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RADIOACTIVITY OF SPRING AND SURFACE WATERS IN THE REGION OF THE URANIUM ORE DEPOSIT AT ŽIROVSKI VRH

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Data are presented on ^{222}Rn, ^{226}Ra, natural uranium concentrations and gross beta activity of spring and surface waters in the region of the uranium ore deposit at Žirovski vrh. The concentrations were found to be relatively low. There is some increase in the vicinity of the explorative Uranium Mine but is, at least up till now, only of a local character.

Introduction

In connection with the introduction of nuclear energy to Yugoslavia, two years ago this Laboratory started determinations of ^{222}Ra, natural U and gross beta activity in springs and hot spring waters in Slovenia.

In the Republic of Slovenia (see Fig. 1) there is an explorative uranium mine at Žirovski vrh,[1,2] which is to be opened for exploitation in about two years. Near Krško on the border between Slovenia and Croatia, a 630 MW nuclear power plant (JEK) is being built and will begin to operate in 1979. These two programes, when realized, will increase the radioactivity in the environment, primarily in surface waters and subsequently in underground waters. There is already a slight increase due to explorative mining in Žirovski vrh, but fortunately it is of a local character.

The aim of our work is to estimate the background radioactivity in waters before the begining of the anticipated artificial radioactive contamination.[1] This will enable us later to detect the changes caused by the above mentioned activities. On the other hand, springs should be investigated to select those with the lowest possible level of radium for municipal water supplies.

In this long-term program we intend to determine the above mentioned components in the waters of main Slovenian rivers (Sava, Drava, Sora, Mura, Savinja, Soča, Ljubljanica, Krka) and in waters of springs from different geological regions in Slovenia, as well as waters originating from geological boreholes.

In this paper results obtained in 1976 for the Sava and waters in the region of the uranium ore deposit at Žirovski vrh are presented.

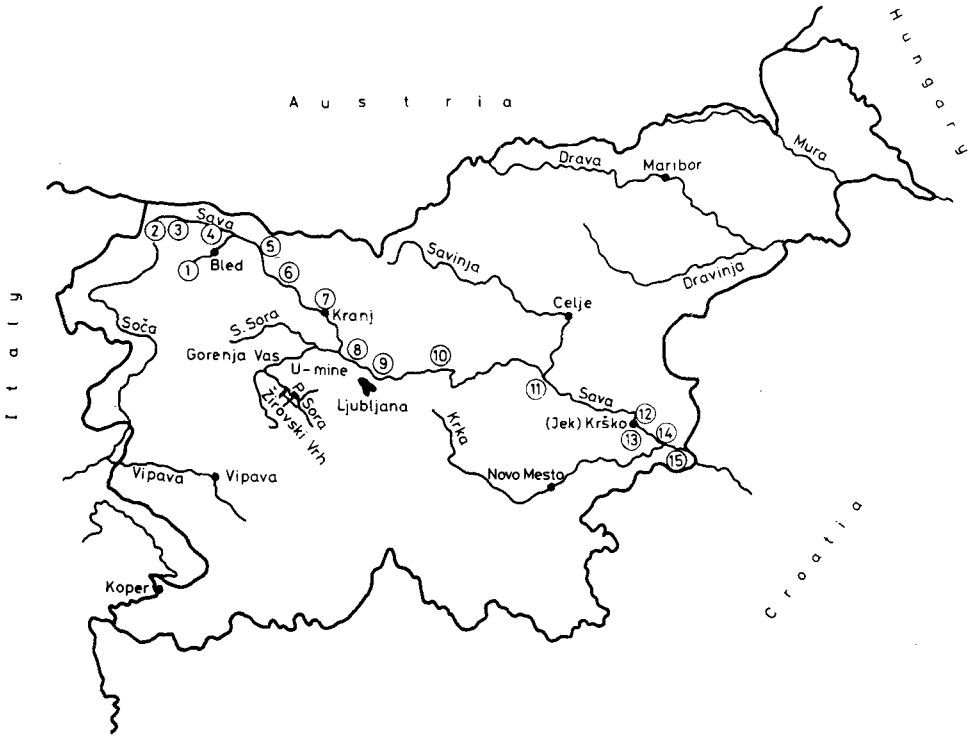

Fig. 1. Sampling sites of the Sava

Sampling and analytical methods

For radon determinations, the water sample was enclosed in a 0.6 litre glass flask, radon gas being subsequently transferred[3] from the sample to an alpha scintillation cell[4] and after three hours, the alpha activity in the scintillation cell was measured.

For radium determinations, 20 litre water samples were collected, radium was concentrated on a cationic exchange resin and after three to ten days, the radon formed by radioactive decay of radium sorbed on the resin, was determined by the sorption-emanation method.[5] In both cases the experimental errors proved to be about 30% for low concentrations (e.g. 1 pCi/l for Rn and 0.02 pCi/l for Ra) and approximately 10% for high concentrations (over 5 pCi/l for Rn and 0.1 pCi/l for Ra).

