river mouth, and some water mass shift to the left bank 70,3...68,8 km away from river mouth. Considering these, left bank and bottom erosion is probable together with the following resiltation in the downstream area and oseredoks forming.

5. Arrangement of SGM underwater storehouses near the bank can lead to stream shift and strengthening of bottom erosion between the storehouse and next bank (especially during flood fall) and it can increase frazil ice drift density (during the floating of ice).
6. Considering all these, it is not recommended to arrange storehouses at the places of stream narrowing and in the curvilinear areas. The least negative consequences are expected, when SGM storehouses are arranged at the low part of Enekov island (63,0...61,5 km away from river mouth) along with prior shore drawdown and storehouse arrangement within old boundaries of the island.
7. Watercourse of the Tom river within the limits of Tomsk city in the south part (in upper bridge range, 73 km away from river mouth) during 2003–2006 is generally stable. Downstream from the bridge significant deformations are marked within some part of cross-section (more than error estimation 0,58 m), but deformations are generally insignificant within vertical section (less than 0,58 m).
8. If natural and man-made conditions of sediment load forming of the Tom river within the limits of Tomsk city, definite river-bed level lowering is probable downstream from upper bridge, 73 km away from the river mouth.

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RADIOGRAPHIC RESEARCHES IN RADIOECOLOGICAL MONITORING

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The possibilities of one of the radiographic methods – the method of fission-fragment radiography for evaluation of radiographic condition of territories, which are characterized by different source of man-caused and natural radiating loading, are considered.

Monitoring research of radiation condition plays a great role in state of environment control. To perform a proper evaluation one needs a great number of data on concentration of radioactive elements, its forms of presence and some other various parameters in different objects of natural environment.

High-accuracy methods should be applied to define an accumulation level of radioactive nuclides in the objects of natural environment, which are characterized both by high and relatively low concentration. Radiographic methods give complete information about a character of radioactive elements distribution in the objects of research. Among well-known radiographic methods a special place occupies a method of fission-fragment radiography (*f*-radiography). Fission-fragment radiography is a unique method of fissioned radionuclide analysis in various objects. This method allows defining with high accuracy the quantitative content of fissioned radionuclide, their spatial distribution and forms of presence in the objects of research [1]. This method is an instrumental one and allows performing an analysis without chemical preparation and sample destruction.

The basis for f-radiography method is a reaction of atom nuclear division of some elements (uranium, plutonium, etc.) under the influence of thermal neutrons and registration of fission fragments on the detector. Here, the detector, lavsan pellicle can be used as to perform this function, fixates the traces from fission fragments (tracks), which can be observed in an electronic microscope, and, after proper processing, in an optical microscope. The tracks quantity is proportionate to radionuclides content in the given point of the object of research [1].

Radiographic researches in Tomsk Polytechnic University (TPU) started from 1972 at the chair of minerals and rear elements geochemistry, with the help of research nuclear reactor IRT-T of research institute of Nuclear Physics. At the first stage f -radiography method was used for solving geological tasks (examining the content and character of uranium and thorium distribution in minerals, ores and rocks; revelation of uranium dispersion and concentration peculiarities in the process of mining systems development, etc.) [2 and others]. In 1991, at Tomsk the collective of the chair of minerals and rear elements geochemistry held the III All-Union radio geochemical conference «Radiographic research methods in radiochemistry and adjacent spheres» [3]. Today f-radiography method is used for solving ecological tasks.

The usage of f-radiography method for examining such natural objects, as vegetation, soil, peat gives an opportunity to hold monitoring research of radio ecological situation in every territory. Here, fissioned radionuclides are indicators of environmental radioactive pollution. By these we understand the whole number of transuranium radionuclides (^{239}Pu, ^{241}Am, etc.). This group of radionuclides draws attention for a variety of reasons. Firstly, uranium and transuranium elements belong to highly toxic radionuclides, they have a very long half-life period, so, their presence in environment is a long-term radiological danger. Secondly, transuranium radionuclides are among the least studied artificial substances, which arrive at environment, as for their identification and qualitative determination specific and expensive methods are necessary. Meanwhile, these radionuclides exist practically in every emissions and wastes, which took place because of human nuclear energy usage activity.

