

K-40 RADIOACTIVITY IN UNDERGROUND MINERAL WATERS OF SEISMOACTIVE ZONE

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The gamma radiometry technique was used for the detection of ⁴⁰K natural radionuclide in thermal mineral waters from the Tashkent geodynamic polygon where the powerful earthquake (1981 y) took place. For the study of the change in ⁴⁰K radioactivity connected with the process of the occurrence of powerful earthquake, the method of regular observation has been applied. The detection of ⁴⁰K radioactivity during 610 days showed that it changed strongly before (~ 3.5 d) powerful earthquake processing most strong property of the earthquake's harbinger. The ⁴⁰K radioactivity has higher value 33-45 hours until the earthquake. After the earthquake during 2-3 days the value of ⁴⁰K radioactivity was decreased till the daily average level.

Keywords: *K-40, Underground Mineral Waters, Seismoactive Zone*

INTRODUCTION

Nuclear methods based on the investigation of content of chemical elements in underground thermal mineral waters are of great significance to study of seismological problems because it is considerably changed during the seismic process of an earthquake [1]. By now, a large number of articles devoted to "the underground water - earthquake" correlation have appeared [2]. The systematic study of composition of underground waters is being carried on [3]. Nuclear methods have been widely used to investigate water composition [4-7]. The variations of some radio-genetic gases in underground waters were discussed elsewhere [5].

The purpose of our present investigation is the study of the variation nature of ^{40}K radioactivity connected with the process of the occurrence of powerful earthquake. The method of regular observation was applied for hydro-geo-seismology to study the behavior of ^{40}K radionuclide in thermal-mineral waters from the Tashkent (Uzbekistan) geo-dynamic polygon.

EXPERIMENTAL PROCEDURE

Natural abundances of potassium isotopes ^{39}K , ^{40}K and ^{41}K are 93.08, 0.0119 and 6.9%, correspondingly. ^{40}K is a long-lived radionuclide with half-life of $1.28 \cdot 10^9$ year that is decaying into ^{40}Ar by E-capture (10.7%), and into ^{40}Ca by β^- -decay. In the first case the γ -quantum with energy of 1460.8 keV is emitted which was detected systematically.

The change of ^{40}K radioactivity in underground thermal-mineral water from four holes bored in the Tashkent geo-dynamic polygon was studied. Water samples were taken every day from March (1980) till October (1981). This period was characterized by seismic activity, which began to manifest itself. During these observations two powerful earthquakes and plenty of aftershocks took place.

The ^{40}K radioactivity was measured by NaI(Tl) detector of large volume (150 mm x 100 mm) that, with the sample holder made of special polymeric cup was placed up into Pb-shield. Water in the cup mounted immediately on the surface of detector is distributed uniformly around it. The radioactivity of water samples of 0.5 l volume poured into the sample holder was detected every day. From this technique we determined the geometric factor connected with large volume of samples. For this purpose we took KCl salt of 0.5 g weight and measured its ^{40}K -radioactivity standing up the cup on the center of detector surface. Again ^{40}K -radioactivity of KCl salt dissolved in water of 0.5 l volume and poured into the sample holder was detected. The geometric factor was obtained as

$$\alpha[\varepsilon\omega] = \frac{S_1}{S_2}, \quad (1)$$

where, S_1 - the area of photo-peak in the case of point geometry, S_2 - the area of photo-peak in the case of sample with large volume, ω -the geometric factor for point sample, ε -the detection effectively.

The geometric factor was 0.01. Consequently, ^{40}K -radioactivity was obtained using the photo-peak area of γ -quantum with energy of 1460.9 keV as

$$A = \frac{dN}{dt} = \frac{S \alpha}{t_{\text{det}} \varepsilon \omega I_{\gamma}} \quad (2)$$

where, t_{det} - the detection time, that was 1 hour for all measurements, I_{γ} - intensity of γ -quantum.

In the detector position the background was detected before and after every measurement of sample radioactivity that was again averaged and deducted every time from the value of detected radioactivity of water samples. Detection time of 1 hour provides good statistics data and the number of detected pulses was not smaller than 700. The average value of disintegration rate corresponds to the ^{40}K - radioactivity of $2.3 \cdot 10^{-10}$ Ci/l.

RESULTS AND DISCUSSION

Experimental results for ^{40}K radioactivity investigated during our study for one hole bored in the Tashkent polygon are presented in Figure 1., where the arrows show powerful earthquake or its aftershocks. The regular observation of the daily change of ^{40}K radioactivity in thermal mineral waters for the Tashkent geodynamic polygon during the Nazarbek Earthquake showed that the daily distribution of ^{40}K radioactivity was different from its daily average values. It is seen that ^{40}K radioactivity increased strongly before earthquake or its aftershocks. The intensity of ^{40}K photo peak began to increase 3.5 days until an earthquake and reached its maximum 33-45 hours before it. Again this phenomenon began to stabilize during 2-3 days until it reached daily average values. Daily and average values of ^{40}K -radioactivity (p/min.) for observed earthquakes for the studied four holes are presented in Table 1.

