in annual rings of trees // Geochemistry. – 2002. – № 1. – P. 1238–1245.
41. Aturova V.P., Kovalenko V.V. Plutonium in soils of Siberia // Radioactivity and radioactive elements in human environment: Materials of the International conference. – Tomsk, 2004. – P. 54–62.
42. Rikhvanov L.P. Application of geochemical methods for studying of survival of nuclear complex objects // Problems of prospecting and ecological geochemistry. – Tomsk, 2003. – P. 197–199.
43. Rikhvanov L.P. et al. Ecologic-geochemical features of Tomsk Oblast environments and diseases of the population. – Tomsk: Kursiv, 2006. – 215 p.
44. Ivanov A.Yu., Arkhipov V.S., Sudyko A.F. Uranium and thorium in bottom depositions of lakes of the south of Tomsk Oblast // Geochemistry and ore-formation of radioactive, noble and rare metals in endogenous and exogenous processes: Materials of the All-Russia conference with the foreign participation, devoted to the 50th anniversary of the Siberian branch of the Russian Academy of Sciences and the 80th anniversary of the member of the Russian Academy of Sciences F.P. Krendelev: in 2 volumes. – Ulan-Ude, April 16–18 of 2007. – Ulan-Ude: Publishing house of BNTS of the Siberian Branch of the Russian Academy of Sciences, 2007. – P. 79–81.
45. Shatilov A.Yu. Material structure and geochemical characteristic of dust atmospheric losses on the territory of Ob pool: Abstracts of the dissertation of a candidate of geological-mineralogical sciences. – Tomsk, 2001. – 24 p.
46. Baranovskaya N., Rikhvanov L. Trace elements in composition of biosubstates of people living in a district of the nuclear plant of Russia // Macro and trace Elements / 21 Workshop 2002. – Jena, 2002. – P. 1266–1271.
47. Yazikov E.G. Ecogeochemistry of urbanized territories of the south of Western Siberia: Abstracts of the dissertation of a candidate of geological-mineralogical sciences. – Tomsk, 2006. – 48 p.

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ECOLOGIC-GEOCHEMICAL CONDITION OF NATURAL WATERS OF THE ACTIVE WATER EXCHANGE ZONE OF THE SOUTH OF KUZBAS

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Pollution of surface and underground waters of the active water exchange zone of the south of Kuzbas has been considered. The evaluation of the level of modern condition of natural waters is conducted based on the materials of five years of researches. The conformity of the maximum concentration limit of the investigated waters is ascertained. The main contaminants of natural waters are revealed.

Introduction

From all the known directions of social production the most essential technogenic influence on the environment is noted in the field of the mining industry. Today, the tendency of simultaneous development of a large group of closely located to each other ore deposits and coal deposits in the basins having the complicated environment is precisely traced. Frequently all the structural divisions which are a part of the mining enterprise (mountain shop, sppetroleum product banks of dead rocks and oxidized ores, concentrating factories, storehouses of industrial runoffs, metallurgical and chemical plants, water-intake constructions and city territories) are compactly located on a rather small area which leads to essential and concentrated technogenic loading on the environment.

The listed above features of development of the mining and the processing industries have defined an essential and a long-term technogenic influence on change of a condition and properties of the geological and often the environment as a whole not only on the local sites of individual deposits but also in the regional plan covering the great areas of the technogenic influence. A lot of enterprises of mining and processing industry are concentrated on the territory of the south of Kuzbas as well as the largest cities and settlements of the area. Congestions of a large number of water-consumers and water-users on the small territory have affected the quality of natural waters. In this connection, the purpose of our researches was the determination of a modern ecological-geochemical condition of natural waters of the zone of the active water exchange of the investigated area (fig.).

Technique of researches

The materials obtained by the authors during the work in Verkhneobskiy hydro-geological expedition group at Tomsk Branch of Institute of Oil-and-Gas Geology and Geophysics of the Siberian Branch of the Russian Academy of Science under the supervision of S.L. Shvartsev conducted during 2001–2006 and the data found in references are used in the research.

The researches were carried out in few stages. The first stage was the field works with the primary goal of qualitative sampling of water, from sites with a various degree of anthropogenous loading and depths. The field chemical analysis included determination of such rapidly-changing elements as *t*, pH, Fe_{gen}, NO_2^-, NH_4 and was carried out directly at the point of selection. Besides, the sampling was performed for their subsequent studying in stationary laboratories.