Application of the f-radiography method for examining stratificated natural formations (annual rings of a tree, ground sedimentation, etc.) appear to be highly perspective for solving retrospective radio ecological monitoring tasks [4]. Thus, using the f-radiography method for investigating, for example, elemental composition of annual rings of a tree, one is able to examine the level and character of fissioned radionuclide accumulation in a various time periods, and, thereby, restore dynamics of radio ecological situation on any territory of trees' vegetation for a long period.

Using the f-radiography method for examining different natural objects, special, unique methods should be applied. The chair of minerals and rear elements geochemistry developed unique methods of wood, soil, peat and other elements sample preparation for radiographic research. For example, preparation of wood samples for further radiographic analysis includes fulfillment of the following procedures:

- two plates with level beaming surfaces are cut out from the place of sawing, at two radial directions;
- calendar time of every annual ring formation is determined;
- glue standard with definite amount of uranium and its isotope characteristics is put on the surface of the samples;
- after glue standard indication, a detector is put on every sample, for example, lavsan pellicle, which should be in a dense contact with the surface of a sample;
- preparation are covered with lavsan pellicle three more times for screening each preparation from external pollution;
- group of prepared preparations is put into a special foil container.

In general, the scheme of annual rings radiography is presented in the Fig. 1.

As uranium standard, the collective of a chair suggested a method of its preparation, silicate glue with a definite number of uranyl nitrate water solution is used. The total content of uranyl is determined by laser- luminescent method. In explotable glue standard it comes to 12,16 mg/kg, and isotope proportion ^{235}U to ^{238}U basing on mass spectrometric analysis is 0,00432. Considering broken isotope proportion, uranium number in a standard is evaluated as 7,2 mg/kg [5].

Prepared samples are irradiated by steam of thermal neutrons on research nuclear reactor IRT-T of research institute of Nuclear Physics, TPU. After irradiation and recession of activity, a detector is put out of the samples and chemical etching operations are fulfilled according to standard methods. After etching procedure, tracks from fission fragments, fixed at a detector, are available for examining with optical microscope.

For receiving statistically correct results, tracks are counted on at least 30 accidentally chosen elemental ar-

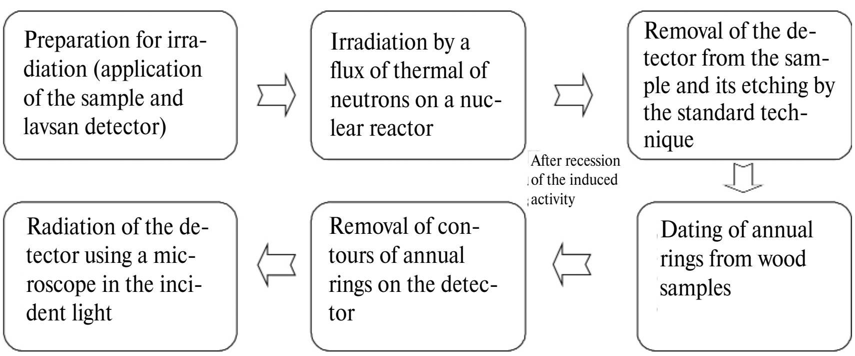

Fig. 1. *The scheme of works at radiography of wood samples*

eas in every annual ring zone in every sample. After statistic results handling on each ring and defining the mistakes of measuring, percentile curves of fissioned elements on time periods are constructed, forms of presence of fissioned radionuclides in the investigated sample (molecular-disseminated, microinconclusions) are fixed, Fig. 2.

Studying of form of presence of fissioned radionuclides allows revealing the presence of «hot particles» or highly active micro inclusions which represent a serious radiological danger.

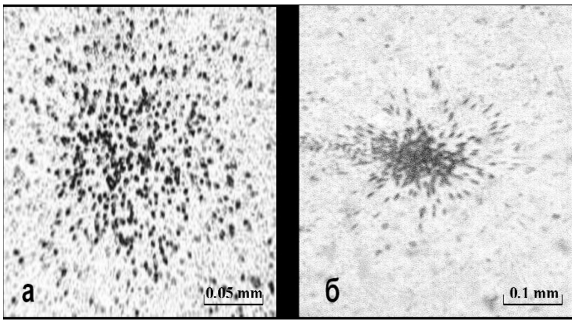

Fig. 2. *Distribution of tracks on lavsan detector, an agglomeration: a) with high density; b) «star» form*

Using patented by us technology of radio ecological pollution estimation, based on annual rings radiographic analysis [6], researches were made, investigating long-term dynamics of inflow of fissioned radionuclides to environment in territories characterized by different man-caused and natural nuclear load in Siberian region, Altai region, Central Europe and etc. [7–9].

