Radiation survey activities in the early stages after the atomic bombing in Hiroshima

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Abstract

As one of the first steps to start reevaluating radiological consequences from the so-called "black rain" after the Hiroshima bombing, radiation survey activities soon after the bombing by both Japanese scientists and the US military were reviewed. Although intensive studies were conducted to measure residual radiation in the city area of Hiroshima, radiation survey in the mountainous area where strong black rain was reported was found to be sparse and insufficient.

Introduction

It is well known that the so-called “black rain” after the atomic bombing was experienced in Hiroshima in the wide areas extending to the north and north-west directions from the hypocenter. Regarding radioactivity deposited with the black rain, however, only the radioactive contamination in the Koi-Takasu area about 3 km west from the hypocenter was confirmed through the radiation survey activities soon after the bombing (Committee for the Compilation of Materials on Damage Caused by the Atomic Bombs in Hiroshima and Nagasaki 1979). As one of the first steps to reevaluate the radioactive contamination by black rain, radiation survey activities during the early stages after the bombing in Hiroshima both by Japanese scientists and by US military forces are reviewed in this report.

As far as is known to the author, only the following 6 groups of scientist (4 Japanese and 2 US military) were involved in measurement of residual radioactivity in Hiroshima during the period from two days after the bombing up to the beginning of 1946:

- Dr Nishina Y. and his colleagues from Riken (Institute of Physical and Chemical Researches) in Tokyo.
- Dr Arakatsu B. and his colleagues from the Physics Laboratory, Faculty of Sciences, Kyoto Imperial University.
- Dr Asada J. and his colleagues from the Physics Laboratory, Faculty of Sciences, Osaka Imperial University together with officers from the Japanese Navy in Osaka.
- Dr Fujiwara T. and colleagues from Hiroshima Bunri University.
- A radiation investigation team from the Manhattan Engineering District headed by Tybout R. A.
- Pace N. and Smith R. E. from the US Naval Medical Research Institute.

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Most activities of the Japanese scientists can be found in “Collection of investigation reports on the atomic bomb disasters” (GENSAIPOU 1953). US military activities are reported by Tybout (1946) and Pace and Smith (1959).

Radiation survey activities

Osaka Imperial University group

Dr Asada from the Faculty of Science, Osaka Imperial University together with naval officers arrived at Kure City from Osaka in the morning of August 10, 1945 with a leaf electrode and a GM counter (Yamaoka et al 1953). In the afternoon of that day Asada et al. entered Hiroshima city and found an increase of radiation level at the West Parade ground using the leaf electrode and took a soil sample there. That evening in Kure, they detected strong radioactivity in the soil using the GM counter. On August 11, Dr. Asada collected soil samples at various places in Hiroshima and measured them in Kure. The results are shown in Table 1. Gokuku shrine is located just north of the hypocenter. Entrance of the West Parade ground is about 200 m distant. Residual radiation at these two locations are considered due to neutron-induced radionuclides in soil materials. Sample No. 5 at Koi station is 2.5 km west from the hypocenter and the area of black rain. So, the radioactivity of No.5 is considered to be radioactive fallout deposited with black rain. Ujina is 4-5 km south from the hypocenter without serious damage and black rain was not reported.

Table 1 Radioactivity measurement in Hiroshima by Osaka University group

(Sampling and measurement on August 11, 1945. Natural BG: 27 cpm)

No.	Location	Counts/min
1	Gokoku shrine	120
2	Chugoku army headquarters	40
3	Entrance of the west parade ground	90
4	Hatchbori	37
5	Near Koi-station (bridge)	90
6	Ujina	37
7	Mukainada station	Slightly less than natural
8	East parade ground	〃
9	Yokogawa bridge	〃
10	Near Koi station	〃

Kyoto Imperial University group

During the final period of World War II, researchers of Physics Laboratory, Kyoto Imperial University were involved in a project developing an atomic bomb following a request of the Japanese Navy. Hearing the news that a new-type bomb was dropped on Hiroshima, Dr Arakatsu, the leader of the Physics Laboratory decided to visit Hiroshima.

The first expedition of Kyoto Imperal University

Drs Arakatsu and his colleagues Kimura and Shimizu arrived at Hiroshima station around noon on August 10. They took soil samples and went back to Kyoto by the night train. Next day

they began to measure soil samples using a GM counter at their laboratory and found beta radioactivity in the soil from the West Parade ground (Arakatsu 1953). The beta energy of 0.9 MeV was reported to have an approximate half-life of 20 hr.

The second expedition of Kyoto Imperial University

The second expedition team from Kyoto Imperial University, consisting of Drs Shimizu, Ishiwari and Kondo arrived at Hiroshima on August 13. During the two days they stayed in Hiroshima, they took soils, metals, insulators and bones from more than 100 points and went back to Kyoto on August 15. Sampling locations and results are shown in Figure 1 and Table 2, respectively (Arakatsu 1953).

