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RADIOACTIVE ELEMENTS IN THE ENVIRONMENT

L.P. Rikhvanov, S.I. Arbuzov, N.V. Baranovskaya, A.V. Volostnov, T.A. Arkhangelskaya, A.I. Mezhibor, V.V. Berchuk, L.V. Zhornyak, Yu. L. Zamyatina, A.Yu. Ivanov, A.V. Talovskaya, S.S. Shatilova, E.G. Yazikov

Tomsk Polytechnic University
E-mail: leorikh@b10.tpu.edu.ru

Indicated role of natural radioactive elements (U, Th) in geospherical layers and various environmental components is discussed. Induced radionuclide problems are examined.

Today in every material object of the real world and its geospherical spheres there exist hundreds of bearers of radioactivity phenomenon, radioactive isotopes. Essentially, all the chemical elements from periodic table have radioactive isotopes. For some of them they were always inhere (U, Th, ^{40}K, etc.), others were formed in a small amount due to natural atoms interaction with space radiation (^{14}C, ^{3}H, etc.), but essential part of radioisotopes and radio elements is a product of man-made activity (Pu, Am, ^{137}Cs, etc.).

These components are identified practically in all objects of environment, owing to unique characteristic of radioactive elements to change from nonequilibrium state to equilibrium position with emission of gamma-ray photon or charged particle (α, β) of definite energy; this allows using them as definite indicators.

Radioactive elements ubiquity in material world is proved today by researches of many scientists' generations. In geophysical and geochemical reference books or encyclopedias [1–3] one can find content Clarkes of radioactive elements (or their evaluative level) and radioactive isotopes of stable chemical elements of natural or man-made origin in various environmental components [4–6].

Nowadays one can affirm that radioactivity is the fundamental matter property, and its bearer is founded various quantity in every material objects. They were, are and will be always.

Moreover, with a high probability, it is possible to suppose that living matter appearance and evolution was partly determined by presence of the radiation factor. For example, radioactive tracer of potassium, (^{40}K), which is a β-radiator with long half-live period, can perform a function of power source for a bioplast.

Geochemistry of natural radioactive elements, especially of uranium and thorium in the environmental objects of various planet geospherical spheres is studied rather profoundly.

Geochemistry of radioactive elements in geological processes is entirely studied by the following soviet geologists: V.I. Vernadskiy, A.P. Vinogradov, D.I. Scherbakov, V.I. Baranov, V.I. Gerasimovskiy, A.I. Perelman, V.V. Scherbina, L.V. Tauson, L.V. Komlev, I.E. Starik, V.G. Khlopin, A.I. Tugarinov, Y.I. Belevtsev, N.P. Yermolaeva, G.V. Voiytkevich, A.A. Smyslov, V.E. Pluschev, G.B. Naumova, M.N. Altgauzen, F.A. Alekseev, R.P. Gottikh, N.A. Titaeva, S.G. Nerychev, A.I. Germanov; and by foreign scientists: Adams, Larsen, Roders, Lovering, Sackett, Rosholt, Husmann, Heier, Davis, Tatsumoto, Vine et al.

Summing up their researches and not less fundamental works of Siberian geochemists, including Tomsk radioactive school (F.N. Shahkov, F.P. Krendelev, V.M. Gavshin, A.S. Mitropoljskiy, S.M.Zhmodic, A.G. Mironov, A.D. Nozhkin, L.P. Rikhvanov, S.I. Arbuzov, V.A. Gavrilenko, Y.M. Puzankov, V.A. Zlobin, V.I. Klimov, V.A. Bobrov, A.M. Gofman, A.A. Kulikov, Y.A. Fomin, V.V. Erschov, A.V. Volostnov, etc.), we can conclude the following: radioactive elements can be used as tracer elements, with their help one can solve tasks of stratigraphical dismemberment of sedimentary and metamorphic strata, abyssal complexes, define their formational characteristic and geodynamical forming conditions, to perform typification of ore-abyssal systems, work out criterion and characteristics forecasting and search of nonradioactive raw materials field.

Basic conduct regularity and accumulation in various geological formations are defined nowadays. For example, among growing silicate-alkalinity uranium and thorium content increases, it reaches maximum in alkaline granites [8]. This regularity can be broken just in alkaline, alkali-ultrabasic and ultrabasic rocks. Ascertained statistic interconnection between natural radioactive elements (NRE) and petrochemical indices, allowed several authors [9] to suggest radio-geochemical key-determinant for abyssal rocks in a-Q coordinate.