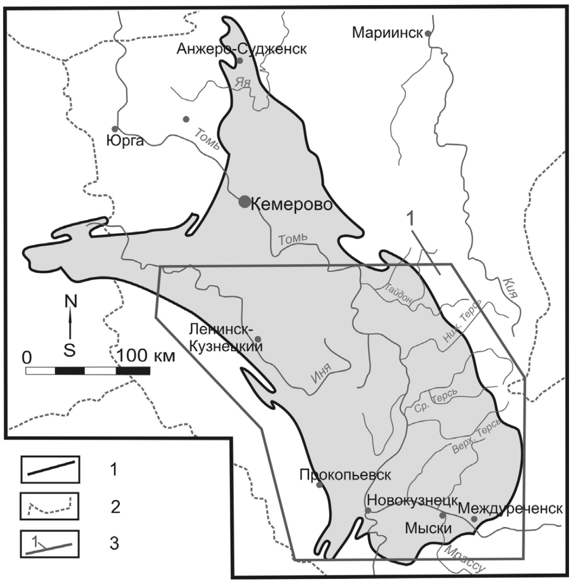

Fig. *Arrangement of the area of works: 1) border of Kuznetsk coal basin, 2) administrative border, 3) area of researches*
Explanation to Fig.: Анжеро-Судженск – Anzhero-Sudzhensk; Мариинск – Mariinsk; Юрга – Yurga; Кемерово – Kemerovo; Ленинск-Кузнетский – Leninsk-Kuznetskiy; Прокопьевск – Prokopyevsk; Новокузнетск – Novokuznetsk; Междуреченск – Mezhdurechensk; Мыски – Myski

The second stage of researches consisted in chemical analysis of the selected samples. The basic macro and microcomponents were investigated in the accredited task scientific-research hydrogeochemical laboratory and the nuclear-geochemical laboratory of Tomsk Polytechnic University.

The third stage of works consisted in analytical and statistical processing of all the obtained materials. All results were directed on solutions of the following problems: characteristic of water features of the active water exchange zone of the area, determination of a modern ecological-geochemical condition of natural waters by a wide complex of elements, determination of conformity of the investigated waters to the established ecological specifications.

Results and discussion

The zone of active water exchange in the south of Kuzbas takes up the top part of the cut composed of friable Meso-Cenozoic (mainly quaternary) deposits, and the zone of intensive jointing of bedrocks of the Kolchuginskaya series.

The capacity of the active water exchange zone in the southern part of Kuzbas ranges from 30 up to 450 m. The capacity of the zone reaches the greatest value on watersheds represented by high-permeability deposits, and the least in valleys of the rivers. On a greater part of the south of Kuzbas the capacity of the active water exchange zone reaches 80...150 m [8].

Development of the HCO_3-Ca type of waters is characteristic for surface waters of the active water exchange zone of the south of Kuzbas. River waters are fresh mainly neutral or alkalescent. The average content of total mineralization makes 0,15...0,25 g/l, values pH 7,7. In separate samples of river waters there is a high content of the sum of anions and cations which reach up 0,96 g/l at value pH 9,4. The given waters are attributed not to the typical surface waters but to the technogenically changed waters. Such contents are established in inflows of the river Tom in the area of Novokuznetsk and lower along the downstream.

The development of the HCO_3-Ca, Ca-Na и Na-Ca types of waters is characteristic for the underground waters of the active water exchange zone of the south of Kuzbas. These are fresh waters with mineralization of up to 0,4...0,6, less often 0,9 g/l, more often alkalescent with average value pH for the considered areas 7,5...8,0. With the depth there is an increase in growth of total mineralization and pH. Waters gradually turn into the hydrocarbonaceous sodic.

The change in a chemical compound of waters of the active water exchange zone of the investigated area and in the regional plan is traced. It consists in increase of mineralization from 0,2...0,3 up to 0,6 g/l from the east (from Kuznetsk Alatau) to the West, i.e. towards the reduction of the relief marks caused by gradual transition from one landscape to another. Similar dependence is observed for values pH [2].

One of the purposes of our researches is the definition of a modern ecological condition and quality of waters of the active water exchange zone of the investigated area. The criteria of quality evaluation are the set of any quantity indicators. By the term criteria of quality according to the State Standard 17.1.1.01-77 we understand «characteristics of composition and properties of water, its defining suitability for various kinds of water use». The maximum permissible concentration (maximum concentration limit) of chemical elements is used as a quantitative estimation of a modern ecological-geochemical condition of water objects of the investigated region.

