properties, relief, geological age, lithological and geochemical composition of mud volcanoes contribute to the formation of new types of landscapes. In addition, some assessments were made to identify the potential hazards and risks to the environment, as well as human health and life related to the geochemical properties of volcanic landscapes located at various hypsometric heights.*

Key words: *landscape, mud volcano, geochemistry, clarke, breccia, trace elements, concentration.*

Language: *English*

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Introduction

The purposes of the investigation consist of estimation the distribution of the migration and concentration of macro and microelements characterizedfor landscapes of widespread mud volcanoes in the south-eastern part of the Major Caucasus and surrounding areas, identification of specific geochemical characteristics of landscapes spread across different altitudes, generally investigation impacts of geochemical conditions on environment, on living organisms, and in particular on human health due to volcanic activity**.**

Description of the study

Some mud vulcanoes spread in different landscape types across investigation area and their breccia, rock, plant and water samples have been chemically and spectively analyzed to estimate geochemical conditions of landscapes of the investigation areas from the ecological point of view.Distribution method of chemical elements due to their migration and concentration has identified by the related and comparative analysis method of landscape components in areas with different biological climatic characteristics.

The map of «Ecogeochemical landscapes of Shamakhi-Gobustan» has been preparedbased on A.I. Perelman's (1972) related and comparative analysis method of landscape componentsaccording to the results of chemical and spectral analysis of expeditions materials (Fig. 1). Alluvial (Al), transalluvial (TA), supaqual (SA), trans-accumulative (TAc) and accumulative (AC) geochemical landscapes have determined on the map according to the migration conditions of the chemical elements within the landscape types.

Surplus microelements in numerator and deficit microelements in denominator let follow geochemical condition in map-scheme and its legend (Table 1).

Landscape types have defined in the south-eastern part of the Major Caucasus according to the geochemical classification of landscapes, areas where biogenic migration prevails are classified as biogenic landscapes.

Formation and development of geochemical landscapes in the investigation area havehappened due tothe different factors. Vertical zonality is observed in the formation of soil and vegetation covers. The landscapes in the south-eastern part of the Major Caucasus are divided into four groups according to the biological circulation: A. Moderately humid mountain-forest, B. Moderately humidmedium altitude mountains and low mountains, C.Arid and semi-arid steppes of low mountains, D. Semi-desert landscapes of dry subtropical plains, and these groups are divided into different landscape types (Table 1).

In the south-eastern part of the Major Caucasus, where mud volcanoes are widely spread, the following landscape types have formed due to natural-historical development: 1. Peanut-hornbeam and oak- hornbeam forest landscapes of medium altitude mountains and partly high mountains, 2. Forest-steppe and meadow-steppe landscapes of low and medium altitude mountains, 3. Arid-denudation dry steppe and steppe landscapes of low mountains and depressions, 4. Arid-forest, forest-shrub and shrub landscapes of low mountains, 5. Arid-denudation semi-desert landscapes of low mountains and intermontane plains, 6. Intrazonal landscapes of accumulative-denudation plains, 7. Semi-deserts of accumulative-marine plains (Table 1).