Coniferous trees (a pine and a larch) were the research object. Samples of sawing were chosen in territories of radiationally dangerous objects (Tomsk region, Krasnoyarsk region, Irkutsk region); at the territories where radioactive waste fell after the Chernobyl disaster (Ukraine, Central Europe); on the places of subterranean nuclear explosions (Krasnoyarsk region, Irkutsk region); at uranium field (Krasnoyarsk region, Czech Republic), in conditionally background areas, etc.

Now we will regard the results of examining the annual rings, which were chosen in the region, which is conditionally regarded as background for Siberia (place of Tungus meteoroid fall). The density and character of track distribution from radionuclides fission fragments according to the annual rings of trees from the place of Tungus meteoroid fall (Podkamenaya Tunguska river, Bublik bog) are shown in the Fig. 3. According to the obtained results, there is a stable tendency of fissioned radionuclides accumulation level increasing is observed from the end of XIX century, and it reached maximum in 80^{th} XX century. To determine the background level of fissioned radionuclides in the «pronuclear» period (till 1945) several time intervals were determined, and average uranium content was counted (till 1945, fissioned radionuclides were introduced in nature only with ^{235}U).

It was determined that during the period from 1840 till 1899 the average fissioned radionuclides' content, in this case, uranium (^{235}U), in the wood was 0,06 mg/kg. During the period from 1900 till 1945 the content increased to 0,09 mg/kg, from 1946 till 1960 to 0,1 mg/kg, from 1961 till 1980 to 0,2 mg/kg. Thus, the background, «pronuclear» uranium content (^{235}U) in the place of Tungus meteoroid fall the level from 0,06...0,09 mg/kg can be accepted, this corresponds to 45...60 tracks/mm^2 tracks' density.

Examining wood samples, chosen in the Krasnoyarsk region territory, at the places of subterranean nuclear explosions (SNE) «Meteoroid-3» (held in 1977) and «Kimberlit-3» (held in 1979), long sequence of observations were received on fissioned radionuclides' accumulation in annual rings from 1936 till 2003, which covers «pronuclear» period (till 1945), a period of tests of nuclear weapons and modern history of fissioned radionuclides inflow to environment. At pic.4 the results of examining of one of the trees, which grew at the location place of SNE wells.

Analyzing the character of track distribution from fissioned fragments according to annual rings, the tracks density increases during the period of nuclear weapon tests in atmosphere: 1949–1950, 1953–1956, 1959–1960,

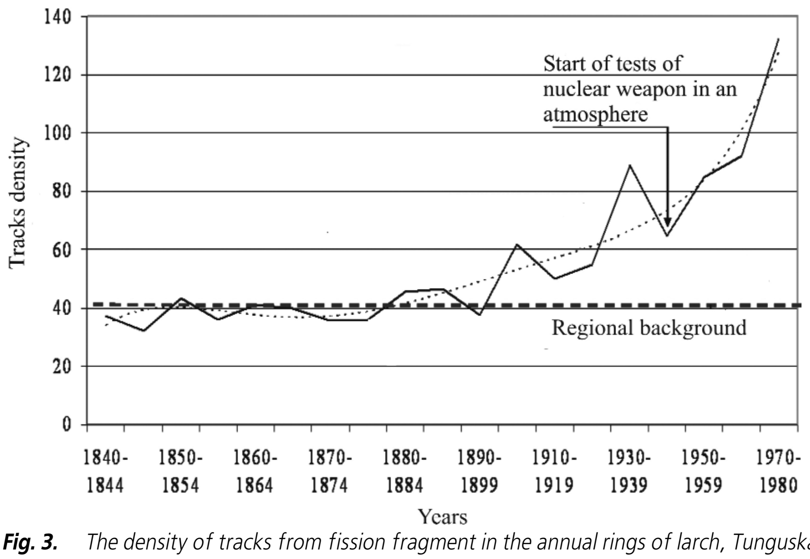

Fig. 3. *The density of tracks from fission fragment in the annual rings of larch, Tunguska river, Bublik bog*