The characteristics of waters of the active water exchange zone of the south of Kuzbas were carried out by 110 tests of underground waters and by 102 tests of surface waters, among them 91 river and 12 lake. Underground waters were selected from the depths in the interval from 30 up to 500 m. A bigger part of underground waters was tested from the depth of 40...140 m from the wells intended for drinking purposes, wells located on various industrial platforms or territories of coal cuts. River waters are represented by waters of the river Tom, Inya and their inflows. Natural and technogenic waters are allocated among lake waters.

We have divided the collected by us results by the following principle: the waters with the elements that do not meet the normative requirements (exceeding maximum concentration limits) are attributed to the «polluted» waters and the waters in with the elements that are in concentration satisfactory to the normative documents to «pure» waters. The average chemical analysis of both groups is presented in tables 1 and 2.

Table 1. *Content of chemical elements in pure waters of the active water exchange zone*

Parameters		Underground waters			Surface waters					
					River			Lake		
		min.	max.	average	min.	max.	average	min.	max.	average
pH		6,80	7,9	7,38	6,0	8,5	7,7	7,7	7,7	7,7
Total min.	mg/l	114	892	611,41	128	292,5	154,86	240,5	556,9	384,7
HCO_3^-		55,0	683	423,13	18,3	683,2	148,88	183,0	414,8	210,1
SO_4^{2-}		0,09	232	29,32	0,01	39,50	6,75	0,90	11,00	5,95
Cl^-		1,10	86,6	18,29	0,17	39,05	6,62	1,10	1,40	1,25
Ca^{2+}		20,0	158	84,56	4,00	112,0	30,51	40,0	90,0	56,0
Mg^{2+}		2,40	52,5	17,71	0,20	17,08	5,44	9,76	24,4	18,9
Na^+		3,9	110	46,43	1,00	70,0	9,76	5,00	15,0	11,1
K^+		0,50	5,60	1,81	0,10	6,30	1,04	0,40	3,10	1,40
NH_4^+		0,01	1,00	0,25	0,01	0,10	0,076	0,049	0,30	0,19
NO_3^-		0,90	28,8	7,08	0,067	14,43	3,90	0,59	0,64	0,58
NO_2^-		0,003	0,05	0,015	0,008	0,08	0,03	0,0029	0,017	0,003
Fe_{egen}		0,05	0,30	0,27	0,068	0,29	0,27	–	–	–
Si		3,84	9,20	7,05	2,00	5,30	3,35	0,28	4,40	2,46
Al		0,02	0,40	0,14	0,065	0,50	0,29	0,05	0,27	0,19
Sr		0,28	2,50	1,20	0,10	1,70	0,40	0,20	0,70	0,31
Li	mkg/l	1,30	27,0	17,7	1,00	18,5	5,30	8,00	12,0	9,56
Cu		0,10	3,50	1,12	0,20	30,0	2,80	1,07	2,65	1,14
Zn		1,0	90,0	15,35	0,10	71,0	18,12	15,5	123,5	45,7
Pb		0,10	6,40	1,74	0,10	3,80	0,65	0,46	2,30	1,38
Cd		0,01	0,40	0,09	0,10	0,22	0,11	0,053	0,42	0,25
Hg		0,009	0,45	0,18	0,01	0,44	0,13	–	–	–
F		0,11	1,40	0,43	0,006	0,64	0,17	0,21	0,25	0,17
Phenols		0,11	0,31	0,24	–	–	–	–	–	–
PO	mg/l	0,06	3,09	1,26	0,90	4,40	1,92	3,76	7,60	6,20
CAO		0,70	9,00	5,17	0,65	12,3	6,47	0,70	3,52	2,42
PP		–	–	–	0,026	0,091	0,058	–	–	–
Number of samples		45			57			3		

PO – permanganate oxidability, CAO – chemical absorption of oxygen, PP – petroleum product

The waters attributed by us to the group «pure» are characteristic waters of the active water exchange zone. The sum of anions and cations in them ranges within the limits of 0,11 up to 0,89 g/l. Values pH – from 7,0 up to 7,7. The most fresh are river waters and underground waters of shallow horizons. With depth the content of macrocomponents increases and the general mineralization grows which is a natural process.

In general, in the group of pure waters in greater maintenances are noted: in the underground – Si, Sr, Li, Pb, Hg, river – Al, Cu and petroleum product in lake – Zn and Cd.