NRE increasing tendency is noticeable quite confidently from earlier abyssal complexes to the later ones, this reflects basic regularity of residual melt enriching with uranium and thorium. L.V. Tayson made the most fundamental conclusions on uranium geochemistry in granitoid [10], according to him, they are the following:

- uranium is present at practically all minerals in granitoids, so, according to V.I. Vernadskiy it is ubiquitous [11]. At the same time one of his parts is located in accessories, another is timed to rockforming minerals. In rockforming minerals uranium is present in the molecular scattering form and submicroscopic proper uranium minerals;
- in granitoids, uranium is connected crystal-chemically with rare-earths, yttrium, zirconium and thorium, i.e. with elements with close ionic radius and charges;
- uranium geochemical history during magma differentiation is not connected with any of rockforming elements (Si, K, Na, etc.);

- during magma site of granitoids content differentiation, uranium is accumulated in later differentiator;
- some uranium in granitoids is in mobile condition (in weakly connected form) and easily lixiviate by carbon ammonium [$(NH_4)_2CO_3$] without hydrogen peroxide adding [H_2O_2]. 20...70 % of metal volume is timed to such uranium.

Radioactive elements in abyssal rocks are effective indicators of geodynamical conditions, their forming and ore potential [8, 12–14].

Moreover, not only radioactive elements accumulation level is interesting for researches.

First of all, gross content uranium to thorium ratio is very important index in practical and theoretical aspect (Th/U). This index, according to ours scientists [13,14], and foreign ones [8, 15], is of great importance. This ratio is in very narrow interval (2,5... with 3,5...4,5 prevalence), starting from the Solar System in general (Th/U=3,72), till its planets and the Moon (Th/U=3,55), meteorites (Th/U=2,5...8,6). This makes us suppose that there exist common regularity in uranium and thorium distribution, which is determined by the universe laws [16].

The system of uranium and thorium ratio constancy is maintained in various rocks, excluding chemical and biogenic formations, metamorphism and metasomatism products, i.e. quit dynamical natural systems with water participation (Fig. 1).

For abyssal rocks, this ratio can be a criterion of correct rating of the examined rocks to magmatits. If the ratio Th/U is less than 2, and moreover, less than 1, one can definitely affirm, that examined sample relates not to abyssal rocks, but to metasomatic or to metasomatic transformed rocks [14].

