APPLICATION OF PASSIVE TYPE RADON DETECTORS TO FIND FISSURES IN BANKS CAUSED BY THE SOUTHERN HYOGO PREFECTUAL EARTHQUAKE IN JAPAN

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INTRODUCTION

Innumerable fissures were formed widely in Hanshin area in Japan by the former southern Hyogo prefectural earthquake occurred on Jan.17, 1995. It is an urgent necessity for the science of disaster prevention to find these fissures simply and non-destructively. There are thousands of holding reservoirs in the Hanshin area and it is expected that some bank of reservoirs might have fissures inside the bank. In this study, as a preliminary investigation, we applied passive type radon detector Pico-Rad (U.S. Packard Instrument Co. Ltd.) (1, 2) with hemispheric plastic cover over them around the fissure along on the bank of two reservoirs to examine whether there is possibility to find fissures using the characteristics of ^{222}Rn migration. At the same time, we measured the total exposure rate on the ground with NaI(Tl) scintillation surveymeter (Hamamatsu Photonics, SS-γ), radioactivity of soil by sampling method (and low back ground germanium detector) and water contents of soil as supplementary factors of the investigation.

One of the reservoir, Taniyamakami-ike, is located at the north of the Awaji-shima island at a distance of about 4 km from the seismic center of this earthquake. On the whole, ^{222}Rn exhalation rates were high on a line of 2 m below the edge of the bank and got lower in proportion to the distance from this line. Those top of the bank had middle values among the lines. The mean ^{222}Rn exhalation rate was 4.7 mBq m^{-2} s^{-1}, and in these data we found some singularly high ^{222}Rn points.

The other reservoir named Hosho-ike is located at northwestern Nagaokakyo city of Kyoto prefecture and the Komyoji active faulting runs from north to south parallel with the bank about 120 m to the west. In this bank, a fissure about 50 m in length and 0.1 m in width was taken shape. ^{222}Rn exhalation rates were relatively high on the top of the bank compared with on the slope of the bank. The mean ^{222}Rn exhalation rate of 5 points which were measured on the fissure was 16 mBq m^{-2} s^{-1}, and that which were measured on about 1 m to the east from the fissure was 4.9 mBq m^{-2} s^{-1} and in case about 1 m to the west was 4.2 mBq m^{-2} s^{-1}.

From these results we concluded that there is a possibility to find fissures inside the bank using the characteristics of ^{222}Rn migration. Our future objective is to find fissures inside banks non-destructively.

PRINCIPLE AND METHODS

^{222}Rn ($T_{1/2}$=3.8 d) originates from the decay of ^{226}Ra ($T_{1/2}$=1600 y) that distributes widely in the soil. Typical processes of the ^{222}Rn transport below the ground surface are molecular diffusion and/or convective flow, and also the macroscopic flow in channels or fissures as this case. So if there is any fissure in the bank, it is expected that high ^{222}Rn concentration will be observed above the fissure.

In this survey we used Pico-rad detectors for the measurement of ^{222}Rn concentration. It is a compact ^{222}Rn detector using the adsorption of ^{222}Rn to the activated charcoal and ^{222}Rn concentrations are evaluated by LSC counting. The detectors are passive collection devices requiring no power. It is come onto market by U.S. Packard Instrument. Some of the detectors were covered with hemispheric plastic cover to get higher ^{222}Rn

activity and to evaluate area exhalation rates.

Besides there are a lot of papers related to the radiological survey using the terrestrial gamma ray (3), we had not been certain about applying these method to the investigation because our object is the fissures which were made recently not the fault. But for the present we measured the total exposure rate on the surface of the earth with NaI(Tl) scintillation detector (Hamamatsu Photonics, SS-γ), radioactivity of soil by sampling method (and low background germanium detector) and water contents of soil as supplementary factors of the investigation. Measuring methods and conditions of the survey of the Taniyamakami-ike and Hosho-ike are shown in Table 1.

Table 1 Measuring methods and conditions of the survey on the Taniyamakami-ike and Hosho-ike.

	Taniyamakami-ike reservoir	Hosho-ike reservoir
Measuring date (weather)	15-17 Oct., 1995 (clear and cloudy)	17,18 Apr., 1995 (clear)
Pico-rad detectors used	**No. 1-95** set on the ground with the hemispheric plastic cover **No. 96-100** set at 5 cm high above the ground without cover	**No. 1-21** set on the ground with the hemispheric plastic cover **No. 22-24** set in the fissure without cover **No. 25-26** set at 5 cm high above the ground without cover
Arrangement	lattice (interval 2 m)	across (5 lines) and along the fissure
Total sampling time	23～25 hr	about 19 hr
Supplementary measurements	**Total exposure rate** (NaI(Tl) scintillation detector, 56 points) **Radioactivity of soil** (sampling, Ge detector, 9 points) **Water content of soil** (sampling, 28 points)	**Total exposure rate** (NaI(Tl) scintillation detector, 8 points) **Radioactivity of soil** (sampling, Ge detector, 1 point) **Water content of soil** (sampling, 21 points)

RESULTS AND DISCUSSION

1) Taniyamakami-ike reservoir.

