EXPERIENCE OF REGISTRATION EXTREMELY HIGH VALUES OF RADON EXHALATION RATE IN THE VICINITY OF THE PYATIGORSK WATER RESORT , RUSSIA

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INTRODACTION

The main aim of our researches is the assessment of the components of "natural terrestrial gamma radiation" and radon in natural environment in the territory of disused uranium mines in the Mount Beshtau (North Caucasus) in the vicinity of the Pyatigorsk water resort area.

This region is one of the most radon-hazardous in Russia and characterized by the increased radioactivity of rocks, a system of deep faults and radioactive groundwater discharge.

The mining of the uranium ore was carried out in the Mount Beshtau from 1949 to 1985.

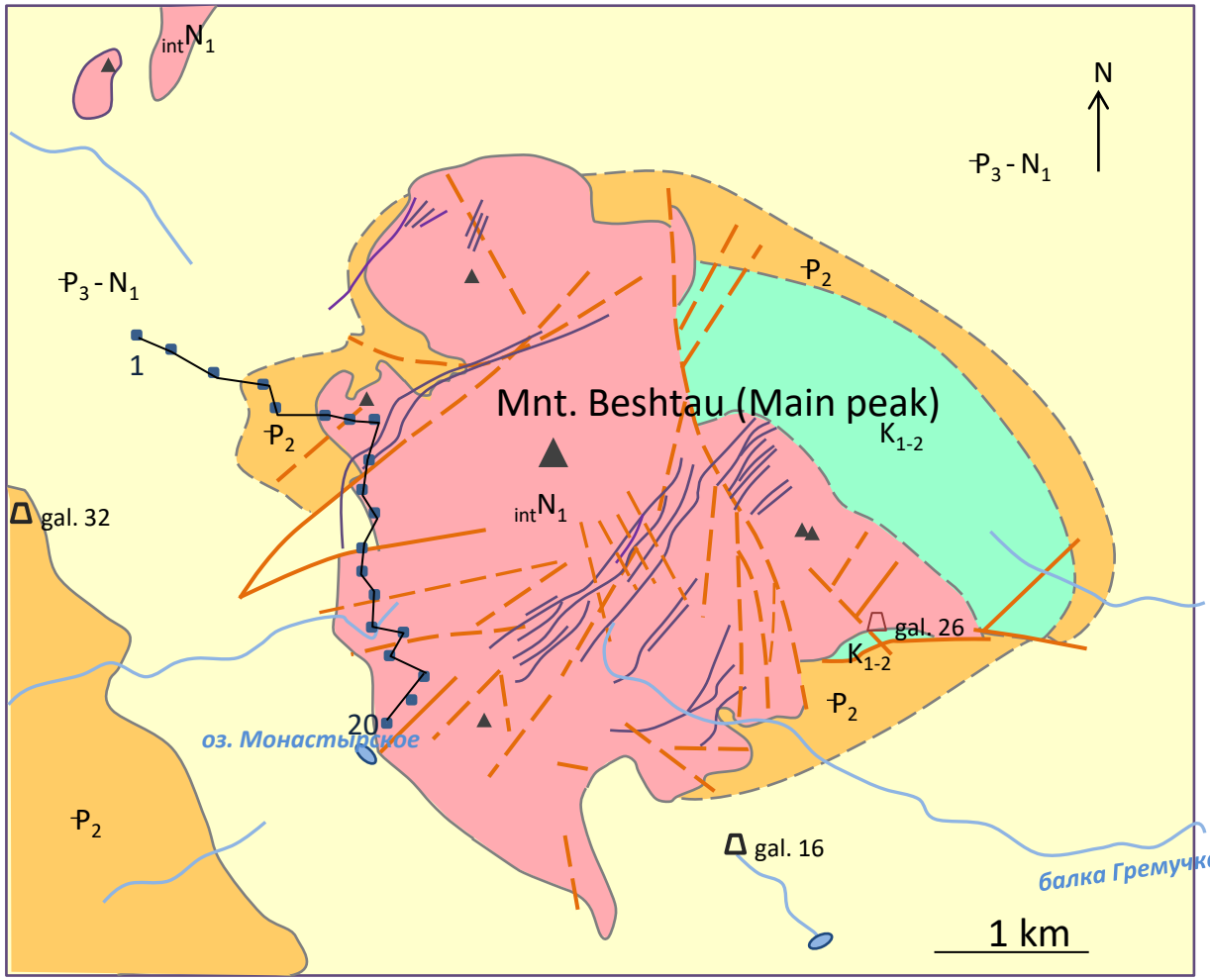
The measurements of radon exhalation rate from soil surface, radon activity concentration in the air, gamma-doze rate, radium content in soils were carried out from June 2017 to June 2018

Location of the studied area

PYATIGORSK WATER RESORT AREA

Mount Beshtau is located in the North Caucasus region. Water resorts Pyatigorsk, Zheleznovodsk, Essentuki are located nearby the Mount Beshtau.