The waters attributed by us to the group «polluted» are not homogeneous in structure. The mineralization in them varies from 0,12 up to 0,9 g/l in river and from 0,13 up to 2,9 g/l in underground waters. The value pH in subsurface waters ranges from 7,2 up to 9,9, and in underground 6,2...8,2. Cases when the content of macrocomponents, are found in values exceeding the maximum concentration limits in waters of the investigated area in the zone of active water exchange are almost always caused by the influence of technogenic sources.

Table 2. *Content of chemical elements in polluted waters of the active water exchange zone*

Parameters		Underground waters			Surface waters					
					River			Lake		
		min.	max.	average	min.	max.	average	min.	max.	average
pH		6,2	8,8	7,38	7,2	9,4	8,2	7,7	9,9	8,4
Total min.	mg/l	129,2	2916	843,9	126,0	920,0	379,3	208,3	920,0	478,5
HCO_3^-		61,0	1830,0	624,34	28,0	573,4	245,23	140,3	525	305,21
SO_4^{2-}		0,90	767,0	137,32	0,01	86,5	18,01	0,90	188	54,61
Cl^-		1,42	139,0	36,46	2,1	929,0	45,84	1,10	26,3	7,82
Ca^{2+}		2,40	220,0	72,58	2,4	102,0	53,75	33,0	94,0	70,17
Mg^{2+}		1,20	73,20	22,93	2,4	85,4	16,17	5,40	85,4	26,90
Na^+		8,00	934,0	186,87	0,5	225,0	31,08	5,00	128,0	33,92
K^+		0,30	98,0	7,74	0,2	366,0	18,89	0,40	65,0	11,17
NH_4^+		0,01	10,10	1,09	0,01	0,87	0,18	0,049	0,30	0,15
NO_3^-		0,35	122,8	29,38	0,003	11,36	1,90	0,01	6,72	1,25
NO_2^-		0,003	6,23	0,37	0,004	10,34	1,00	0,0029	8,80	3,73
Fe_{egen}		0,12	12,0	2,06	0,09	2,70	0,91	0,50	1,95	0,93
Si		2,70	10,2	6,38	2,0	5,98	3,44	0,28	5,75	3,37
Al		0,005	0,93	0,29	0,05	0,95	0,32	0,05	0,46	0,28
Sr		0,20	6,20	2,56	0,1	2,30	0,561	0,20	0,70	0,56
Li	mkg/l	1,60	100	38,0	0,002	100,0	8,60	2,00	19,0	12,2
Cu		0,50	16,4	2,52	0,1	8,41	1,62	1,07	6,04	3,22
Zn		1,56	200,0	24,27	0,1	40,0	7,70	1,93	123,5	34,45
Pb		0,10	11,2	1,83	0,1	9,69	1,58	0,46	5,20	3,09
Cd		0,026	0,30	0,129	0,027	7,20	0,60	0,04	0,42	0,15
Hg		0,012	3,55	0,69	0,01	3,94	0,42	0,06	1,90	0,80
F		0,109	190,0	16,15	0,11	18,10	1,66	0,21	350,0	5,69
Phenols		0,40	184,0	11,13	1,4	12,20	4,06	3,04	9,70	6,37
PO	mg/l	0,70	31,40	10,79	–	–	–	3,52	17,5	11,9
CAO		0,108	1,98	0,39	0,08	0,34	0,21	0,45	0,45	0,45
PP		0,23	0,54	0,29	0,05	0,29	0,23	–	–	–
Number of samples		6,2			7,2			7,7		

Biogenic elements in the increased contents are most often found in waters where there are other substances in concentration above the maximum concentration limit. As a whole it is possible to note that for surface waters of the south of Kuzbas the systematic detection of Fe, NO_2^-, NH^{4+} in contents exceeding maximum concentration limits is characteristic, and contents of Fe are in the majority of the investigated waters of the active water exchange zone. On average the content of Fe_{gen} in surface waters makes 0,9 mg/l, and in underground waters 2,06 mg/l. Cases of the increased content of NO_3^- are established in a number of surface wells. The reason, most likely, consists in non-hermiticity of wells or a weak protection of underground waters on the given site. It is expedient to notice that the problem of nitrate pollution, characteristic for river waters of many regions of the world, is not the issue for surface waters of the given area even near the large cities [6].