This phenomenon of ^{40}K radioactivity variation during the earthquake may be used as the harbinger of powerful one's. In this case in the capacity of the certainty edge of the prevention of possibility of the earthquake formation may be served by the rise of variation gradient of ^{40}K radioactivity from its average value \bar{S} to $\Delta S \approx a \sqrt{\bar{S}}$, where, a - coefficient depending on the dynamic character of the underground mineral water in studied region which changes in range of 1.7-3; S - the registered ^{40}K radioactivity, p/min.;

The beginning of fall time of the variation gradient of ^{40}K radioactivity from maximum till minimum shown by the arrows may serve as the prevention time of possibility of the earthquake formation which is 33-45 hours.

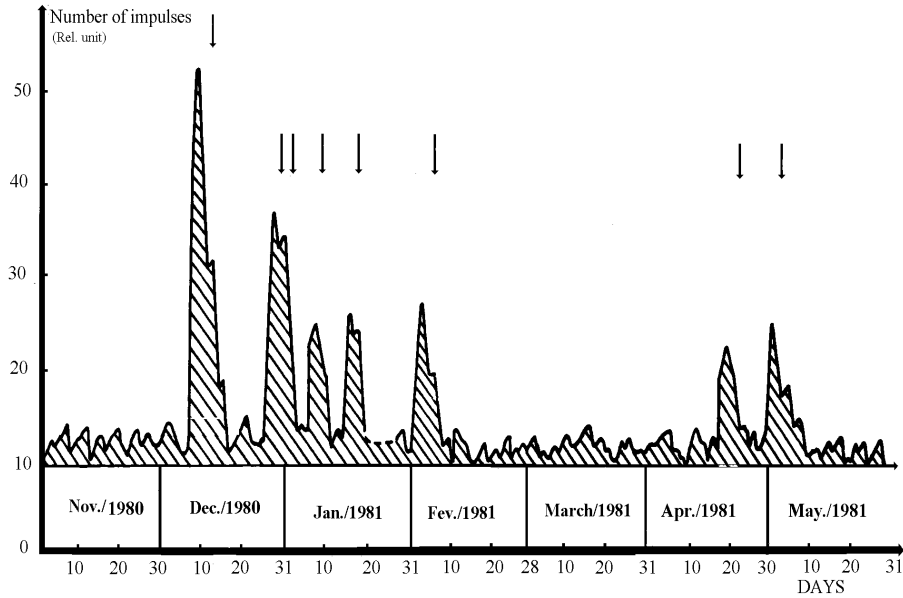


Figure 1. The distribution of ^{40}K -radioactivity in underground thermal mineral waters in dependence on observation time.

Table 1. ^{40}K -radioactivity (p/min) measured during powerful earthquakes

Date									
→	12/11/80	12/30/80	01/01/81	01/09/81	01/18/81	01/24/81	02/05/81	04/21/81	Average
↓ No _{hole}									
3	45	34	33	29	30	31	29	29	8-14
2	53	38	35	26	27	28	26	26	11-15
8	48	36	35	31	34	35	33	33	9-15
9	62	48	45	35	40	41	41	41	13-17

The maximum variation gradient of the registered ^{40}K radioactivity $\Delta S_{\max} = S_{\max} - \bar{S}$ directly depends on the earthquake power $k \approx \alpha \Delta S_{\max} + \beta$, where, α - coefficient depending on characteristic of the holes, β - The minimal power that can be detected by the used technique.

The regular observation of the daily change of ^{40}K radioactivity in thermal mineral waters for studied holes in the Tashkent geodynamic polygon during the Nazarbek Earthquake showed that the variation gradient of ^{40}K radioactivity depends on the remoteness of a hole from the earthquake epicenter that was increased near a hole where, of course, the earthquake power was high.

The variation gradient of ^{40}K radioactivity in all holes 33 hours until basic shock increased more than 4 times in comparison with the average value. For aftershocks this phenomena was 2-3 times.

CONCLUSIONS

1. The variation gradient of ^{40}K radioactivity from maximum till minimum may serve as one of the means of the prediction of possibility of the earthquake formation.
2. The maximum variation gradient of the registered ^{40}K radioactivity directly depends on the earthquake power and the remoteness of a hole from the earthquake epicenter.

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النشاط الإشعاعي للبوتاسيوم ٤٠ في المياه الجوفية لمنطقة نشطة زلزالياً

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استخدمت طريقة النشاط الإشعاعي الجامي للكشف عن النظير المشع الطبيعي بوتاسيوم ٤٠ في المياه الجوفية الحارة من منطقة طشقند النشطة زلزالياً، والتي حدث بها زلزال قوي عام ١٩٨١. استخدمت طريقة المتابعة المنتظمة لدراسة التغير في النشاط الإشعاعي للنظير بوتاسيوم ٤٠ والمرتببط بحدوث النشاط الزلزالي. وأظهر الكشف عن النشاط الإشعاعي خلال ٦١٠ يوم تغيراً قوياً قبل حوالي ٣,٥ يوم من حدوث الزلزال. ووصل النشاط الإشعاعي لقيم عالية خلال ٤٥-٣٣ ساعة، قبل الزلزال وفي فترة ما بعد الزلزال إنخفض النشاط الإشعاعي إلي مستوي القيمة المتوسطة اليومية خلال ٣-٢ أيام.