POSSIBILITY ASSESSMENT OF DETERMINATION OF THE PLACE OF THE UNDERGROUND NUCLEAR TESTS BY MEANS OF ARTIFICIAL RADIONUCLIDES PRESENCE IN GROUNDWATER WITH STS EXAMPLE

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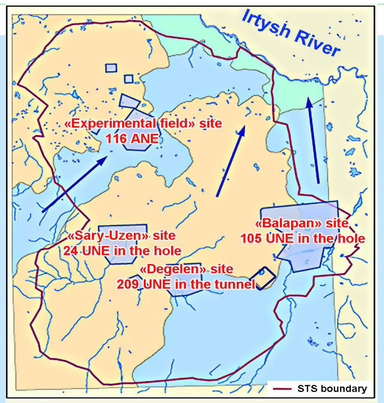


INTRODUCTION

456 nuclear tests were conducted at the territory of Semipalatinsk Test Site (STS) including 30 surface, 86 air and 340 underground nuclear explosions (UNE). Underground nuclear explosions were conducted in horizontal underground workings called tunnels at the «Degelen» site and in vertical underground workings called boreholes at the «Balapan» site.

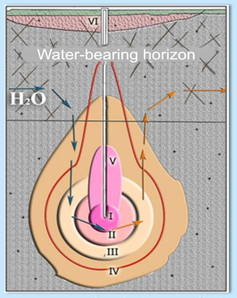
As a result of conducted nuclear tests there is a huge amount of radioactive products concentrated in blocks of geological environment, containing UNE central zones at the small area. Resulted fields of radioactive contamination significantly change with time, first of all, as a result of different types of radionuclide migration. The main radionuclides, currently participating in the STS underground water contamination, are ^{3}H, ^{90}Sr, ^{137}Cs and $^{239+240}$Pu.

«Balapan» site

Cavities of UNEs, which were conducted in boreholes, are located significantly below the level of underground water. High temperature in a cavity remains for a long time due to existence of the layer of overlying rocks. Presence of high temperature leads to thermal convection. Water gets heated in a UNE cavity, washes out chemical elements and radionuclides, and then returns to an aquifer.

Fracture water and fracture-vein water are main transporters of UNE radioactive products at "Balapan" test site. High concentrations of ^{137}Cs and ^{90}Sr in underground water are detected only in immediate vicinity to «warfare» boreholes. As research results show, in majority of samples, picked up on distance from «warfare» borehole more than 300 m, concentration of radionuclides drops to minimal detectable activity (MDA) values of the equipment used is <0.001 Bq/l.

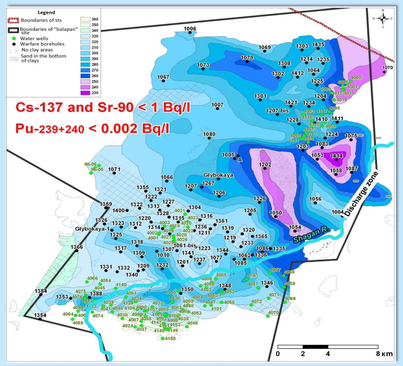
At the same time, concentration of ^{3}H in samples of underground water changes from MDA to values more than 500 times exceeding permissible level in drinking water.



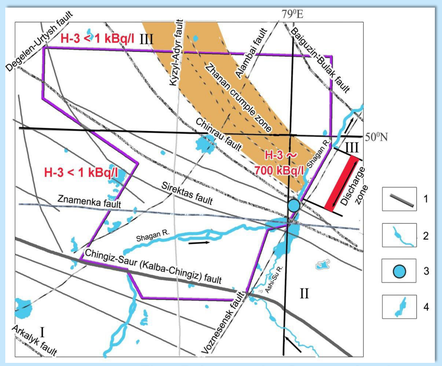
I- cavity and melt;
II- crushing zone;
III- intense fracturing zone;
IV- block fracturing zone;
V- collapse column;
VI- splitting off-off zone

Central zone of UNE in the hole

In the streams of underground water running outside "Balapan" site, concentration of tritium does not exceed 1.0 kBq/l (concentration of ^{137}Cs and ^{90}Sr does not exceed MDA). The exception is the area of underground water discharge into Shagan river, where concentration of ^{3}H reaches 700 kBq/l, that nearly 100 times exceeds permissible level for drinking water.



Map bedding depths of roofing water-bearing rocks



1 - test site boundary;
2 - water objects: rivers with permanent stream, lakes, rivers with intermittent stream;
3 - «warfare borehole» 1004 («Atomic» lake, internal reservoir);
4 - «Atomic» lake, external reservoir

The «Balapan» site. Structural and tectonic scheme

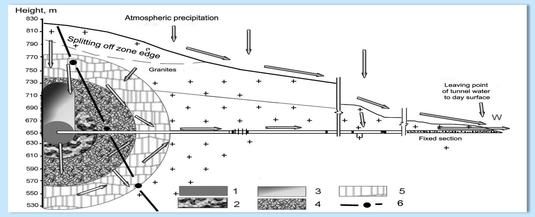
At the 10 km section of the riverbed from the border of STS concentration of tritium slowly decreases to the safe level. The main discharge of radioactively contaminated waters from "Balapan" site into surface waters occurs along the zones of tectonic fault at the territory of feathering-out of the confining stratum – neogene clays.