High content of a number of microcomponents is expected in the investigated area due to active development of the extracting and the processing industries. There is an excess of maximum concentration limit of Al, Hg, Li, Cd in river waters. High contents of the specified elements are found in the river Tom on the site between Mezhdurechensk and Kemerovo, in the river Kondoma (near Novokuznetsk city), the river Uskat, and the river Kyrgay. Maximal content of Al reaches 0,95 m/l, Hg 3,94 mkg/l, Li 100 mkg/l, and Cd 9,69 mkg/l. In the lakes located in territory of Erunakovskogo area the content of Hg reaching 8,08 mkg/l is established. In Novokuznetsk area in several wells the concentration Al reaches 0,93 mg/l.

In underground waters the content of the majority of the defined microcells and heavy metals are present in higher contents than in superficial.

The found excess of norms by a number of microcells testifies to anthropogenous loading on water objects, and on local sites this influence leads to irreversible changes [6].

Separately the attention should be paid to the established high contents of F in the investigated waters. In a number samples taken from river waters the concentration of F reaches 10...18 mkg/l (the river Kazachka, Novokuznetsk city). In lakes close to the aluminum factory of Novokuznetsk city the concentration of F reaches 350 mkg/l. Pollution by F is also noted and in underground waters at the marked site and reaches 190 mg/l. Total mineralization of these waters reaches 2,9 g/l. The condition and features of this territory waters are described in details in the work [5]. The revealed contents of fluorine are the highest for the given area.

Petroleum products is an organic trace contaminant characterizing a condition of runoffs flowing from the territory of cities into a sewer system and at its adverse condition seving as a source of secondary pollution of waters. Sometimes petroleum products find themselves in waters as a result of misuse of a gas station and different types of storehouses. The content of petroleum products pure the tested by us waters makes 0,026...0,0,91 mg/l, in polluted 0,05...0,54 mg/l. In the majority of tests, where the content of petroleum products was defined, their concentration exceeds the normative (the content of PP was defined in 19 tests). That fact, that in underground waters where contents of petroleum products were defined was unexpected enough also, they were established in greater contents than in surface waters.

Phenols in surface waters are contained in values from 1,4 up to 12,1 mkg/l, in underground waters from 0,4 up to 184 mkg/l. It is considerably lower than normative values.

At evaluation of the anthropogenous influence on water objects it is necessary to remember that some elements in a natural condition can be in concentration very close to the maximum concentration limit or even exceed them [4]. In such cases it is a question of not technogenic, but of natural content of elements in waters and as consequence the pollution has not technogenic but natural character.

In territory of the investigated area the content of Fe_{gen} in natural waters is often found in concentrations exceeding the maximum concentration limits, but in the given case it is a question of not technogenic changes but about natural geochemical processes. Conetents of F and Li are of natural and technogenic origin. In waters where the mineralization does not exceed 0,7 g/l the specified elements are in natural values peculiar to ground hydrogeochemical conditions, but in waters with a smaller mineralization and the greatest concentration of these elements they are obviously of technogenic origin. Cd, Hg, petroleum products and some other defined hydrochemical parameters established in waters of the given zone are an attribute of the technogenic influence on water objects.

If to compare the quantitative parities of contents of the defined elements in surface and underground waters it is possible to note that majority of the defined hydrogeochemical elements in underground waters is found in higher concentration. Cd, Hg and Al are established in high values in superficial waters.

Conclusion

Natural waters of the active water exchange zone of the south part of Kuzbas are generally HCO_3-Ca, Ca-Na by the structure, Ca-Na, less often Na-Ca, ultrafresh or fresh (the total mineralization does not exceed 0,9 g/l). With depth an increase in contents of macrocells and, as consequence, mineralization is observed.

By macrocomponental structure the features of pollution are revealed only on the small site, in the area of Novokuznetsk city. As a whole the content of macrocomponents in superficial and underground waters is above the maximum concentration limit is not characteristic for the territory. In a greater part of cases the pollution of natural waters is marked only by the content of metals, biogenic components and petroleum products.

The established cases of excess in concentration of various elements regarding the maximum concentration limit have both natural and technogenic origin. The found contents of Fe, F, Li and the majority of biogenic elements are mainly connected with natural processes of aeration and soil formation and are of natural character. Concentrations of Hg, other elements and petroleum products are, obviously, of technogenic origin.

Features of technogenic pollution are established in surface and in underground waters. Surface waters, to some extent, are polluted practically everywhere by various components. Underground waters are polluted locally. It is necessary to note that contents of some obviously technogenic elements in underground waters are established in higher concentrations than in surface waters.