Geological conditions of the studied area



The central part of the Beshtau is a complex of Neogene alkaline granite porphyries, trachytes and liparites that are known collectively as "beshtaunites“

The peripheral part is composed of sedimentary deposits — clays, limestones, and marls.

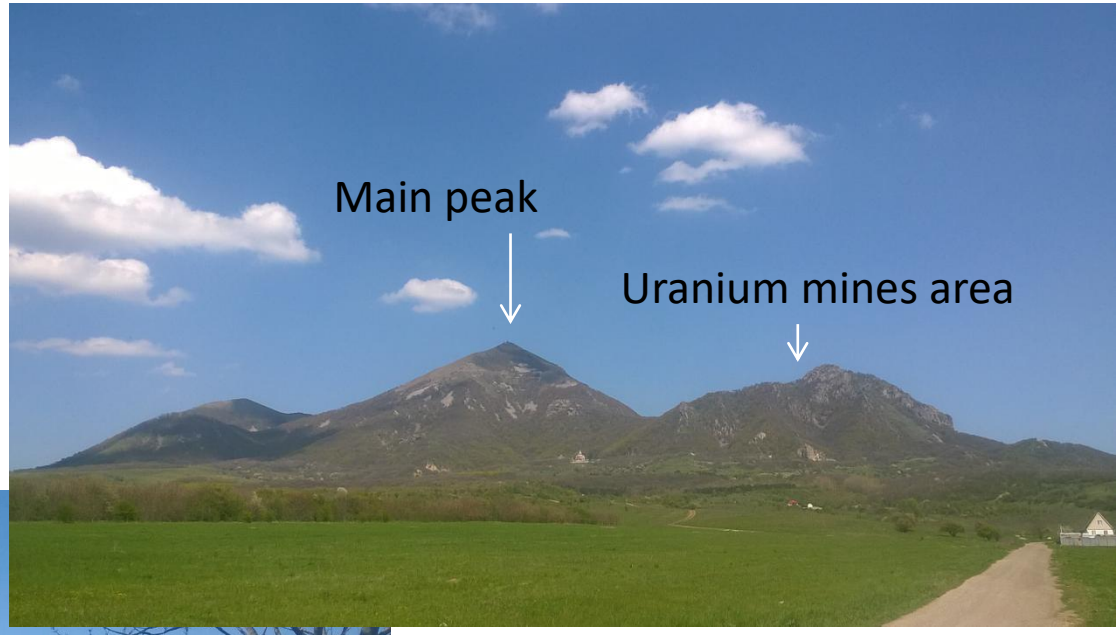
The mountain is dissected by system of faults.

The uranium ores are located in generally in the south part of mountain .

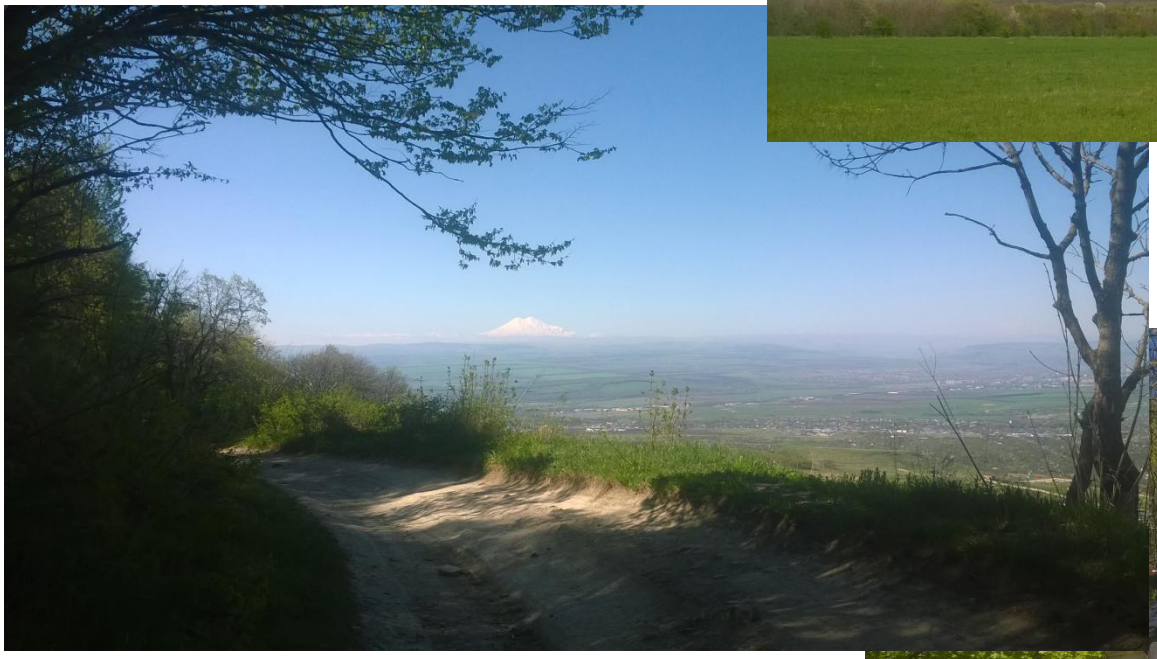
LEGEND:

1 – limestones, 2 – marls, 3 – clays (Maikop sequence), 4 –granite porphyry and trachytes (beshtaunites), 5 – faults, 6 – uranium viens, 7 –adits, 8 – measurement profile

View of mount Beshtau from Pyatigorsk



Translated from the Turkic Beshtau means " five mountains"



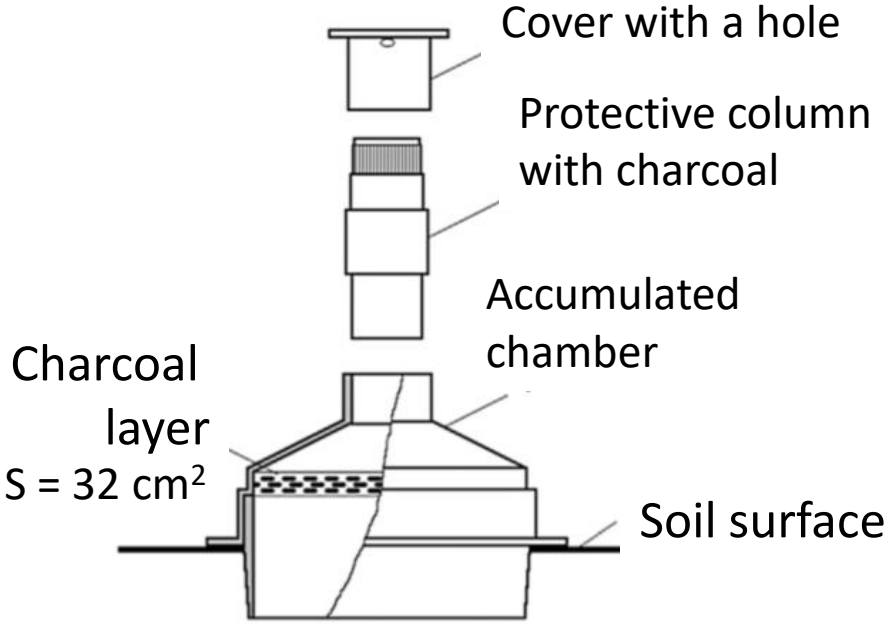
View from mount Beshtau to Elbrus (Caucasus Ridge)

Disused uranium gallery

Method of radon exhalation measurement

We used the coal method to measure radon exhalation. The principle of the method is in the adsorption of radon exhaling from soil surface by the activated charcoal, located in the accumulated open chamber