Here we can expect significant change in concentration of tritium in the discharge zone, because this migration process depends on hydrogeological factors and amount of atmospheric precipitations. Due to this, surface waters of Chagan river is one of the main sources of radiation danger, due to secondary contamination with products of nuclear tests conducted at the territory of STS.

«Degelen» site

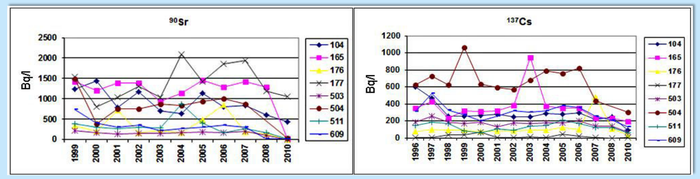
Radioactive contamination of Degelen massif underground water happens due to «wash out» of artificial radionuclides from rocks with atmospheric precipitations, coming to zones of nonreversible deformations through artificial fracture and fault systems. After this, a part of contaminated water comes to the day surface through the tunnel cavity and with spring water, the rest part comes to the ground water basin.

In tunnel waters of "Degelen" site high concentrations of artificial radionuclides were found. These concentrations significantly exceed permissible levels for drinking water (^{137}Cs – up to 1000 Bq/l, ^{90}Sr – up to 2000 Bq/l, ^{3}H – up to 1300 kBq/l and $^{239+240}$Pu up to 110 Bq/l).



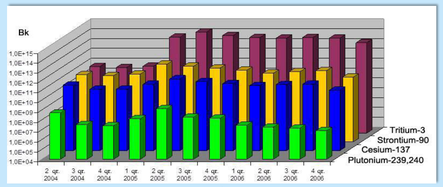
1- explosion cavity; 2- crushing zone; 3- collapse column;
4- intense fracturing zone; 5- zone of repainting of natural fractures; 6- deep faults

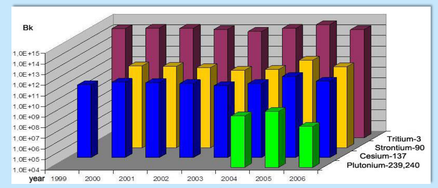
Central zone of UNE in the tunnel



Monitoring results of tunnel waters

Concentration of radionuclides' washed out with tunnel water is shown on the basis of quarter and annual data. By comparison quarter and annual data conclusion is made, that annual variations of washed out elements are much less than quarter variations – from year to year radionuclide concentration remains stable.



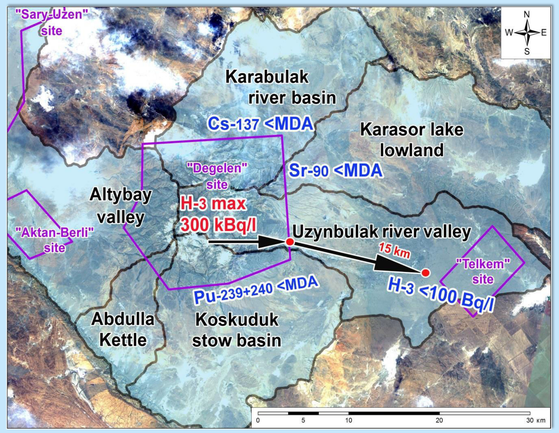


Results of: a) quarter; b) annual monitoring of tunnel waters

Contaminated tunnel water discharges into natural drain canal – valleys of creeks. All the underground waters, running outside of Degelen mountains, are divided into individual streams according to their belonging to local watersheds, where feed, transition and discharge appear within the area of basins, with the length up to 20 km.

At the territory, where underground water streams run beyond Degelen massif, concentrations of ^{137}Cs, ^{90}Sr and $^{239+240}$Pu in water do not exceed the MDA. At the same time, values of ^{3}H concentrations varies depending on direction. Maximal values on tritium, within the borders of massif, reach 260 kBq/l. At the distance of 10 km from mountains, the concentration of tritium reaches values of 10 - 30 kBq/l, and at the distance of 15 km, the concentration drops to 0.10 kBq/l.

So, the process of underground water contamination beyond the "Degelen" site is still in progress, and according to radiation monitoring data, it has quite a stable character. Long-term monitoring data and theoretical calculations have shown that in the foreseeable future increasing concentrations of ^{137}Cs, ^{90}Sr and $^{239+240}$Pu in the flow of underground water running beyond boundaries of test sites will not happen. Only tritium will be the main radioactive contaminator of underground waters at the territory of the STS at the present time and in the future.



The «Degelen» site. Schematic arrangement of local reception basins

CONCLUSION: The research experience of UNE in the territory of STS can contribute to the more successful development of on-site inspection technologies. Efficiency of on-site inspection can be significantly increased with use of method, which is connected with measurement of artificial radionuclides in ground water. Presence of tritium in ground water is evidence of UNE conduction in about 20 km radius. Detailed research of ^{137}Cs and ^{90}Sr dissemination in ground water can show more precise place of UNE conduction.