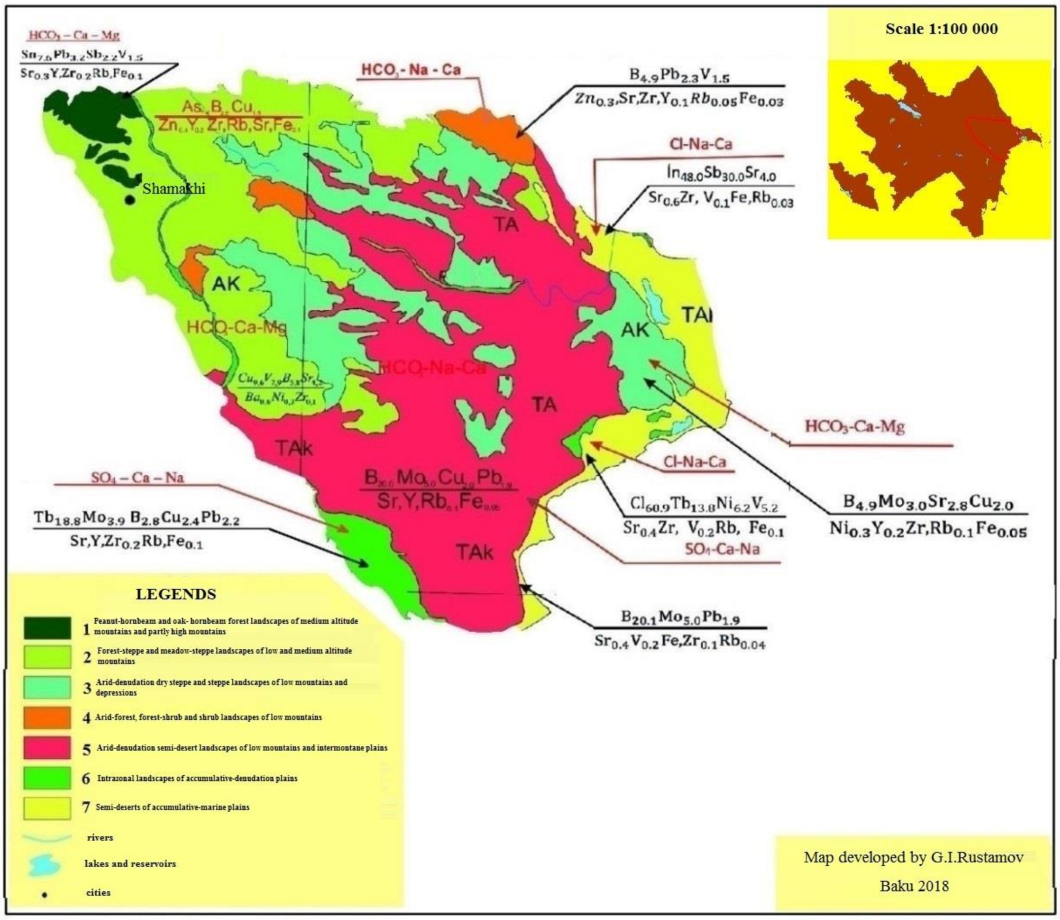

Figure 1 - Ecogeochemical landscapes of Shamakhi-Gobustan (the map legend is given in Table 1)

Table 1. Semi-deserts of accumulative-marine plains.

GEOCHEMICAL LANDSCAPES															
COLUMNS	GROUPS	TYPES	ROCKS According to migration of chemical elements					CLASSES According to typomorph microelements							Microelements (surplus-in numerator, deficit-in denominator)
According to migration types	According to volume of biological mass	Bioproductivity of biomass relation	Alluvial	Transalluvial	Supaqual	Ttrans-accu-mulative	Accu-mulative	SO_4-Na	SO_4-Na-Ca	SO_4-Ca-Na	SO_4-HCO_3-Na	SO_4-Na-Mg	HCO_3-Na-Ca	SO_4-Mg-Na	
BIOGENIC LANDSCAPES	A. Moderately humid mountain-forest	1 Peanut-hornbeam and oak-hornbeam forest landscapes of medium altitude mountains and partly high mountainst	AL		SA		AC	+	+	+	+	+	+	+	$\frac{Zn_{10,5}Sn_{3,9}Ag_{3,3}}{Mn_{0,5}Ba_{0,4}Sr_{3,3}}$
	B. Moderately humid medium altitude mountains and low mountains	2 Forest-steppe and meadow-steppe landscapes of low and medium altitude mountains		TA		TAc	AC	+	+	+	+	+	+	+	$\frac{Cu_{9,6}V_{7,9}B_{5,8}Sr_{4,2}}{Ba_{0,6}Ni_{0,3}Zr_{0,3}}$
	C. Arid and semi-arid steppes of low mountains	3 Arid-denudation dry steppe and steppe landscapes of low mountains and depressions	AL		SA			+	+	+	+	+	+	+	$\frac{Mo_{10,2}B_{8,9}B_{6,3}Cu_{4,9}}{Zn_{0,5}Ba_{0,3}Zr_{0,1}}$
		4 Arid-forest, forest-shrub and shrub landscapes of low mountains	AL		SA			+	+	+	+	+	+	+	$\frac{Ag_{7,3}B_{6,3}Cu_{5,6}Hg_{3,4}}{Co_{0,6}Ti_{0,4}Zr_{0,1}}$
		5 Arid-denudation semi-desert landscapes of low mountains and intermontane plains		TA		TAc	AC	+	+	+	+	+	+	+	$\frac{B_{25,3}Mo_{10,2}Sr_{3,2}Pb_{2,1}}{Ni_{0,5}Ca_{0,3}Zr_{0,2}}$
		6 Intrazonal landscapes of accumulative-denudation plains				TAc	AC		+	+		+		+	$\frac{B_{10,0}V_{2,4}Pb_{2,3}Co_{1,5}}{SrZr_{0,1}Rb_{0,03}Fr_{0,04}}$
	D. Semi-desert landscapes of dry subtropical plains	7 Semi-deserts of accumulative-marine plains				TAc	AC	+	+	+	+	+	+	+	$\frac{Sn_{8,0}B_{3,6}V_{2,7}Cu_{2,4}Pb_{1,9}}{Zn_{0,4}Sr_{0,2}ZrRb_{0,3}Fe_{0,03}}$