Time of radon accumulation is 4 – 8 hours

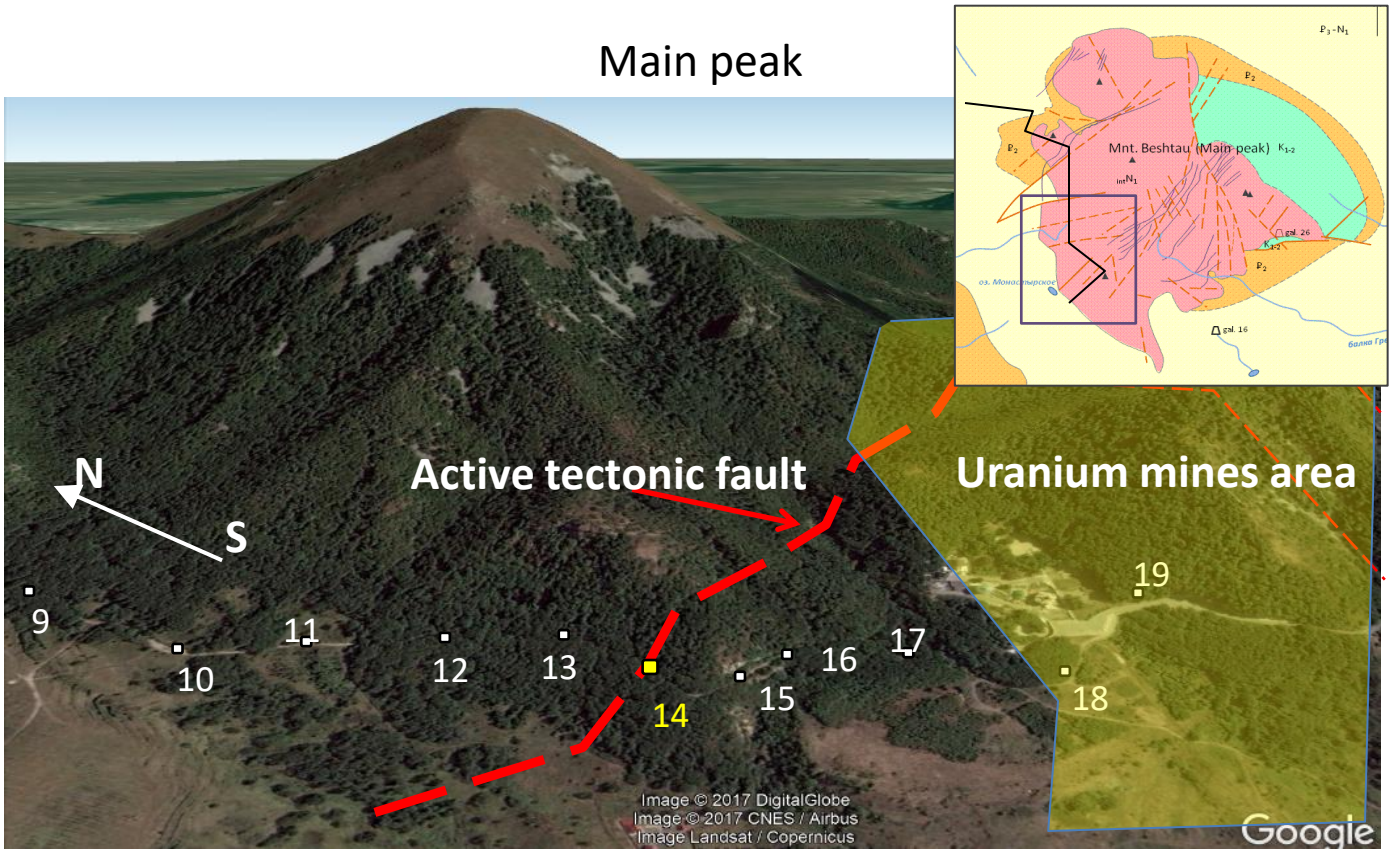


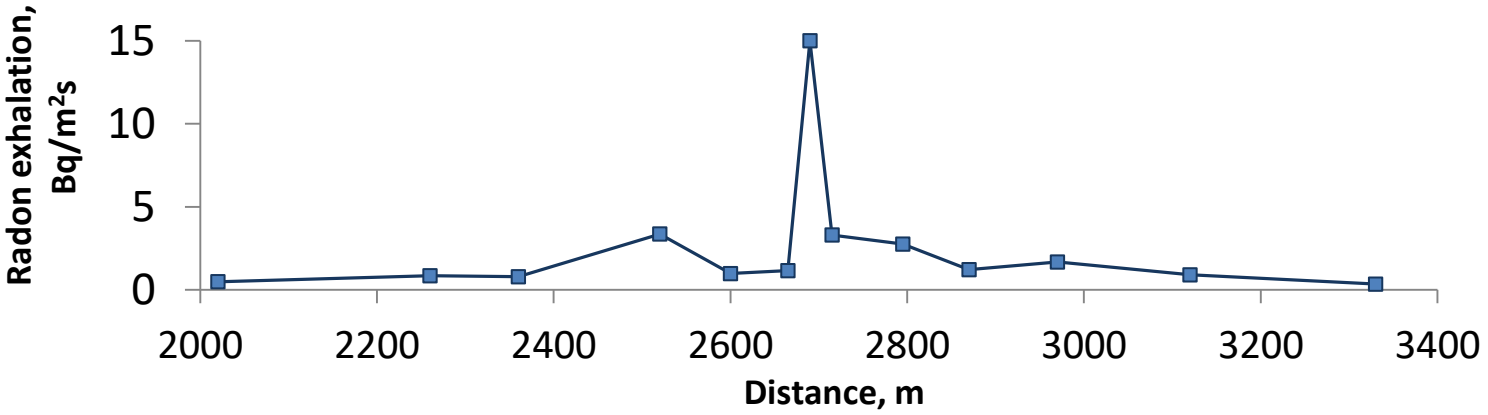
After accumulation radon activity in charcoal determine in laboratory by means the gamma-spectrometer (*NaI(Tl)*) or beta-radiometer (Geiger-Mueller). The radon exhalation rate calculates as a function of radon activity in the charcoal, the square of the base of accumulation chamber and accumulation time

Radon anomalous zone at mount Beshtau

The measurement profile locate on the western slope of Behstau in near of the uranium mines

In active fault zone (point #14) were obtained the strong abnormal radon levels.