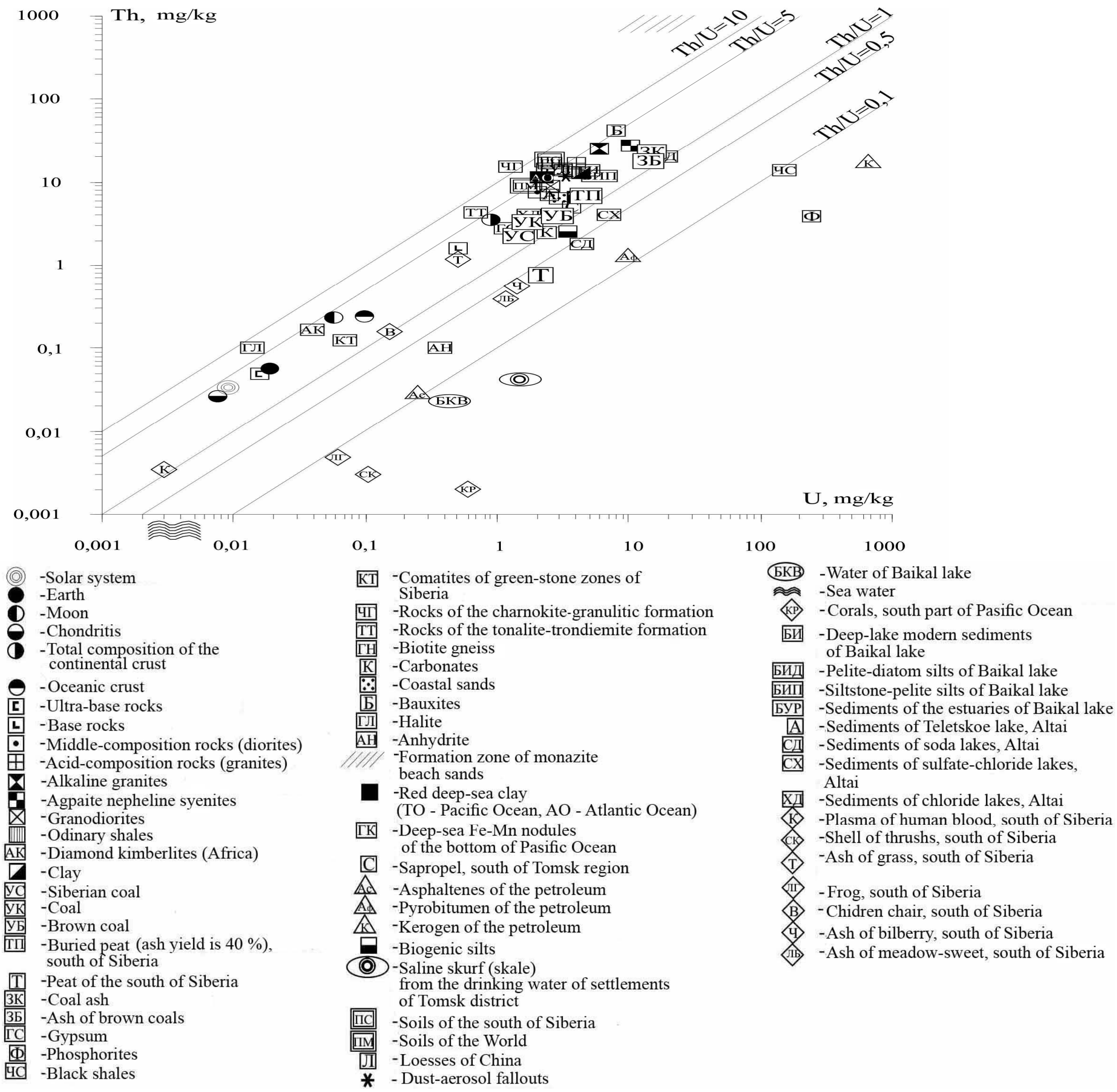

Fig. 1. *Generalized scheme of radio-geochemical characteristics of geospherical layers. Comment: during scheme working out, we used data from published sources, indicated in the list of the used literature, and from works of S.I. Arbuzov, V.M. Gavshin, A.A. Bogyslavskiy, A.D. Nozhkin, R.P. Gottich, B.L. Scherbov, Y.E. Ydovich, V.D. Pampura, I.V. Sandimirov, G.M. Shora, E.G. Yazikov, N.V. Baranovskaya, A.Y. Shatilova, I.T. Kudashev, S.R. Taylor, Adams, Junliang Tian, Whitehead, Kunzendorf, Anders, Ganapathy, etc*

As an exception, we can enumerate ultrabasic rocks and primitive oceanic basalts, which are characterized by low NRE level and practically always are in the metasomatic (metamorphic) transformation.

As contemporary analytical methods (ICP-MS, etc.) allow titrating uranium and thorium in any rocks, so during characterizing of some petrochemical metallogenic types, there exists a possibility to check the accuracy of sample accordance to abyssal objects.

For example, in the Altai a new type of rare-metal lithium granites is evolved (Allakhinskiy massif), but rocks of this massif are characterized by anomaly low thorium to uranium ratio. This prejudices the possibility to evolve this new granitoid type [13].

Many researches [17, 18] emphasize in their works, that in zones of hydrothermal and metasomatic processes, the dispersion of the NRE triad distribution increases. At the same time, an extremely important fundamental theoretical and practical conclusion is made: «within homogeneous NRE distribution one can not reckon on discovery of endogenous concentrations of nonradioactive crude ore» [13]. This is a paradigm of radio-chemical minerals, not only ore ones, search methods.

According to dispersion indices of NRE distribution, correlation violation between NRE and NRE interrelation are used in forecasting and hydrocarbon pools search, structures presorting according to their favorability for hydrocarbon localization [20–22].

It was also determined, that interconnection value of radioactive elements with other ore components has an indicated role.

For example, correlation of NRE with Mo, Ag, Sb, Hg is a peculiar feature for hydrothermal pools for tectonomagnetic energization of Transbaikalia [19].

This conclusion was affirmed by us during ore formation examining in Altai-Sayansky region [14]. Radio-geochemical method usage allows solving various geological tasks, including irregular situations, for example, during works in the fields of trappean magmatism development, during forecasting and searches of platinoid pools of Kingashaks type in East Sayan.

It was determined that ore-bearing intrusions of Norilsk-Talnakhskiy type have rather distinct radio-geochemical peculiarities [23].

Sediment rocks complexes have very indicative characteristics, including thorium-uranium ratio. F.P. Krendelev and others [17] determined the changes in regularity, connected with intermittence of sediment accumulation, it was proved by the example of examining of Precambrian rocks mass of Enisey range.