In a planned distribution of contents of main contaminants it is distinctly traced that waters of the active water exchange zone in southern part of the investigated territory are much more polluted than waters of its northern part. The greatest concentrations of the defined elements are established close to cities and main industrial complexes of the south of Kuzbas.

REFERNCES

1. Gas-bearing ability of coal basins and deposits of the USSR. Coal basins of Siberia, Kazakhstan and the Far East / Edited by A.I. Kravtsov. V. 2. – Moscow: Nedra, 1979. – 455 p.
2. Domrocheva E.V. Hydrogeochemical features of coal areas of the south of Kuzbas: Referats of diss. ... cand. of geol.-min. – Tomsk, 2005. – 22 p.
3. Kontorovich A.E., Shvartsev S.L., Zuev V.A., Rasskazov N.M., Turov Yu.P. Organic microimpurities in fresh natural waters of basins of the river Tom and the river Verkhnyaya Ob // Geokhimiya. – 2000. – № 5. – P. 533–544.
4. Kraynov S.R., Ryzhenko B.N., Shvets V.M. Geochemistry of underground waters. Theoretical, applied and ecological aspects. – M.: Nauka, 2004. – 677 p.
5. Ludwig V.M. Technogenic pollution by fluorine in the area Forshtadt of Novokuznetsk city // Obskoy bulletin. – 1999. № 3-4. – P. 117–119.
6. Savichev O.G. Rivers of Tomsk Oblast: condition, protection and use. – Tomsk: Publishing house of TPU, 2003. – 202 p.
7. Shvartsev S.L., Ognetova M.P Ecological-geochemical condition of natural waters of the river Tom basin // Materials of the VI Siberian meeting on climate-ecological monitoring. – Tomsk, 2005. – 572 p.
8. Shvartsev S.L., Domrocheva E.V., Ognetova M.P. Capacity and structure of underground waters of the active water exchange zone of the south of Kuzbas // Materials of the VI Siberian meeting on climate-ecological monitoring. – Tomsk, 2005. – P. 534–537.

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MAPPING OF ECOLOGIC-ECONOMIC RISK ON EROSION-HAZARDOUS TERRITORIES

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The erosive processes and the mudflow phenomena can cause severe social and ecological damage, therefore division into districts by the degree of risk serves as an information basis for nature management.

The success of the optimization strategy of the environment and the rational nature management in many respects is defined by necessity of the duly account of the probable ecological risk of geosystem degradation connected with planning and realization of specific nature protection actions. For this purpose it is important to define the criteria of ecologic-economic risk, to develop methods of acquisition and territorial interpretation of the data about the interaction of human and the environment. Criteria of ecological destabilization of the environment differ in a great variety. Integrated specifications of quality estimation of the environment are not yet developed [1]. Ecological risk – probability of the environment degradation or its transition to the unstable condition as a result of the current or planned economic activities; possibility of control loss over the occurring ecological events [2]. Within the limits of the anthropocentric approach the subject of probable estimation is the risk of loss occurrence (disease, death) depending on a condition of the environment and its components.

Any subject can collide with the economic risk – single person (group), industrial-economic unit, the state on behalf of the government agencies. Economic risk – an opportunity of casual occurrence of the undesirable losses measured in money terms. The concept of economic risks does not cover only those risks which occurrence leads to monetary damage. They also include the risks leading to damage of the non-economic nature which would be possible (directly or indirectly) to estimate in the monetary form.

The aim of the research is: to develop methods of calculation allowing to define potential losses depending on the social-demographic condition of the region, existential scale and destructive force of natural phenomena, quality of the environment and the importance of ecological objects; to reveal laws of territorial distribution of ecologic-economic risk for geosystems that are subject to the influence of erosion and mudflows.

The lithogenic basis of the landscape (geological condition and relief) substantially predetermines the spatial distribution of soil differences and biotopes, their external borders. Contours of the territories with various ecological situations in many cases are expedient for coordinating with geomorphological borders. The relief directly influences the processes of geodynamics, including being the factors of ecological risk (collapses, landslips, mudflow, flood). The estimation of risk assumes allocation of potentially unstable conditions of geosystems on the basis of the analysis of topographical, engineering-geological or geomorphological maps and taking into account the information about previous events on the given and similar territories. It means the development of the lists of extreme situations, possible within the limits of the considered territorial units, with an estimation of probability of their occurrence and a degree of danger of natural systems infringement.

The evaluation of occurrence of the situations provoked by economic activities, technogenic failures and accidents with human casualties or infringements in functioning of geotechnical systems prevails among the