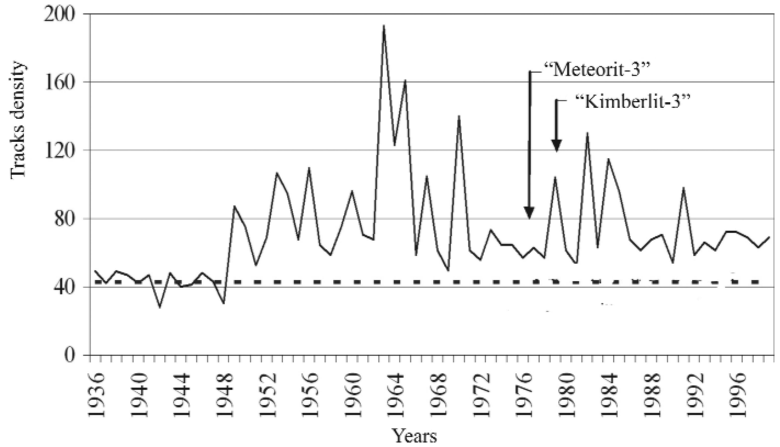

Fig. 4. *The distribution of tracks of fission fragments in annual rings of larch, at the site SNE «Meteoroid-3» and «Kimberlit-3», Tura settlement, Krasnoyarsk region*

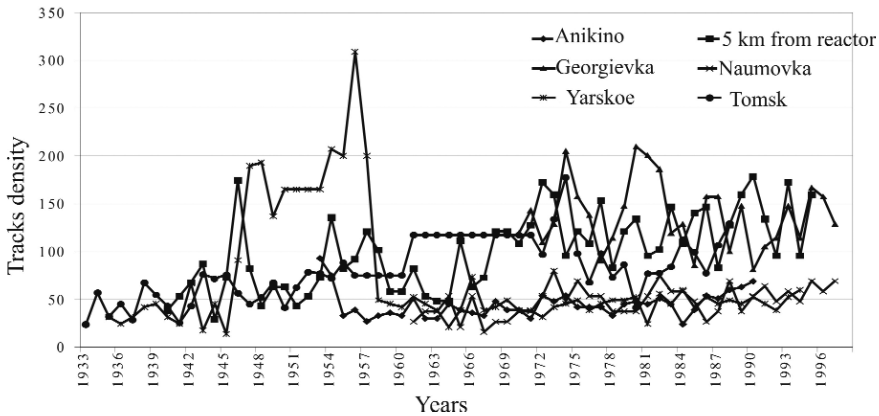

Fig. 5. *Track density of fissioned fragments in annual rings of pines from different places of SCC's influence, Tomsk Oblast*

1964, 1979. The maximum inflow of fissioned radionuclides into a wood was fixated (with small displacement according to annual rings for 2–4 years) during well-known periods of most active nuclear weapon tests at the polygon Novaya Zemlya (till 193±38 and 161±32 tracks/mm^2 in annual rings of 1963 and 1965), that exceeds the background level for this territory in 3–4 times.

These results show that application of f-radiography method allows fixating correctly the increase in content level of fissioned radionuclides, connected with its additional inflow to the environment. Further, in the annual rings of the time period when nuclear weapon tests were not hold (stopped in 1981 in all countries), the increased density of tracks, regarding the background level is observed in 1982, 1984, 1985, 1991. This means, that there were additional inflow of fissioned radionuclides into environment, which is probably connected with SNE «Meteoroid-3» and «Kimberlit-3», held in 1977 and 1979.

Peculiarities of track distribution of fissioned fragments in annual rings of trees, located in the influence zone of one of the nuclear-fuel-cycle enterprises- Siberian Chemical Combine (SCC), Seversk, are shown on Fig. 5.

As diagrams show, the character of accumulation of fissioned fragments in annual rings of trees from different places of SCC's influence are extremely heterogeneous. A steady tendency of increase in track density for the period of 1963–1997 is noticed, which indicates the constant inflow of fissioned radionuclides to the environment, and differs greatly the dynamics of their accumulation in comparison with background level. In one of the background areas (Yarskoe settlement) inflow of fissioned radionuclides during the period of nuclear weapon tests at 1945–1958 is fixed rather accurately.