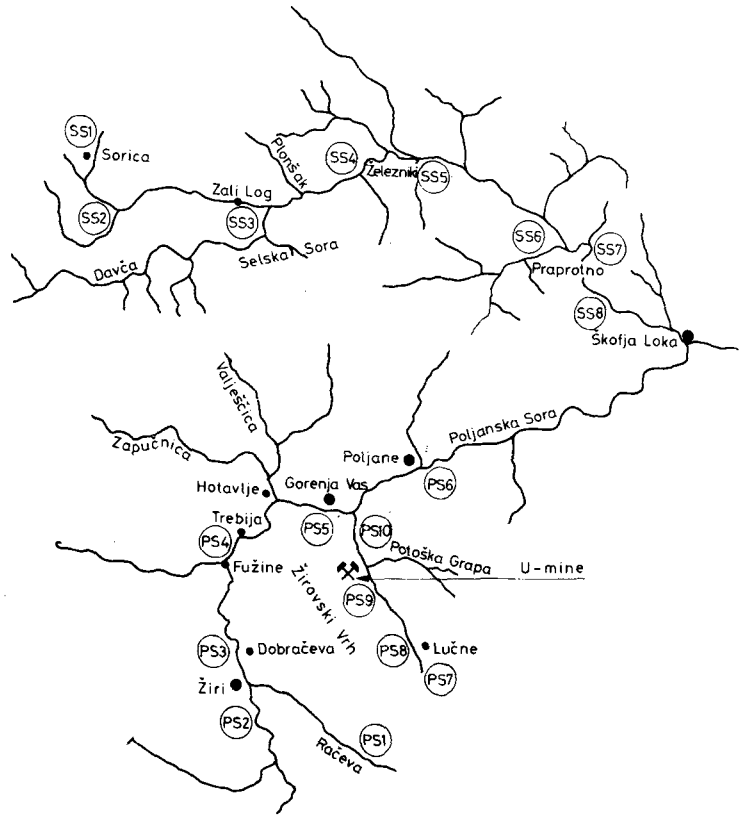

Fig. 2. Sampling sites of the Poljanska Sora and Selška Sora

Gross beta activity was determined in the residue of a 1 l sample, ignited at 450 °C, by counting on a low background anticoincidence Philips G. M. counter. The counter was previously calibrated with a K standard.

Uranium was determined by the fluorimetric method with a K–Na carbonate-fluoride flux, following TBP extraction.

Sampling sites and results

Sampling sites are shown in Figs 1 to 4 and may be divided into 5 categories:

(1) uranium mine water (symbol U) and the river Brebovščica about 200 m upstream (B1) and about 200 m downstream (B2) with regard to the inflow of the mine water (Fig. 3);

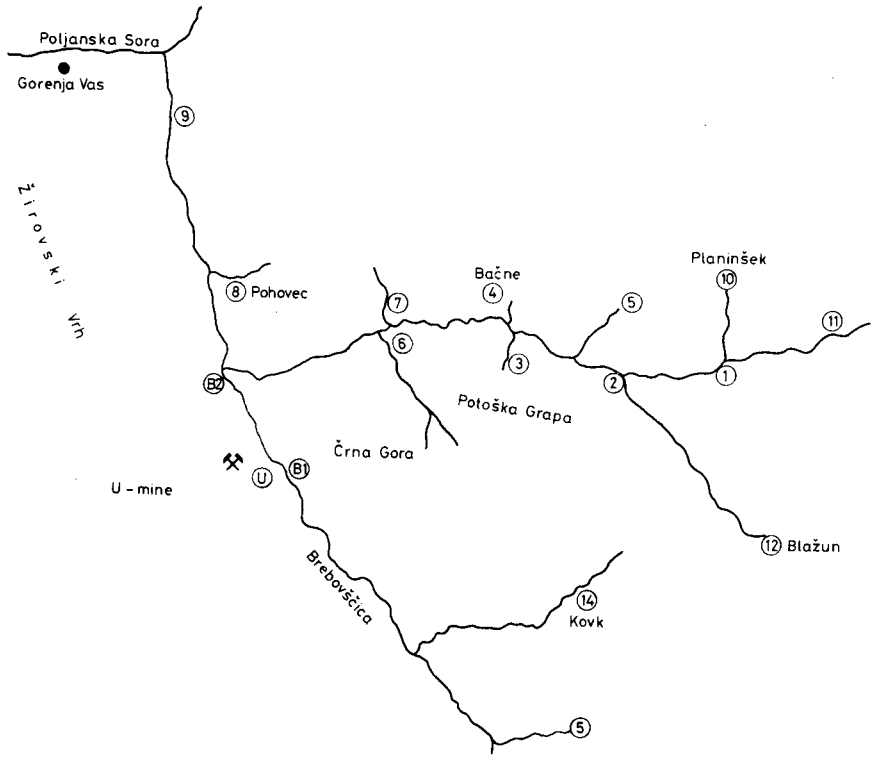

Fig. 3. Sampling sites of waters originating from Potoska grapa

(2) surface waters in the broad U mine region (rivers Poljanska Sora and Selška Sora and some local brooks (PS, SS in Fig. 2);