Table 2. The average amount of some microelements contained in mud volcano breccias (percent-%)

№	Mud volcanoes	Ni	Cu	Zn	As	Sr	Zr	Mo	Cd	Sn	Pb	V
1	Boyuk Harami	0,0058	0,0039	0,0074	0,00110	0,0431	0,0071	0,00011	0,000026	0,00013	0,00124	0,012
2	Yandara	0,0074	0,0043	0,0080	0,00105	0,0414	0,0083	0,00013	0,000025	0,00025	0,00145	0,013
3	Durovdagh	0,0075	0,0038	0,0075	0,00135	0,0407	0,0064	0,00014	0,000022	0,00014	0,00126	0,011
4	Kichik Maraza	0,0042	0,0032	0,0098	0,00142	0,0185	0,0125	0,00018	0,000026	0,00034	0,00206	0,018
5	Pilpila-Garadagh	0,0057	0,0043	0,0082	0,00146	0,0331	0,0096	0,00027	0,000031	0,00016	0,00151	0,013
6	Davaboynu	0,0054	0,0044	0,0090	0,00146	0,0389	0,0100	0,00046	0,000031	0,00020	0,00169	0,013
7	Dashgil	0,0053	0,0045	0,0078	0,00143	0,0351	0,0085	0,00038	0,000037	0,00019	0,00146	0,013
8	Bahar	0,0051	0,0041	0,0074	0,00132	0,0342	0,0072	0,00017	0,000025	0,00014	0,00134	0,012
9	Ayrantokan	0,0060	0,0044	0,0073	0,00138	0,0344	0,0081	0,00033	0,000028	0,00015	0,00140	0,012
10	Duzdagh	0,0089	0,0040	0,0071	0,00134	0,0467	0,0071	0,00010	0,000021	0,00013	0,00122	0,012
11	Aghdam group	0,0039	0,0034	0,0072	0,00110	0,0186	0,0086	0,00067	0,000063	0,00016	0,00116	0,015
12	Shekikhan group	0,0056	0,0053	0,0105	0,00184	0,0242	0,0110	0,00101	0,000134	0,00024	0,00176	0,023
Clarke of microelements in earth crust, percentace - % (A.P.Vinaqradov,1962).												
		0,0058	0,0047	0,0083	0,00017	0,034	0,017	0,00011	0,000013	0,00025	0,0016	0,009

Table 3. Clarke concentrations of mud volcano breccias.

№	Mud volcanoes	V	Ni	Cu	Zn	As	Sr	Zr	Mo	Cd	Sn	Pb	V
1	Boyuk Harami	1,3	1	0,8	0,8	6,4	1,2	0,4	1,0	2,0	0,5	0,7	1,3
2	Yandara		1,2	0,9	0,9	6,1	1,2	0,4	1,1	1,9	1,0	0,9	1,4
3	Durovdagh		1,2	0,8	0,9	7,9	1,1	0,3	1,2	1,6	0,5	0,7	1,2
4	Kichik Maraza		0,7	0,6	1,1	8,3	0,5	0,7	1,6	2,0	1,3	1,2	2,0
5	Pilpila-Garadagh		0,9	0,9	0,9	8,5	0,9	0,5	2,4	2,3	0,6	0,9	1,4
6	Davaboynu		0,9	0,9	1,0	8,5	1,1	0,5	4,1	2,3	0,8	1,0	1,4
7	Dashgil		0,9	0,9	0,9	8,4	1,0	0,5	3,4	2,8	0,7	0,9	1,4
8	Bahar		0,8	0,8	0,8	7,7	1,0	0,4	1,5	1,9	0,5	0,8	1,3
9	Ayrantokan		1	0,9	0,8	8,1	1,0	0,4	3,0	2,1	0,6	0,8	1,3
10	Duzdagh		1,5	0,8	0,8	7,8	1,3	0,4	0,9	1,6	0,5	0,7	1,3
11	Aghdam group		0,6	0,7	0,8	6,4	0,5	0,5	6,0	4,8	0,6	0,7	1,6
12	Shekikhan group		0,9	1,1	1,2	10,8	0,7	0,6	9,1	10,3	0,9	1,1	2,5