Generalized results of measurements

Type of rocks		Radon exhalation rate, mBq/m^2s	Air radon activity concentration, Bq/m^3	Content of ^{226}Ra, Bq/kg	$^*H(10)/dt$, μSv/h
Granit-porphyries		1438 (1104) 337–3370	3–62	183 (53) 120–280	0.37 (0.09) 0.20–0.50
Clays		295 (137) 136–419	6–27	100 (71) 57–182	0.24 (0.04) 0.21–0.28
Marls & Limestones		66 (22) 58–75	5–6	40 (12) 35-44	0.15 (0.02) 0.12–0.18

in the numerator — the average value (standard deviation), in the denominator — the range

Content of radionuclides in soils and bedrocks and dose rate values on Beshtau

Point no.	Atmospheric air Rn activity concentration, Bq/m^3	Exhalation rate of Rn, Bq/m^2s	Content of radionuclides in soils and bedrocks, Bq/kg			Gamma dose rate, μSv/h	Type of soil or rocks
			$^{226}Ra \pm \Delta$	$^{232}Th \pm \Delta$	$^{40}K \pm \Delta$		
9	<17	0.48±0.07	-	-	-	0.31	Soil
10	<10	0.84±0.12	120±30	220±25	980±99	0.31	Soil
11	<13	0.78±12	-	-	-	0.30	Soil
12	9±7	3.36±0.5	214±13	179±18	979±93	0.38	Bedrock
13	<18	0.97±0.14	-	-	-	0.32	Soil
14	**4062±1800**	**15.00±2.30**	**156±32**	**251±42**	**1586±393**	**0.45**	**Soil**
15	10±5	2.75±0.39	203±38	151±15	1538±210	0.50	Bedrock
16	62±29	1.21±0.18	160±34	169±23	1221±190	0.49	Bedrock
17	9±6	1.67±0.22	130±24	180±23	1002±130	0.40	Bedrock
18	<12	0.89±0.14	-	-	-	0.27	Soil
19	11±6	0.34±0.05	151±24	196±20	1231±140	0.43	Soil

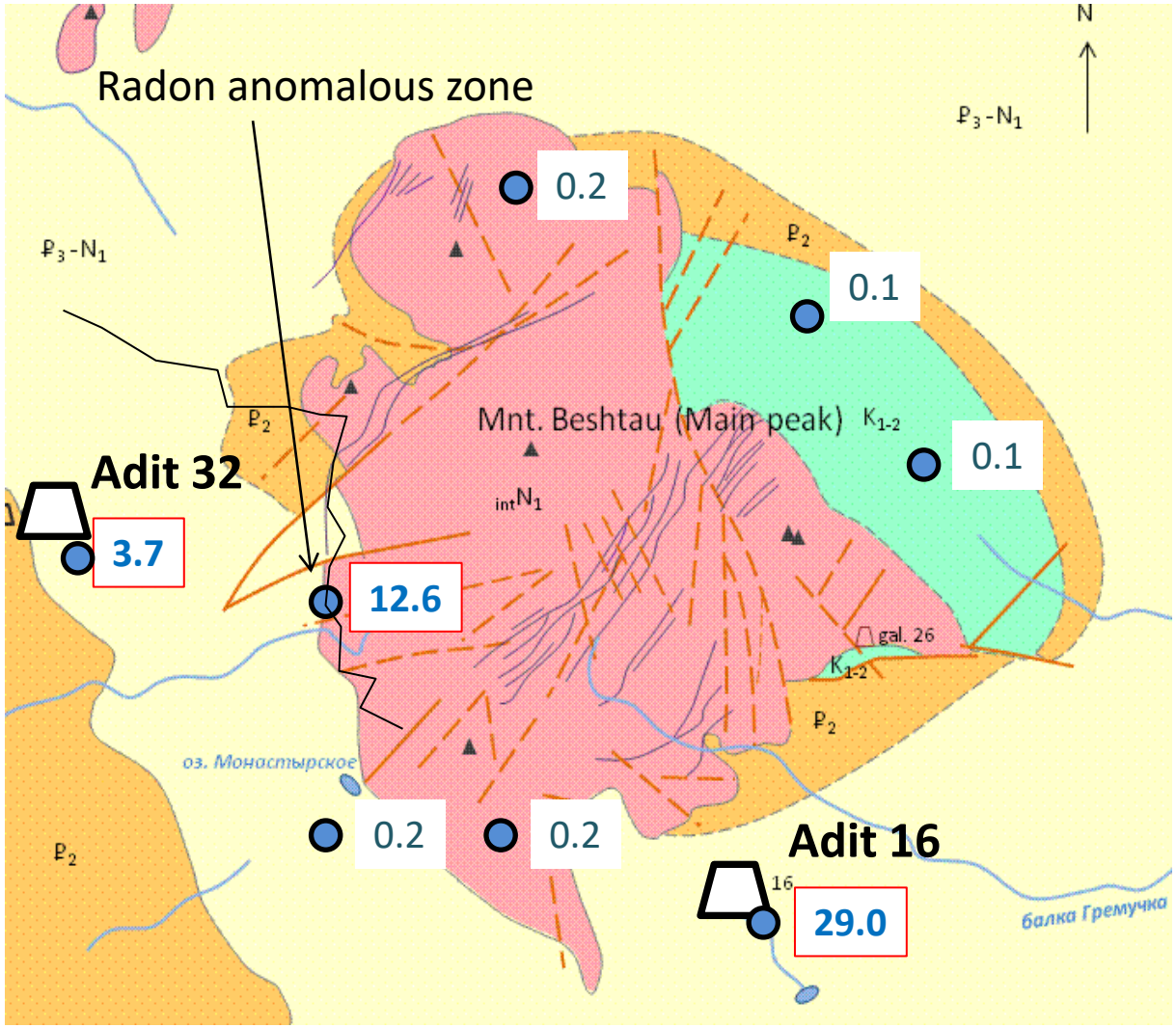
In abnormal zone the air radon activity concentration and radon exhalation are more than 400 times exceeds the world average values. At the other points of the measurement profile, the radon exhalation rate and activity concentration in air corresponded to the background values typical for the mountain Beshtau.