(3) waters from springs and boreholes in the valley of Potoška Grapa where tailings are to be situated (numbers in Fig. 3);

(4) waters from springs originating from the mountain of Žirovski vrh (numbers in Fig. 4);

(5) river Sava, which can be contaminated by waters originating from the U mine region (numbers in Fig. 1).

Uranium mine water (1.3 m^3/min), after a superficial course of about 100 m, flows into the river Brebovščica (having an average flow of 0.74 m^3/sec), which, at about 3 km from the mine flows into the river Poljanska Sora (having an average flow of about 15 m^3/sec). Finally the water comes into the main Slovenian river, the Sava.

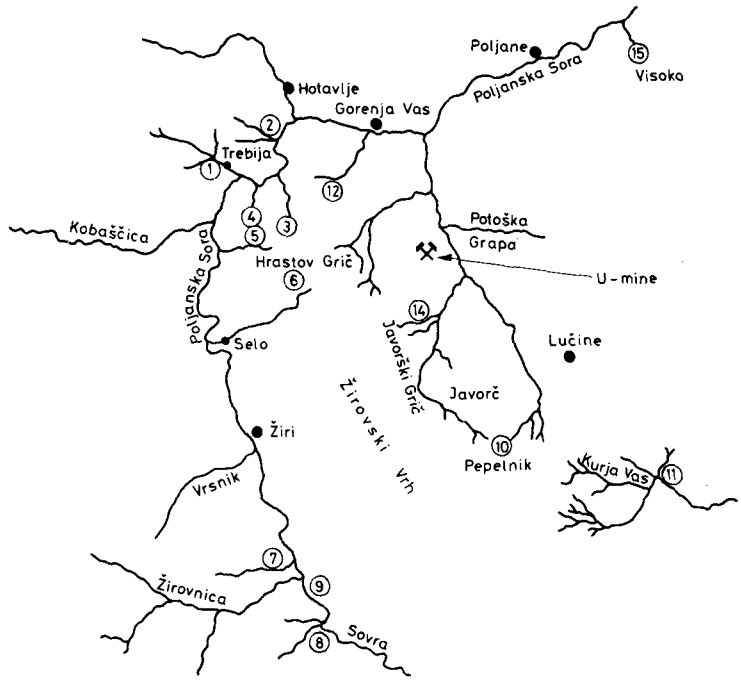

Fig. 4. Sampling sites of waters originating from Žirovski vrh

U mine water (U), as well as the river Brebovščica before (B1) and after the inflow (B2) of the mine water, were sampled monthly. The results obtained are collected in Table 1 (average values for the year 1976.) Only a slight increase of radium and uranium concentration and gross beta activity in the Brebovščica caused by the U mine drainage is evident.

Table 1
Radioactivity of the U-mine water and the Brebovščica (Fig. 3)

Sample	Rn, pCi/l	Ra, pCi/l	Gross β, pCi/l	Nat. U, μg/l
U	200	6.3	50.3	147
B1	16	0.08	2.0	0.6
B2	8	0.36	4.6	9

Table 2
Radioactivity of the Poljanska Sora and Selška Sora (Fig. 2)

Sample	^{222}Rn, pCi/l	^{226}Ra, pCi/l	Gross β, pCi/l	Nat. U, μg/l	Dry residue, mg/l
SS 1	17	3.1	2.0	2.1	92.4
SS 2	9	0.02	2.1	0.1	106.4
SS 3	9	0.02	3.9	0.2	104.4
SS 4	10	0.01	4.4	0.2	102.8
SS 5	19	0.03	3.9	0.4	109.6
SS 6	31	0.01	5.1	0.13	111.7
SS 7	31	0.04	1.0	0.15	53.3
SS 8	33	0.03	1.3	0.1	109.7
PS 1	23	0.02	1.9	0.1	19.2
PS 2	34	0.25	1.5	0.3	127.0
PS 3	48	0.03	1.8	0.23	106.0
PS 4	17	0.04	1.6	0.1	84.2
PS 5*	17	0.11	2.1	0.6	–
PS 6*	31	0.11	1.9	0.8	–
PS 7	20	0.03	1.6	0.11	93.0
PS 8	16	0.18	1.9	0.07	613
RS 10	91	0.13	3.6	4.3	76.7

*Mean values for the year 1976 of the samples analyzed monthly.