Geochemical landscape groups were determined according to the biological mass and the types were determined according to the biological productivity ratio to biomass.

We determined that Na, Ca, Cl, S, Cu, Sn, Pb, As, Hg, Mo, B, V, Ag, Sn, Cr, Ni, Mn, Co, Sr, Ti and other chemical elements were more typical for landscapes of the south-eastern part of the Major Caucasus and Shamakhi-Gobustan. Na, Ca, Cl, S, As and B are typomorphic for the area, and more active from geochemical point of view. The average amountsof these elements in the landscape components are considerably higher than their average amountsin the Earth's crust (Clarke) and they are more intensively migrated in the landscapes.

Average quantities of some microelements contained in mud volcanoes are given in Table 2, concentration clarkes that obtained from comparison of the quantities of identical microelements in the Earth's crust with their quantities which are determined by A.P.Vinoqradov (1962) are given Table 3. Microelements spread in mud vulcanoes are divided into 3 qroups according to the results of Table 3.

Average quantities corresponded to nearly the world clarke as Ni, Sr, Mo, V, sometimes Pb, are included the first group. If the average quantities of these elements show the typical features of the common volcanic breccias spread in the Earth's crust, other elements included in the other two groups only describe the geochemical characteristics of volcanic breccias in Shamakhi-Gobustan. Microelements, the average quantitiesare higher than clarke as Na, Ca, Cl, As, Mo (in the groups of Pilpila-Garadagh, Dashgil, Bahar, Ayrantokan, Aghdam, Shakikhan), Cd (especially in the group of Shakikhan), Ca and Cl are included the second group. Microelements the avarage quantities in the breccias are less than Clarke (CC<1) as Zr (CC=0,3-0,4), Fe (CC=0,1-0,2 and low), Zn, Rb, V are included the third group. According to the results of spectral analysis (Table 3) As, Mo, Cd and V in the all mud volcanoes of the area are characterized by high amounts of concentration clarkes, and thesearedangerous for the health of the living organismsin areas near the mud volcanoes. It would be useful to carry out prophylactic geochemical melioration measures.

As seen from the 1: 100 000 scale map (Medical-ecogeochemical risk map of Shamakhi-Gobustan landscapes – Fig. 1) that we have compiled based on the results of chemical and spectral analysis with the method of A.I. Perelman's «related and comparative analysis of landscape components»,in the western part of the investigation area from north to the south macro compounds with hydrocarbonate-calcium-magnesium (HCO3-Ca-Mg) are replaced by compounds with sulfate-calcium-natrium (SO_4-Ca-Na). In the eastern part of the investigation area compounds with hydrocarbonate-natrium-calcium (HCO_3-Na-Ca), predominanted in the north are replaced by compounds with chlorine-natrium-calcium (Cl-Na-Ca) in central part and then by compounds with sulfate-calcium-natrium (SO_4-Ca-Na) toward south.

Typomorphic macro compounds with sulphate-natrium (SO_4-Na), sulphate-sodium-calcium (SO_4-Na-Ca), sulphate-calcium-sodium(SO_4-Ca-Na), sulphate-hydrocarbonate-sodium (SO_4-NCO_3-Na), sulfate-natrium-magnesium (SO_4-Na-Mg), hydrocarbonate-natrium-calcium (NCO_3-Na-Ca), sulfate-magnesium-sodium (SO_4-Mg-Na) are determined in each landscape types of the investigation area. Only intrazonal landscapes of denudation-accumulative plains are expected. There are compounds with sulphate-natrium (SO_4-Na),sulphate-hydrocarbonate-sodium (SO_4-NCO_3-Na) and hydrocarbonate-natrium-calcium (NCO_3-Na-Ca) in this landscape type.