Results of additional measurements of radon exhalation rate in the anomalous zone

Point no.	Distance from the anomaly (p. #14), m	*H(10)/dt, μSv/h	Atmospheric air radon activity concentration, Bq/m^3	Radon exhalation rate, mBq/m^{2}s
14-1	27	0.34	12±6	1150±171
14-2	7	0.40	1500±250	12700±1900
14	0	0.45	4060±1000	15000±2300
14-3	12	0.37	<8	747±110
14–4	23	0.36	10±6	3900±550

Detailed studies were carried out in the anomalous zone. The distance between the measuring points was about 10 m. The studies show that the width of the anomalous zone is not more than a 30 meters.

Results of measurements of uranium activity concentration in groundwater Beshtau

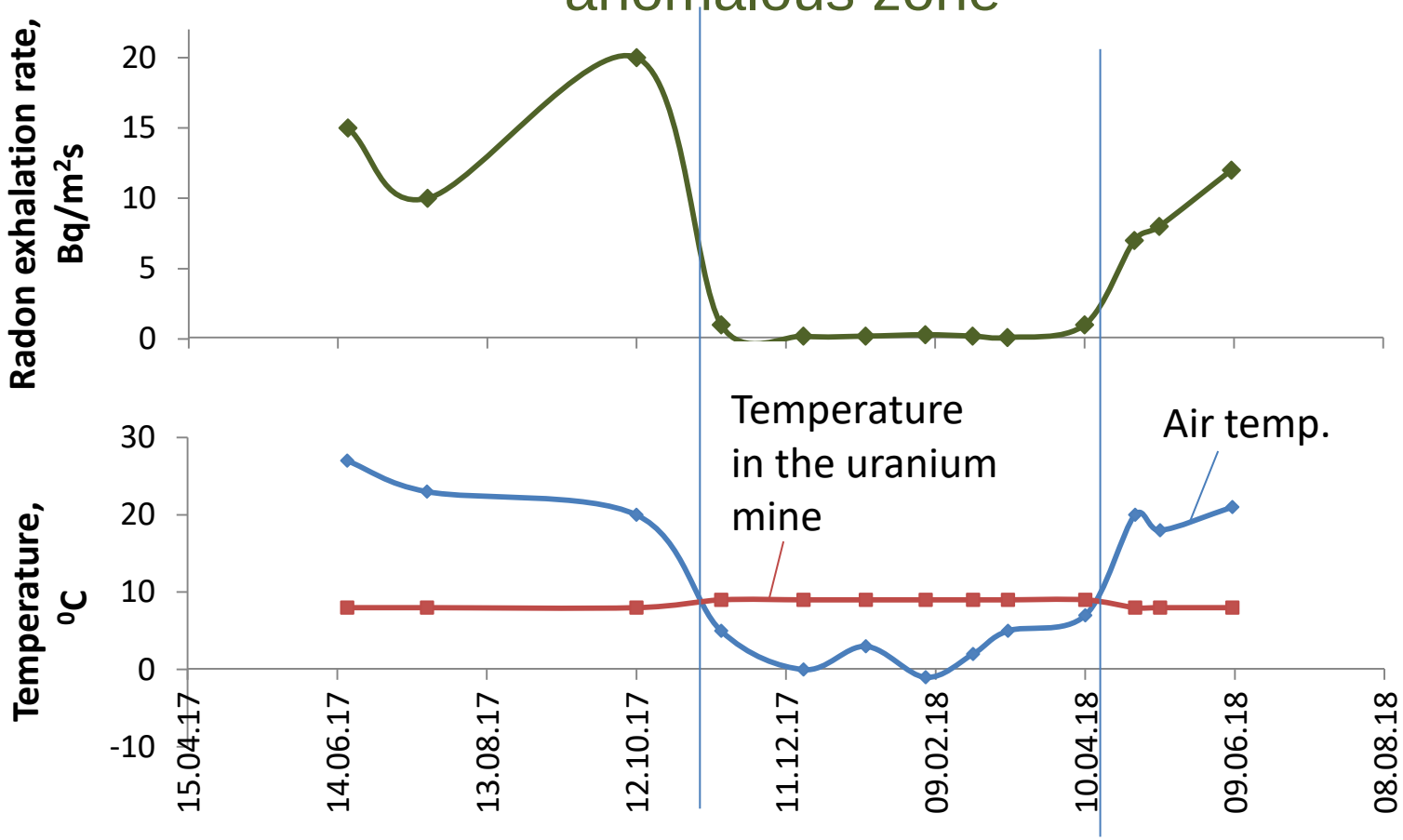


Uranium activity concentrations were measured in groundwater and in the discharge of uranium gallery, as well as in water leaking out of the slope in the anomalous zone.