According to the information received, till 1960 there were practically no difference between the character of accumulation of fissioned fragments in annual rings of trees, moreover, in the time interval of 1948–1960, their accumulation level because of global inflow from nuclear weapon tests in the sector which are out of SCC's influence (Georgievka settlement, Naumovka settlement) is higher. Starting from 1960-1963 the situation changes greatly. The accumulation level of fissioned radionuclides in annual rings out of SCC's influence sector remains at average global level, whereas in the sector of constant SCC's influence concentration of fissioned radionuclides, according to track density of fissioned fragments, increases more than in 2 times. This, from our point of view, can be explained by that fact, that starting from 1961, all 5 industrial reactors of plutonium manufacture and other process of nuclear fuel cycle production starts to work with full force on SCC, that leads to chronic fissioned radionuclides' inflow into the environment in those or other quantities.

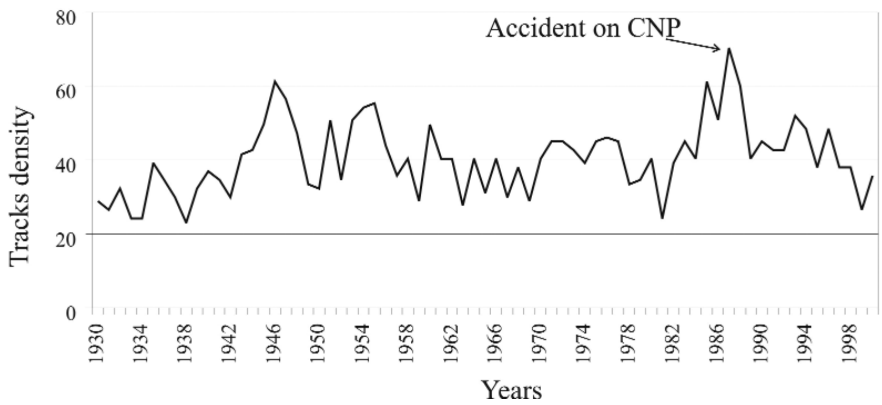

Fig. 6. *Density of tracks from fissioned fragments in annual rings of pines, Czech Republic*

For estimation of the inflow of fissioned radionuclides in the territories that suffered fell of radioactive waste after the Chernobyl disaster trees were examined, which places of sawing were chosen at the territories of Central Europe and Czech Republic. The territories of Central Europe are characterized with another history of radioactive pollution, as regions examined earlier.

The density and character of track distribution of fissioned fragments in annual rings of one of the pines, chosen at the territory of Czech Republic, which suffered Chernobyl's inflow are shown in the Fig. 6. The obtained dynamics shows that in general there is a tendency of increase in the content of fissioned elements in the periods of active nuclear weapon tests in the atmosphere (the accumulation level is much lower than in Russian regions) and during the period from 1985 till 1988 when Chernobyl disaster took place. An increase in the average density of tracks during the period from 1985 till 1988 (up to 65±8 track/mm^2) indicates the inflow after Chernobyl disaster in 1986. Accumulation level of fissioned radionuclides in the territory of Czech Republic during «pronuclear» period (content of elements from 1930 till 1945) corresponds to the average density of 35±6 track/mm^2, and contemporary regional level (from 1990 till 200) is 40±6 track/mm^2) . The obtained data corresponds to the background level defined earlier for Siberian regions.

Thus, using f-radiography method for wood examining, one can reveal for any territory the history of inflow of fissioned radionuclides into environment during definite period of time and also define a period of maximum inflow. As a result of radiography of annual rings one receives the data which correctly indicates general character of radioactive pollution by fissioned radionuclides, caused by global waste from nuclear tests and local inflow as a result of activitie of nuclear-fuel-cycle enterprises. Such reconstruction of events, occurred on any territory, is always relevant, and is caused by the necessity of evaluation of the level and consequences of radioactive pollution, happened because of various reasons (activity of Minatom enterprises, disasters, etc.). This allows estimating the irradiation potential doses and predicting a health level of the population, living in these territories.

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