Surplus amounts of As, B, Cu, Pb, V, Sb and Sr, deficienciesin Zn, Zr, Rb and Fe are observed in the north. But in the south Tb, Mo, B, Cu, Pb, Ni, V are surplus, Sr, Rb and Fe are deficit.

So interpretation of geochemical landscapes of Shamakhi-Gobustan region let us describe the role of geochemical composition of mud vulcano breccias in landscape differentation.

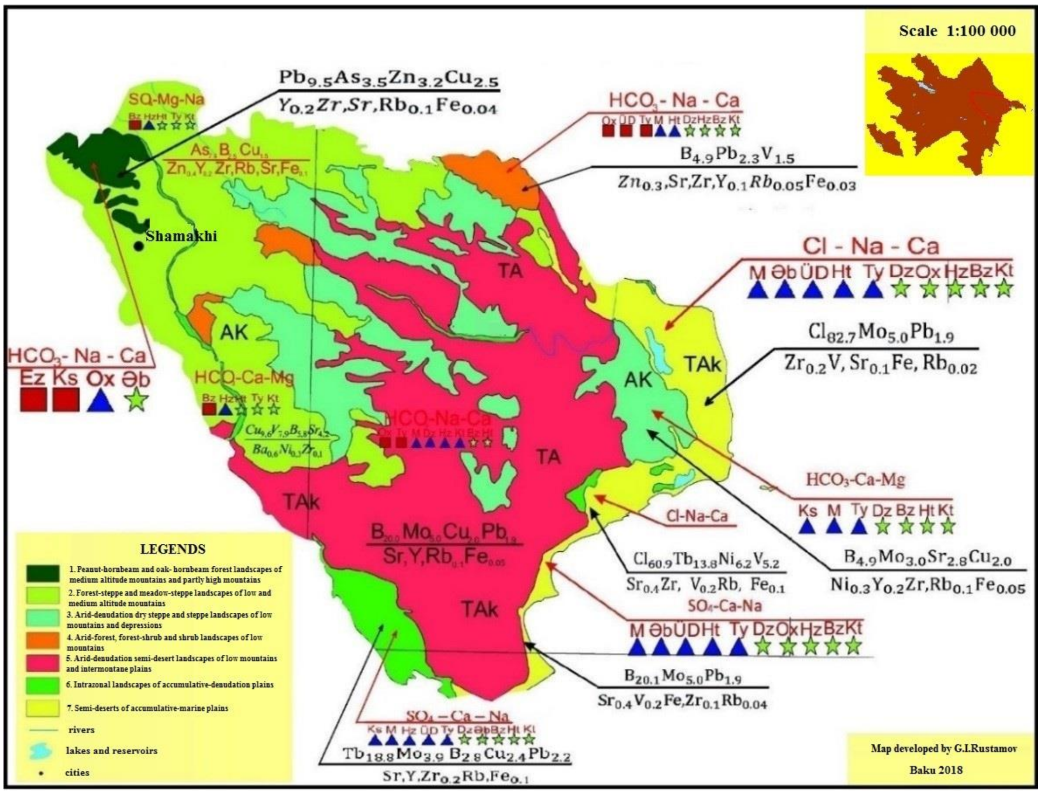

Figure 3 - Medical-ecogeochemical risk map of Shamakhi-Gobustan landscapes (the map legend is given in Table 4).

Table 4. Legend of map.