Samples PS5 and PS6 were analyzed monthly and in Table 2 the mean values for the year 1976 are given. There is no obvious evidence for contamination of sample PS6 (with regard to PS5) due to uranium mining at Žirovski vrh.

Table 2 gives insight into the background radioactivity of the rivers Poljanska Sora and Selška Sora. With only a few exceptions with slightly increased values, concentrations of radioactive components are otherwise relatively, low.

In Table 3 radium concentrations of waters in the valley of Potoška Grapa are collected. These results are very important because this place is one of the locations for tailings from the planned uranium industry.

As is evident from Table 4, waters originating from the mountain of Žirovski vrh (rich in uranium ore deposit) do not contain an increased amount or radioactive components.

Finally, the radioactivity of the river Sava, which might be directly contaminated by waters from the U mine region is presented in Table 5. A glance at the Table assures us that this contamination has been, at least until now, negligible. (It does not reach significantly the river Poljanska Sora at spot PS6, as was shown above).

Table 3
Radioactivity of waters from the Valley of Potoška Grapa (Fig. 3)

Sample	^{222}Rn, pCi/l	^{226}Ra, pCi/l	Gross β, pCi/l	Nat. U, μg/l	Dry residue, mg/l
1	8	0.02	8.2	1.0	47.3
2	281	0.07	1.2	0.25	148.7
3	30	0.03	1.2	0.1	14.0
4	330	0.04	2.9	0.2	73.9
5	27	0.03	1.4	0.2	180.1
6	52	0.13	28.7	0.25	76.3
7	22	0.04	2.1	0.1	58.2
8	8.2	0.06	5.9	0.1	46.5
9	14	0.03	1.6	0.1	23.5
10	100	0.23	6.9	0.13	259.3
11	9	0.02	0.9	0.1	31.3
12	6	0.06	1.9	0.1	23.6
14	205	0.11	1.6	0.1	169.1
15	63	0.13	2.8	0.3	210.3

Table 4
Radioactivity of waters originating from the mountain of Žirovski vrh (Fig. 4)

Sample	^{222}Rn, pCi/l	^{226}Ra, pCi/l	Gross β, pCi/l	Nat. U, μg/l	Dry residue, mg/l
1	258	0.05	3.3	0.4	148.7
2	23	0.02	0.3	0.5	185.2
3	29	0.05	0.2	0.1	27.1
4	108	0.04	0.8	0.2	24.0
5	82	0.01	2.5	0.8	26.0
6	155	0.02	0.2	0.1	15.3
7	42	0.08	1.5	0.32	137.4
8	47	0.03	1.8	0.31	169.9
9	35	0.03	1.0	0.31	143.3
10	101	0.03	2.5	0.07	21.7
11	13	0.03	1.2	0.26	135.9
12	10	0.35	3.0	0.1	28.3
13	42	0.09	1.0	0.1	31.5
14	372	0.89	2.4	0.55	25.2
15	85	0.04	1.4	0.25	143.6

Table 5
Radioactivity of the Sava (Fig. 1)

Sample	^{222}Rn, pCi/l	^{226}Ra, pCi/l	Gross, pCi/l	Dry residue, mg/l
1	0.3	0.16	0.8	121.6
2	34.4	0.09	2.9	168.6
3	1.0	0.02	0.9	82.5
4	8.1	0.04	1.7	110.9
5	1.3	0.05	1.5	148.2
6	6.2	0.02	1.6	139.2
7	7.8	0.01	0.8	146.1
8	17.5	0.01	1.1	144.8
9	19.2	0.02	1.8	155.6
10	21.3	0.01	1.5	166.1
11	36.3	0.25	2.9	182.4
12	11.5	0.16	1.3	177.5
13	13.2	0.20	1.4	178.6
14	14.3	0.15	1.9	186.7
15	12.2	0.11	1.1	214.9

Conclusions

In the year 1976 a number of samples were analyzed of the Žirovski vrh U mine water, boreholes and springs, and surface waters in the region of Žirovski vrh, as well as those which might be contaminated by the U mine water, such as the river Sava. The radium concentrations (radium may be the most important component) were found to be relatively low in comparison with some other literature data.[6–14] Namely, in some regions of uranium deposits, concentrations of 14^{8} and as high as 110^{14} pCi/l were found. This means that great efforts should be expended in planning water cleaning facilities for U mining and milling installations at Žirovski vrh in order to keep the contamination of these waters at sufficiently low levels.

In the following years we intend to continue the determination of ^{222}Rn, ^{226}Ra, natural U and gross beta activity in drinking and surface waters in Slovenia. We shall analyze new samples and repeat some of the determinations of 1976 to reveal seasonal variations. Thus we hope to be able to construct a map of the natural background radioactivity before the commencement of the nuclear industry in this country.

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