The 9 points (on the same line across the bank) mean radioactivity and s. d. of ^{214}Bi, ^{208}Tl and ^{40}K about 10 cm below the ground surface were 23 ± 2 Bq kg^{-1}, 33 ± 3 Bq kg^{-1}, 1140 ± 40Bq kg^{-1}, respectively. We did not find any characteristic feature in this line on the three radioactivity of soil and also on the ^{214}Bi/^{208}Tl ratio. The atmospheric ^{222}Rn concentration measured at 5 cm high above the ground (No. 96～100) was 9.2 ± 3.2 Bq m^{-3}. Figure 1 shows a horizontal distribution of ^{222}Rn concentration inside the hemisphere (No. 1～96). The mean total exposure rate on the ground surface measured by SS-γ was 100 ± 10 nSvh^{-1} (58 points, max. 137, min. 65 nSvh^{-1}). On average, ^{222}Rn exhalation rates were high on a line of 2 m below the edge of the bank and low nearby the bed and at the back slope. Those top of the bank had middle values among the lines. The mean ^{222}Rn concentration was

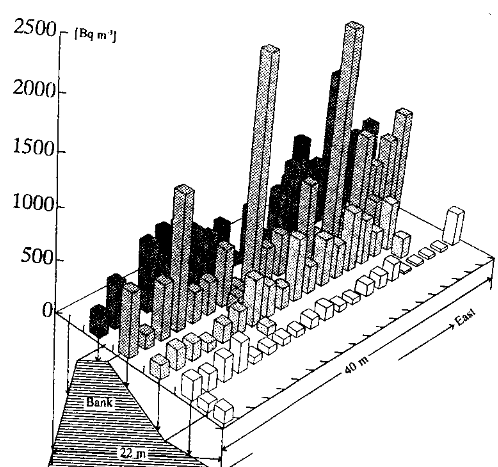

Figure 1. Horizontal distribution of ^{222}Rn concentration around the fissure in the bank of Taniyamakami-ike.

290 Bq m^{-3} (corresponding to 4.7 mBq m^{-2} s^{-1}), and in these data we found some high ^{222}Rn points that concentration was over one thousand Bq m^{-3}. We expect that there are some buried fissures around below this line. The mean water content of soil and its s. d. at about 10 cm deep of 28 points was 14$\pm$12% (max. 58, min. 1.1 %) and we did not find the correlation of ^{222}Rn concentration with water content of soil.

2) Hosho-ike reservoir.

The radioactivity of ^{214}Bi, ^{208}Tl and ^{40}K 10 cm below the ground surface were 7.9, 14, 560 Bq kg^{-1}, respectively. The mean total exposure rate on the ground surface measured by SS-γ was 70 nSvh^{-1} (6 points, max. 100, min. 57 nSvh^{-1}). These values are within the range of that of the normal natural environment. The atmospheric ^{222}Rn concentration measured at 5 cm high above the ground (No. 25, 26) was 11$\pm$ 10 Bq m^{-3}, and ^{222}Rn concentration measured in the fissure at 0.3$\sim$0.5 m deep (No. 22$\sim$24) varied widely from 40 to 4200 Bq m^{-3}. Figure 2 shows a horizontal distribution of ^{222}Rn concentration inside the hemisphere. ^{222}Rn concentration were relatively high on the top of the bank compared with the slope of the bank. The mean ^{222}Rn concentration of 5 points which were measured on the fissure was 1000 Bq m^{-3} (16 mBq m^{-2} s^{-1}), and that which were measured on about 1 m to the east from the fissure was 300 Bq m^{-3} (4.9 mBq m^{-2} s^{-1}) and in case about 1 m to the west was 260 Bq m^{-3} (4.2 mBq m^{-2} s^{-1}). The mean water content of soil at about 10 cm deep of 21 points was 11.4 % (max. 18.5, min. 5.6 %) and there was no correlation of ^{222}Rn exhalation rates with water content of soil. (After the survey, repair work is now in progress on the Hosho-ike reservoir. About 7 m fissure was found in the cross section of the bank (Photo 1)).

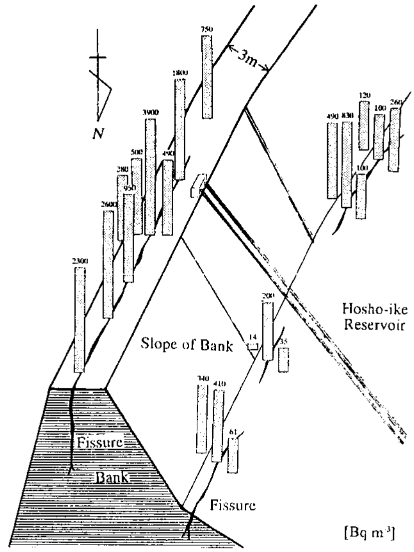

Figure 2. Horizontal distribution of ^{222}Rn concentration around the fissure in the bank of Hosho-ike.

Above mentioned two results showed that it is effective for the survey of new fissures to apply ^{222}Rn gas method rather than the radiological survey using gamma-ray.

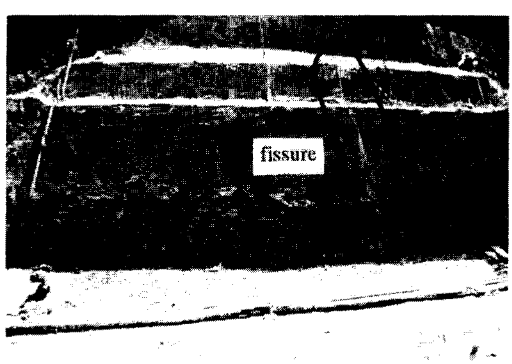

Photo 1. The fissure in the bank of Hosho-ike.

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