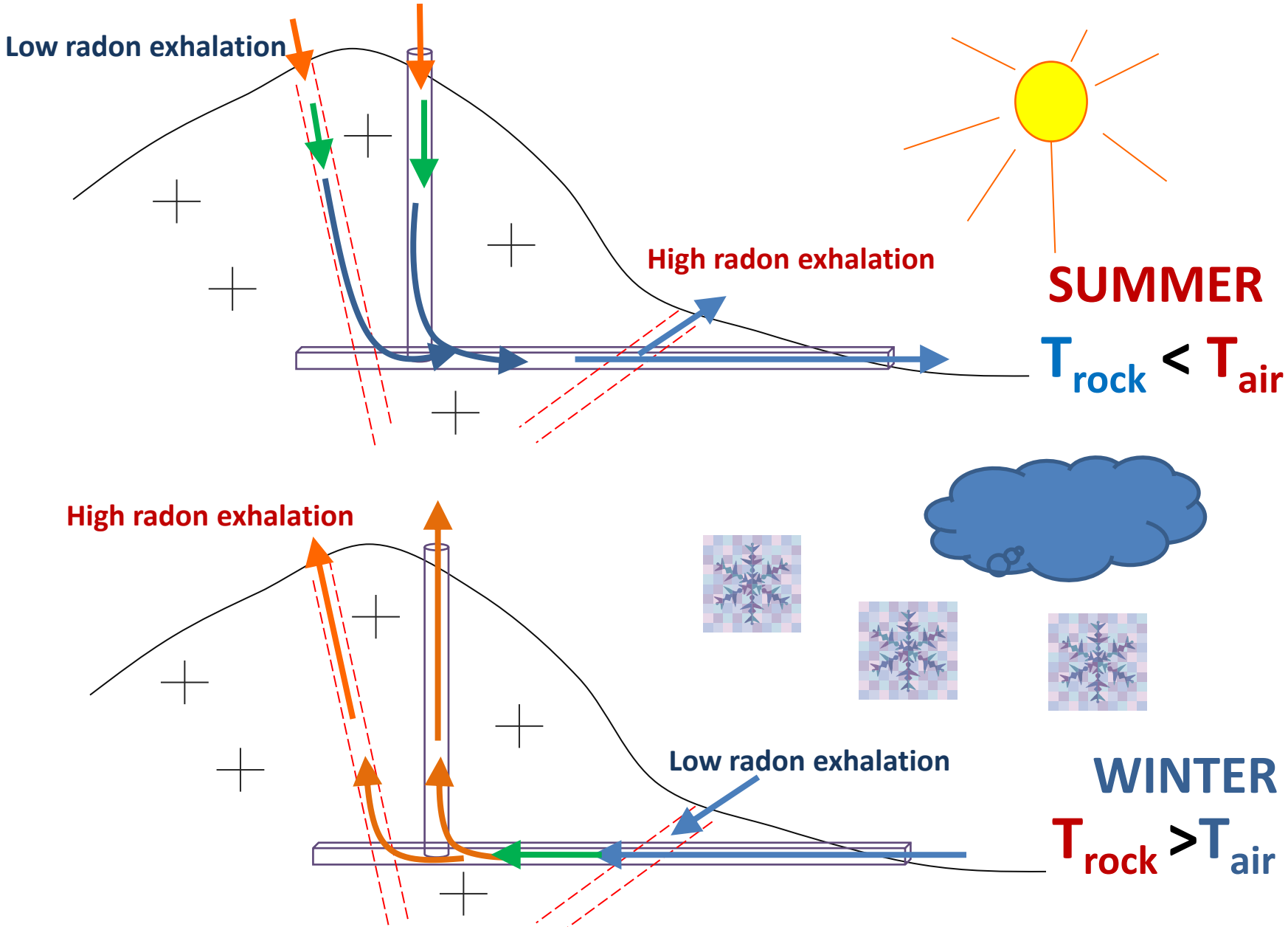
High values of uranium concentration in the water of the anomalous zone showed that this zone is connected with the mine space.