During terrigene rocks forming, there exists an evident tendency to increase the ratio of uranium to thorium content in the line: conglomerates – gravelites – sandstones – siltstones – mudstones. This tendency is broken only by sediment rocks of littoral phases (beach sands) and by rocks, enriched with organic substance and phosphorus. At the same time, many scientists point out direct correlation between carbonaceous substances and phosphorus and uranium and thorium [8].

Maximum uranium accumulation is fixated in rocks, in which carbonaceous substances is located in the form of pyrobitumen, kerites, antracsolites. Rocks of black shale formation are shaped with their help; they are characterized not only by heightened uranium-bearing, but by increased content of noble and rare elements (Fig. 1).

Coaly rocks and coals have anomalously high uranium, all the more thorium, content only in rare cases (Fig. 2). As a rule, they are conditioned by imposed epigenetic processes and coal oxidation. In such formations, there is no direct interdependence between radioactive elements and organic matter, but it exists with ash value and rare-earth and less-common elements. [24–29]

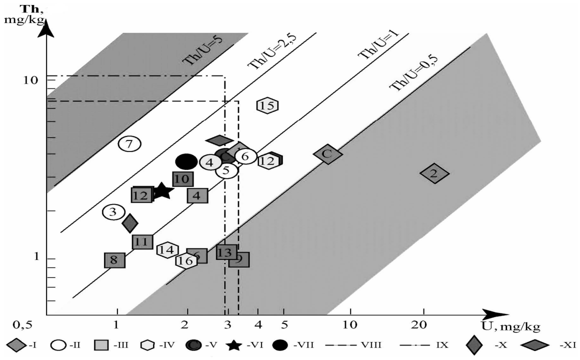

Fig. 2. *Radio-geochemical characteristic of Central Siberia coals: I – Devonian period of coal accumulation; II – Carbon-Permian period of coal accumulation; III – Age of Reptiles period of coal accumulation; IV – Age of Mammals period of coal and peat accumulation; V – average for a period; VI – average for a region; VII – coal clarke; VIII – average for sediments (according to N.A. Georgiev, 2003); IX – average for continental earth's crust (Taylor, Mac Lennon, 1988); X – USA coals; XI – Chinese coals. Coal-fields: 1) Barzasskoe; 2) Ybrusskoe; 3) Gorlovskiy; 4) Kyznetskiy; 5) Minysinskiy; 6) Tyngyskiy; 7) Kyrayskoe; 8) Pizhinskoe; 9) Kansko-Achinskiy; 10) Irkytskiy; 11) Ylygkhemskiy; 12) East-Siberian; 13) Averafe for ASSO; 14) Taldy-Dyrgynskiy; 15) buried peat; 16) modern peat*

NRE indicator role is judged according to examining results of pleistocene fluvioglacial sediments in the form of perfectly shaped ribbon clay of the Altai uneven-aged levels. The most ancient of all, at the age of 260 thousand of years, have a high ratio of Th/U (8;2); according to accumulation level of Th (18 ppm) they are close to argillaceous deposits of the Barents Sea. Ribbon clays at the age of 25...30 thousand of years are close to this index (Th/U=3,5; Th=18,3 ppm); when sediments at the age of 100 thousand of years have radio-chemical characteristics close to contemporary evaluation of upper continental crust (Th/U=3,5; Th=10,2 ppm). This proves a sharp change in the structure of material of glacier forming area. Presence of sediments with high ratio of uranium to thorium can be evidence of high maturity crust existence in the Altai Mountains, which suffered intensive glacial processing. It should be mentioned, that according to radio-geochemical characteristics, sediments of lacustrine- alluvial, sand-gravel complexes of the Katun river upper terrace (lower part of average pleistocene) is close to upper continental earth's crust content (Th/U=3,1...5,4; Th=9,2...12), and to ribbon clays at the age of 100 thousand of years (Inya, the Republic of Altai). Chemical and biogenetic sediments, as a rule, are enriched with uranium, rather than thorium. That is why these formations are characterized by low index of uranium – thorium ratio.