GEOCHEMICAL LANDSCAPES																							
COLUMNS	GROUPS	TYPES	ROCKS According to migration of chemical elements					Microelements	Diseases caused by anomal concentration of microelements												
According to migration types	According to volume of biological mass	Bioproductivity of biomass relation	Alluvial	Transalluvial	Supaqual	Ttrans-accu-mulative	Accu-mulative	(surplus-in numerator, deficit-in denominator)	Endemic goiter (Eg)	Fluorosis (F)	Caries (C)	Malaria (M)	Dysentery (D)	Oncological diseases (Od)	Neurological diseases (Nd)	Digestive diseases (Dd)	Brucellosis (B)	Cardiac (C)	Hypertension (H)	Respiratory diseases (R)	Conjunctivitis (C)
BIOGENIC LANDSCAPES	A. Moderately humid mountain-forest	1 Peanut-hornbeam and oak- hornbeam forest landscapes of medium altitude mountains and partly high mountainst	AL		SA		AC	$\frac{Zn_{10,9}Sn_{3,9}Ag_{3,3}}{Mn_{0,5}Ba_{0,4}Sr_{3,3}}$	■		■			▲	★						
	B. Moderately humid medium altitude mountains and low mountains	2 Forest-steppe and meadow-steppe landscapes of low and medium altitude mountains	AL		SA			$\frac{Cu_{9,6}V_{7,9}B_{5,8}Sr_{4,2}}{Ba_{0,6}Ni_{0,3}Zr_{0,3}}$						■	▲	■	▲		★	★	★
	C. Arid and semi-arid steppes of low mountains	3 Arid-denudation dry steppe and steppe landscapes of low mountains and depressions	AL		SA			$\frac{Mo_{10,2}B_{8,9}B_{6,3}Cu_{4,9}}{Zn_{0,5}Ba_{0,3}Zr_{0,1}}$			▲	▲	★				★		★	▲	★
		4 Arid-forest, forest-shrub andshrub landscapes of low mountains	AL		SA			$\frac{Ag_{7,3}B_{6,3}Cu_{5,6}Hg_{3,4}}{Co_{0,6}Ti_{0,4}Zr_{0,1}}$				▲	★	■		★	★	■	▲	■	★
		5 Arid-denudation semi -desert landscapes of low mountains and intermontane plains		TA		TAc	AC	$\frac{B_{25,3}Mo_{10,2}Sr_{3,2}Pb_{2,1}}{Ni_{0,5}Ca_{0,3}Zr_{0,2}}$				▲	▲	■		▲	★		★	■	▲
	D. Semi-desert landscapes of dry subtropical plains	6 Intrazonal landscapes of accumulative-denudation plains				TAc	AC	$\frac{B_{10,0}V_{2,4}Pb_{2,3}Co_{1,5}}{SrZr_{0,1}Rb_{0,03}Fr_{0,04}}$			▲	▲	★		★	▲	★	▲	★	▲	★
		7 Semi-deserts of accumulative -marine plains				TAc	AC	$\frac{Sn_{8,0}B_{3,6}V_{2,7}Cu_{2,4}Pb_{1,9}}{Zn_{0,4}Sr_{0,2}ZrRb_{9,3}Fe_{0,03}}$				▲	★	★	▲	★	★	▲	▲	▲	★

Higher and lower quantities of macro and microelements than the norm are danger for life andhealth of human and living organisms lived in geochemical anomalies.Higher and lower quantities of chemical elements indicates the importance of the optimization of the landscapes in future, chemical melioration in anomalous areas, necessarry special medical and geographical researching to improve sanitary and hygienic conditions in areas that are hazardous to the life of the living organisms.

Defining correlation relationship between number of diseases characterized bydifferent landscape complexes with concentration of various microelements has allowed to create medical-ecogeochemical risk map of Shamakhi-Gobustan landscapes (Fig. 3). We used «Medical-ecogeochemical landscapes map of the Azerbaijan Republic» (B.A.Budaqov, A.H.Ahmadov, Q.I.Rustamov, 2009, 2010) that published in «Ecological Atlas» for the first time, archive materials of local medical organizations and Ministry of Health of Azerbaijan Republic, also expedition materials, to create map of investigation area.

In this map have been defined diseases and macro- and microelements that cause these diseases that are more characteristic of different landscape complexes of the investigation area. In the map «red squares» defines diseases with high risk levels, «blue triangles » defines diseases with medium risk levels, «yellow stars » defines diseases with low risk levels (Fig. 3).

Influences of geochemical condition to human health in different landscape belts were investigated, diseases characterized by different landscape types and their **prevalence rate** were revealed to assessment of geochemical conditions of landscapes of the researching area due to ecological condition.

To determine the prevalence rate we used quantitiesof diseases per 10,000 people according to the International Classification of Diseases (ICS) and division of different diseases based on ocalization. If diseases quantitiesper 10,000 people are less than 100, these are not widespread diseases, if quantities are up to 200, these are widespread diseases, if quantities are more than 200, these are more widespread diseases.