12.6 sampling point and uranium activity concentration in groundwater, Bq/dm^3

Result of monthly radon exhalation measurement in anomalous zone



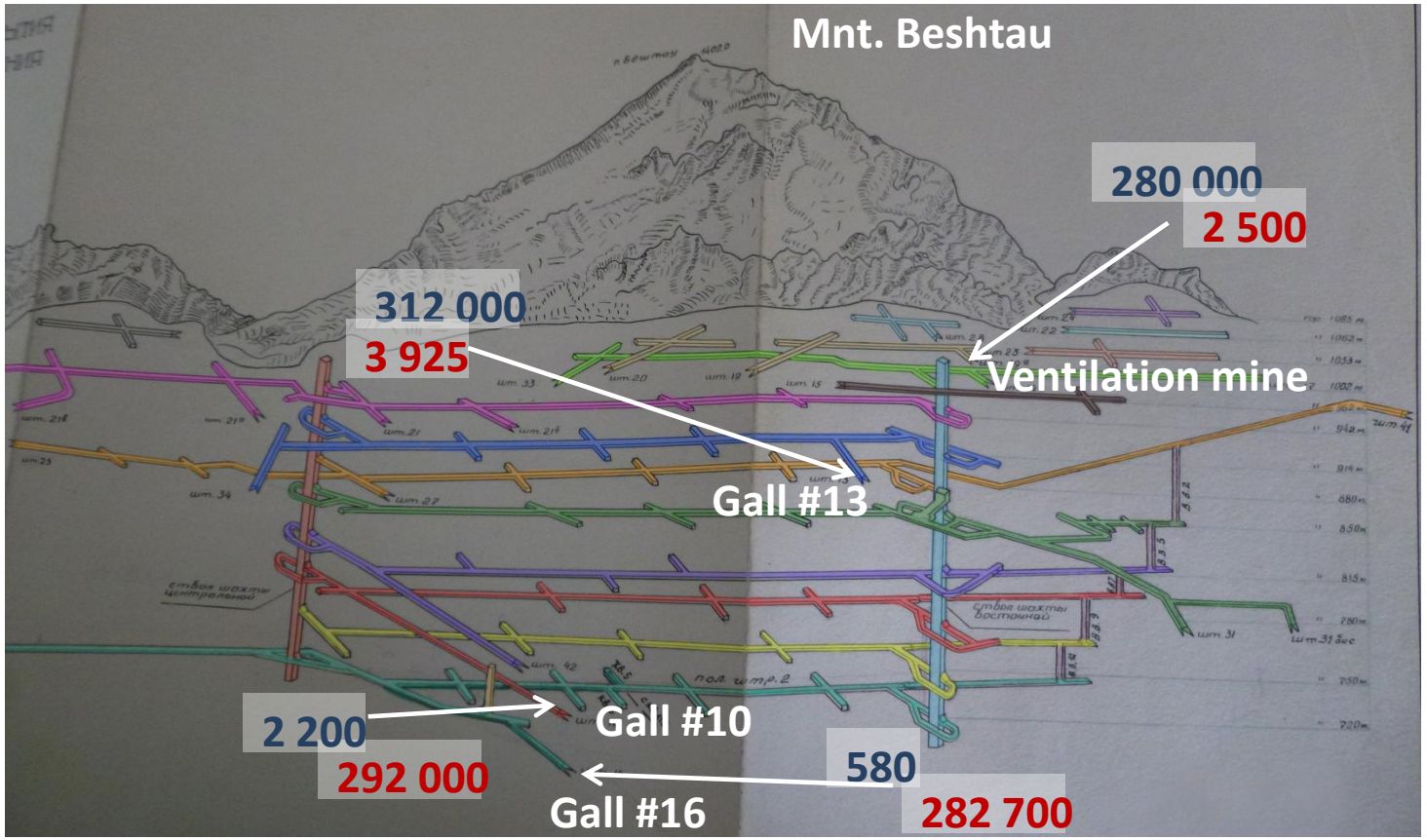
In abnormal point monthly radon measurements were carried out for 1 year. Strong seasonal variations of radon levels were detected: maximum values were obtained in summer and minimum in winter. The relationship between radon variation and the temperature was detected: Radon levels drastically decrease when the soil temperature becomes higher then air temperature. The converse is also true.



The anomalously high radon exhalation rate and radon seasonal variations can be explain by convective radon transfer in the well-permeable tectonic faults in according to the scheme shown in this figure

Result of radon activity concentration measurements in mine air

Scheme of uranium mine and gallery in Beshtau mountain



312 000 - Winter measurements, Bq/m^3

3 925 - Summer measurements, Bq/m^3

Results of measurements of radon activity concentration in uranium main confirm the proposed convective mechanism of radon transport. On the top levels of galleries we can see high radon concentrations in winter and low in summer. In down levels high radon concentrations were registered in summer and low in winter.

CONCLUSIONS

The abnormal values of radon exhalation and extremely high seasonal radon variations in the fault zone were observed on Beshtau region.

The source of the abnormal high radon exhalation rate and air radon concentration is convective radon transfer in the well-permeable tectonic fault

In the fault zone that are connected with the mine space, the formation of the seasonal air circulation is possible due to the temperature difference between the rock mass and the atmosphere

Děkuji moc!

Спасибо!

Thank You!