Table. *Uranium and thorium content, ppm, in different environmental components of Siberia and Tomsk region*

Environmental components	U: x±Δx (n) min...max	Th: x±Δx (n) min...max	Th/U
Coal, Siberia	1,5±0,4 (3600) <0,1...300	2,4±0,4 (3600) <0,5...28	1,6
Upper peat, East-Siberian region	0,2±0,03 (266) 0,04...1,22	0,5±0,04 (266) 0,13...2,43	0,4
Soil	2,5±0,1 (1239) 0,1...10,8	9,9±0,2 (1239) 1,5...23,9	4,0
Drinking water scale	1,48±0,17 (186) 0,06...66,4*	0,17±0,05 (186) 0,01...7,5	0,1
Herbaceous vegetation ash	0,26±0,08 (35) 0,1...2	0,8±0,3 (35) 0,04...9,1	3,1
Snow-melting water from Aktry glacier (Altai) mkg/l	0,02**	0,01**	0,5
Incrustation of snow-melting water Aktry glacier (Altai)	3,7±0,2 (25) 2,1...6,3	7,0±0,2 (25) 5,7...9,5	1,89
South Tomsk region, lakes sediments	3,4±0,5 (165) 0,8...35,2	6,6±0,5 (165) 2,2...11,5	1,94
Lichen ash, Tomsk region	3,11±0,48 (19) 0,5...6,5	5,29±0,53 (19) 2,6...10,8	1,7
Egg shell of birds from thrush family	0,11±0,003 (52) 0,1...0,23	0,03±0,002 (52) 0,02...0,06	0,3
Thyroid gland of an adult, pathologically changed	0,28±0,07 (59) 0,2...4,5	0,02±0,003 (59) 0,007...0,12	0,1
Children' hair	0,16±0,005 (358) 0,01...0,58	0,09±0,02 (358) 0,004...3,5	0,6
Blood	0,14**±0,02 (128) 0,01...2,5	0,013**±0,001 (128) 0,007...0,14	0,1
Moor frog (Rana arvalis)	0,04±0,006 (18) 0,02...0,13	0,02±0,003 (18) 0,001...0,04	0,5

**Anomalous concentration was not considered during average calculation*

***Average evaluation according to unit definition*

Generally, this reflects basic peculiarities of U geochemistry in the environment, conditioned by thorium valency condition (only four – valency condition) and uranium valency condition (four and six – valency condition), with specific compound forming. For example, six-valency uranium is located in uranyl-ion (UO_2^{+2}). All these condition their various solubility in fluids. For one, the solubility of Th^{+4} and U^{+6} in the water differs on three orders.

Exactly this factor, above all, conditions Th and Uranium and thorium geochemical destiny division in hydrothermal, exogenous, biogenic and some man-caused processes. Uranium content prevails greatly over thorium in sea and fresh water, blood plasma and living being in general. Living being, as V.I. Vernadskiy pointed out [11], is an uranium concentrate. Only in biota ash constituent, for example, in plants or keratinous matter (hair) Th/U ratio reaches 1 and can be even more (Fig. 1). From our point of view, an important index of water radio-geochemical characteristic is salted sediments (scale), reflecting all its geochemical peculiarities [30].

Uranium and thorium accumulation levels in various natural Siberian objects, examined by us, are introduced in the table.

It should be mentioned, that their concentration in biota is determined not only by natural factors, but and by man-made ones [31]. At the same time, Th/U ration value becomes an informative index of man-made environmental transformation. Most of all it is plain from hair examination (Fig. 3).

Similar situation is observed during examination of radio-geochemical peculiarities of dust-aerosol fallouts (Fig. 4).

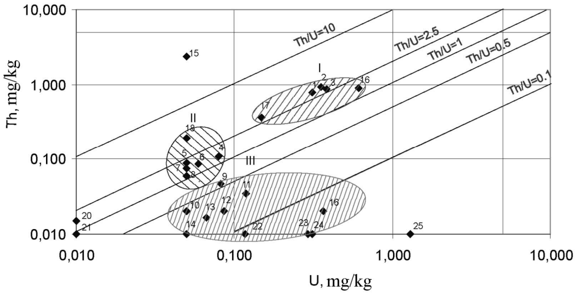

Fig. 3. *Children hair radio-geochemical characteristic from Tomsk region's settlement. Settlement groups: I – with relatively high Th, U content, ratio – Th/U=2,5; II – with low Th, U content, ratio – Th/U from 1 to 4; III – with low Th, U content, ratio – Th/U<1. 1-25 – settlements: 1) Naumovka; 2) Georgievka; 3) Samus; 4) Gubino; 5) Nelubino; 6) Zorkaltsevo; 7) Kopylovo; 8) Voronino; 9) Semiluzhki; 10) Koninino, Kornilovo, Chernaya rechka (Tom), Loskutovo; 11) Tomsk; 12) Rassvet; 13) Sayga; 14) Kizhirovo; 15) Moryakovskiy Zaton; 16) Orlovka; 17) Kozyulino; 18) Oktyabrskoe, Beryozkino; 19) Chernaya rechka (Yuksa); 20) Filimonovka, Semyonovka; 21) Novonikolaevka; 22) Polovinka; 23) Bakchar; 24) Bundyur; 25) Seversk*