Legend of map (Table 4):

1. The risk levels of dental caries (Dc), endemic goiter (EG) are high, the risk levels of oncological diseases (Od) are medium, the risk levels ofneurological diseases are low inpeanut-hornbeam and oak-hornbeam forest landscapes of medium and partly high mountains, and thesecaused by surplus quantities of microelements as Zn, Sn, and deficit quantities of microelements as Mn, Ba, and Sr in the same landscapes.

2. The risk levels of oncological and digestive disease are high, the risk levels of brucellosis and neurological diseases are medium, the risk levels of hypertension, conjunctivitis and respiratory diseases are low in forest-steppe and meadow-steppe landscapes of low and moderate mountains. These diseases caused by surplus quantities of vanadium (V), lead (Pb), and deficit quantities of titanium (Ti), barium (B), zirconium (Zr).

3. The quantities of molybdenum (CC_{Mo}= 10,2), boron (CC_B= 8,9), vanadium (CC_V= 6,3) and copper (CC_{Cu}= 4,9) are surplus in arid-denudation dry steppe and steppe landscapes of low mountains and depressions. Deficit microelements of the belt are zinc (CC_{Zn}= 0,5), barium zinc (CC_{Ba}= 0,3), and zirconium (CC_{Zr}= 0,1). The risk levels of caries, malaria, respiratory diseases are medium, the risk levels of dysentery, brucellosis, hypertension, conjunctivitis are low due to surplus or deficit quantities of these microelements associations.

4. The chemical formula of the microelements association ofarid-forest, forest-shrub and shrub landscapes of low mountains is as follows.

$$\frac{Ag_{7.3}B_{6.3}Cu_{5.6}Hg_{3.4}}{Co_{0.6}Ti_{0.4}Zr_{0.1}}$$

The risk levels of oncological, cardiac and respiratory diseases are high, the risk levels of malaria and hypertension diseases are medium, the risk levels of dysentery, digestive, brucellosis and conjuctivities diseases are low in this lanscape belt.

5. The risk levels of oncological and respiratory diseases are high, the risk levels of malaria, dysentery, digestive and conjunctivitis diseases are medium, the risk levels of hypertension, brucellosis are low in arid- denudation semi-desert landscapes of low mountains and intermontane plains characterized by surplus quantities of boron (B), molybdenum (Mo), strontium (Sr) and lead (Pb), and deficit quantities of nickel (Ni), cobalt (Co), zirconium (Zr).

There is no low risk diseases in the next two landscapes as intrazonal landscapes of accumulative-denudation plains and semi deserts of accumulative-marine plains.

6. The risk levels of caries, malaria, digestive, cardiac and respiratory diseases are high, the risk levels of dysentery, neurological, brucellosis, hypertension diseases are low in intrazonal landscapes of accumulative-denudation plains. These diseases caused by surplus quantities of boron (B), vanadium (V), lead (Pb), cobalt (Co) and deficit quantities of strontium (Sr), zirconium (Zr), rubidium (Rb), iron (Fe)

7. The risk levels of malaria, neurological, cardiac, hypertension, respiratory diseases are medium, the risk levels of dysentery, oncological, digestive, brucellosis, conjunctivitis diseases are low in semi deserts of accumulative-marine plains. These diseases caused by surplus quantities of tin (CC_{Sn}=8,0), boron (CC_B=3,6), vanadium (CC_V=2,7),

copper (CC_V=2,7), lead (CC_{Pb}=1,9), deficit quantities of zinc (CC_{Zn}= 0,4), strontium (CC_{Sr}=0,2), zirconium (CC_{Zr}=0,1), rubidium (CC_{Rb}=0,1), iron (CC_{Fe}=0,05).

Conclusion

It was revealed that, most of mud vulcanoes of investigation are have spread in dominant mountain semideserts and dry steppe landscapes, and they bring about formation of mud vulcano landscapes which have different structure-functional characterizes due to relief forms, geological ages, litho-geochemical composition of rocks.

The risks and dangers for human life that geochemical and medical characterizes of mud vulcano landscapes makes due to hypsometric levels assessed at three risk levels: low, medium and high. It was revealed that, diseases are not widely spread in steppe and semi-desert landscapes of plains. The risk levels of caries, and endemic goiter diseases are high, the risk level of cancer is medium, the risk level of neurological diseases is low in mountain forest landscapes.

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