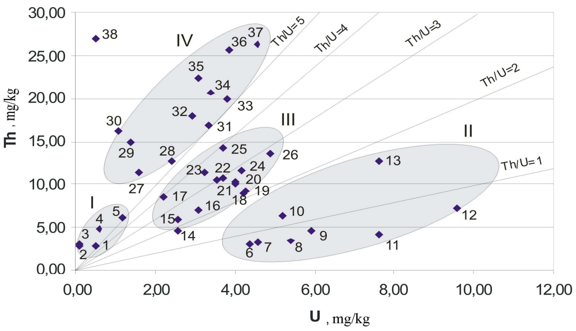

Fig. 4. *Radio-geochemical typification of snow cover incrustation of East Siberia region background and urbanized territories: I – background area; II – V – zone of various plant facilities influence. 1–38 – settlements: 1) Myldzhino; 2) Megion; 3) Sredniy Vasygan; 4) Strizhevoy; 5) reserve «Tomskiy»; 6) Zyryanskoe; 7) Semyonovka; 8) Novokuskovo; 9) Ust-Kamenogorsk; 10) Novonikolaevka; 11) Minaevka; 12) Filimonovka; 13) Porosino; 14) Berlinka; 15) Kolomino; 16) Luchanovo; 17) SJSC «Sibelektromotor»; 18) Timiryazivo; 19) Tomsk; 20) Mezhdurechensk; 21) Kaltay; 22) collective farm «Tom»; 23) Seversk; 24) Rubtsovsk; 25) North industrial centre, Tomsk; 26) Vilenka; 27) Kargala; 28) Bakchar; 29) Orlovka 30) Kizhirovo; 31) Stepanovskiy; 32) Kozyulino; 33) Dzerzhinskiy; 34) Moryakovskiy Zaton; 35) Samus; 36) Georgievka; 37) Naumovka; 38) Krasniy Yar*

Soils from man-made influence zones, as rule, are close to 3...4,5 Th/U ratio. In the man-made transformation zones this index becomes significantly low [32]. It deflects from the norm and in the zones of it transformation under the fluid stream influence from hydrocarbon pools, located at the depth of several km [20–22].

It should be mentioned that, examination of dynamics uranium coming-in biosphere, with peat usage, proves it more intensive entry during last 60 years, accumulation maximum was observed in 60–70th of XX century [13]. At the same time, Pu and other man-made radionuclides (Fig. 5) coming-in is taking place, this proves commonality of coming-in source.

Relatively high (2 and more times) uranium and thorium accumulation level is observed in downstream bog regarding upstream ones. Maximum uranium concentration is fixated in peat deposit, located in the zone of direct nuclear-energy cycle [33].

$^{238}U/^{235}U$ ratio is one more extremely important radio-geochemical index. It is a physical constant for a definite time period and is determined for today at 137,8. Deviation from this value shows that either processes of nuclear fission together with ^{235}U burnup took place, as it happened on natural radio reactors 2,5...3,0 mlrd years ago (uranium and thorium field Oklo, Bogomo and others in Afrika) [34], or this is the influence of nuclear-power plants, occupied with separation of uranium isotopes (Seversk, Angarsk, etc.) or with some other activity, including nuclear explosion carrying out, during which isotope separation or formation takes place. It was shown by us and American scientists (Drew Comelian, et al.) that the ratio in the zone of such an influence can vary from 1 to 500.

As a result of nuclear weapon test, development of nuclear power engineering, starting from 1945, in all natural environment (soil, water, biota, etc.) absolutely new, unknown before, radioactive elements and their isotopes appeared (technetium, promethium, plutonium, americium, ^{90}Sr, ^{137}Cs, etc. [6, 35, 36]). Heretofore they could be find out only in some local points, where about 2 mlrd years ago natural nuclear reactors functionated [34]. Nuclear weapon test (NW) in world testing area resulted in significant change of geospherical area geochemical content [6, 37, 38]. Similar situation developed in the areas of subsurface nuclear explosion (SNE) carrying out and places of nuclear-energy cycle plants (NECP) location

First of all, this results in mass man-made radioactive elements (MRE) coming-in the biosphere with various nuclear-physical (half-life, kind of radioactive emanation energy), geochemical, biological characteristics [6, 35].

Our scientists [39, 40] proved, that in natural environment, accumulation level of fissile elements (^{235}U, Pu, Am and other transuranium elements) increased in 2...3 times in global scale, and this level changed more significantly in local areas, testing nuclear range (TNR) location.

During mass NW testing radio-ecological situation was evaluated, first of all, according to exposure rate (ER) of gamma rays and according to total sediments beta activity. This allowed evaluating effectively general radiation situation at those times. This approach preserved even nowadays, when territories regulation according to radio-ecological parameters is evaluated by ER, density of ^{137}Cs, ^{90}Sr fall-out. After Chernobyl disaster, Pu accumulation level started to be evaluated, but fixed normative index (more then 0,1 Ku/km^2) can characterize only emergency area, not the territory condition, suffered carried over influence of man-made radionuclides of relatively low concentration.

Decade after NW testing stop, short- and-long living MRE decayed, relatively long-living ^{90}Sr and ^{137}Cs decayed partly, and migrated from the surface to more deep soil horizons, or were transported into lakes, falling backs and other negative relief forms during the process of areal erosivity. That is why traditional approach to radioactive elements examining can not reflect the real situation. So it is not surprising that in articles, dedicated to this problem, even to TNR, one can find

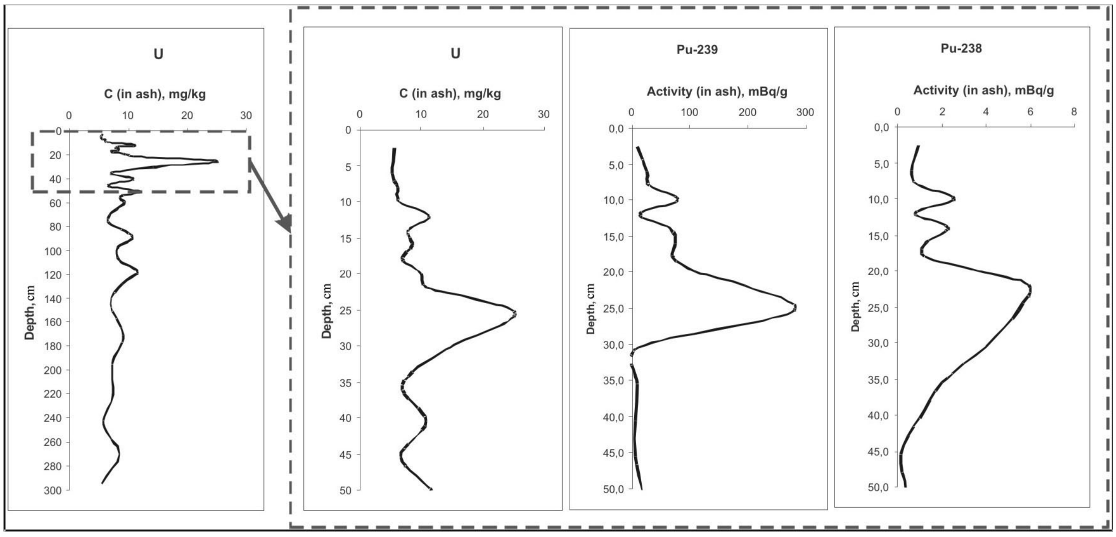

Fig. 5. *Distribution of uranium and plutonium in the upper peat of Tomsk city area*

such a view that according to ^{90}Sr and ^{137}Cs accumulation level in soils, examined in the range do not differ from global level; and ER reflects natural radioactive elements content (U, Th, K).

The situation looks exactly this way according to gamma-emitting components. Only more detailed researches prove that Pu and Am concentrations are high in these territories. Today radio-ecological situation in TNR and adjustment areas is, as we see it, is determined and will be determined in the future by α-emitting long-living radionuclides accumulation level, Pu and Am first of all [37].

Real state of affairs with environment pollution by these components is still poorly examined [41]. Primarily, global level of their falling out is not determined. Analysis of numerous researches in the key radio-ecological world magazines, including in the territory of Russia (M. Baskaran J. Kirk Cochran, etc.) proves that as a global level one can take Pu specific activity in soil on the 0,2...0,3 Bk/kg level [37].

In the places of nuclear weapon test, nuclear explosions for peace aims, places of NECP work other geochemical anomalies can be fixated nowadays [35, 42]. These areas would differ in uranium isotope ratio in environmental conditions. This is properly shown according to Rocky Flats, USA area and Siberian chemical plant (SCP) [35, 42].

Nowadays, reliable geochemical reference points appear, proving specific natural and man-made systems functioning in different areas (TNR, SNE, NECP). For example, geochemical characteristics of SCP influence on environment are the following [35, 42]:

- more than background content in soils (with excess in 2 times and more) of uranium, thorium, ^{137}Cs, ^{90}Sr, lanthanum, samarium, lutecium and some other elements; $^{238}U/^{235}U$ ratio, differ greatly from natural; presence of great amount of fissile elements, in the form of microinclusion («hot particles») (L.P. Rikhvanov, V.V. Arkhangelskiy, Y.G. Zubkov, etc.);
- global accumulation level excess in dust-aerosol fallouts of ^{137}Cs, ^{60}Co, some other man-made radionuclides (G.G. Glukhov, G.V. Merkulov), and specific (Co, Be, Zr), heavy metals (V.A. Zuev), rare-earth elements, uranium and thorium, and their broken ratio [35]. In snow incrustation [43] man-made minerals are discovered, characteristic for this production type (graphite, uranium oxide, etc.);
- presence in surface and underground waters in the amounts, prevailing regional background in 2 and more times of uranium, tritium, ^{137}Cs and ^{90}Sr in some places, fluorine, quicksilver, tributyl phosphate and some other chemical components (V.A. Zuev, Y.P. Turov, V.K. Popov, etc.);
- quicksilver revealing in water and in other natural environment in the areas of nuclear-energy plant locations, as in the USA (K. Campbell and others, Okridz region, Tennessee, USA);
- man-made radionuclides (^{137}Cs, ^{90}Sr, ^{14}C) and other chemical elements (lanthanide, uranium, promethium, etc.) revealing as in separate organs and in organism in general in some species of small mammal and amphibian (N.S. Moskvitina, V.N. Kuranova, S.V. Savelyev, V.D. Nesvetaylo, etc.);
- changes in accumulation level and ratio character of rare and radioactive elements in man's blood and hair;
- man-made radionuclides presence (^{137}Cs, ^{90}Sr, ^{14}C), and fissile elements (^{235}U, Pu, Am, etc.) and Hg in annual rings of trees sawings (V.D. Nesvetaylo, M.G. Buzhinniy, T.A. Arkhangelskaya, L.P. Rikhvanov, etc.);
- revealing of man-made, including fissile radionuclides (^{137}Cs, ^{60}Co, etc.) in river fish (Y.G. Zubkov, I.G. Berzina, N.N. Ilyinskikh), in big wildlife meat (A.Y. Zubkov), in birds (N.N. Ilyinskikh).

Analysis of pace-time localization regularities of ascertained geochemical indices proved the following:

1. In the various natural environment, in zones of nuclear objects influence, indicated chemical elements form united structure of geochemical space, characterized by aureole axis elongation according to «wind rose» or basic outfall drain [37, 43].
2. Accumulation level of numerous indicated components in natural environment have a marked tendency to increase as approaching to nuclear-power production; though some elements, uranium, for example, have other tendency, this is explained by various volatility degree of its compounds.
3. Their coming-in the environment has cycle, irregular character, as during a year, and during functioning of the nuclear objects.

Problems of man-made radionuclides migration and accumulation are far from being solved. Every year, new data, proving a baffling complexity of geochemistry of man-made radioelements, appear. This creates additional difficulties in the record of their influence on a biota and a man [6, 35].

Contemporary level of methods of nuclear-physical analysis's development, including remote ones, allows using the possibilities of radioactive elements for solving questions of new methods development, mineral deposit search, including deposits of hydrocarbon [30], differentiation of various geochemical process, including typification of rocks [14], soils [32], fertilizers, sapropels [44], peats [33], coals [24, 27], dust-aerosol fall-outs [45], biotas [46]. This is proved by researches, made by us. Ecological and radio-ecological task, such as territories zoning according to their man-made transformation degree and evaluation of environmental safety for a man can be solved according to this methods [43, 47].

Radioactive elements ubiquity, their perfect nuclear-physical characteristics, availability of great information amount on basic geochemical NRE characteristics in natural processes, all these allow asserting that natural radioactive elements and their isotopes were used, are using and will be using as indices for solving of lots of tasks in Earth sciences, biology, ecology and technological processes.

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

M.P. Andreeva, E.V. Domrocheva

Tomsk Polytechnic University
*Tomsk branch of Institute of Oil-and-Gas Geology and Geophysics of the Siberian Branch of the Russian Academy of Science
E-mail: omp2004@mail.ru

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.