In Table 2 it is shown that strong radioactivity was found in No.16 'East side of Asahi bridge', which is several 100 m west from 'Nishi Ohashi' where a strong ^{137}Cs concentration was found by recent remeasurement of the 'Nishina soil sample' using a Ge detector (Shizuma et al 1996). Meanwhile, no radioactivity was found in samples from Nos.14 and 15 where the Asada group found strong radioactivity, suggesting a significantly inhomogeneous nature of black rain fallout. It is also noted that all four locations with weak radioactivity are located on the north side of the hypocenter.

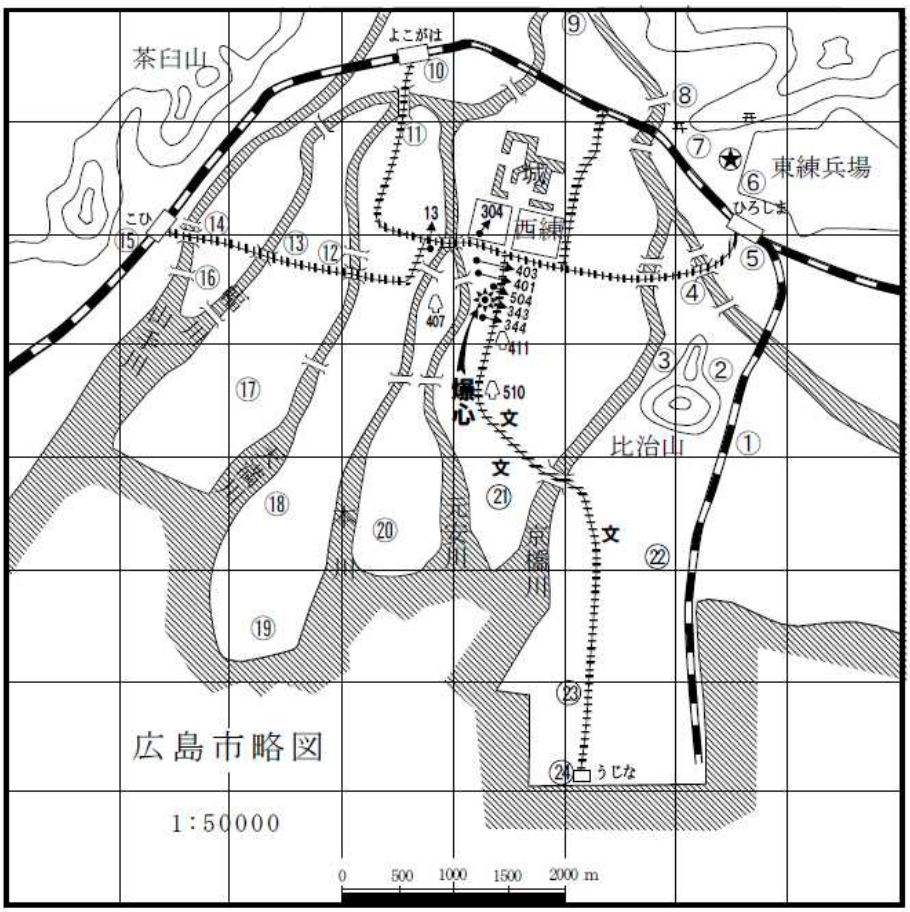

Figure 1 Sample points of the 2nd expedition team from Kyoto Imperial University: Numbers in circles correspond to No. in Table 2.

Table 2 Radioactivity measurement around the city

(Date of measurement: August 15 & 16)

(Note: "no" means natural level of about 18 counts/min.)

No	Sample place	Direction and distance from the hypocenter		β-ray activity
1	Logistics centre	SE	2.5 km	no
2	East foot of Mt. Hijiyama	SE	2.5 km	no
3	Shrine at west foot of Mt. Hijiyama	E	2.0 km	no
4	West side of Kojin bridge	ENE	2.5 km	Weak 11～13
5	East side of Hiroshima station	NE	2.5 km	no
6	East parade ground	NE	2.5 km	no
7	In Nikitsu shrine	ENE	2.0 km	no
8	Hakushima-Higashinaka-machi	NNE	2.0 km	no
9	Near the gate of 5th engineering battalion	N	2.5 km	Weak 8～10
10	East side of Yokogawa st.	NNW	2.5 km	Weak 8～10
11	South side of Yokogawa st.	NNW	2.5 km	no
12	West side of Tenma br.	W	1.5 km	no
13	East side of Fukushima br.	W	2.5 km	Weak 12～14
14	East side of Koi br.	W	3.0 km	no
15	300 m south-west of Koi st.	W	3.5 km	no
16	East side of Asahi br.	W	3.5 km	Strong 106
17	Near postal office in Minmai-Kanon	SW	2.5 km	no
18	Funairi-Kawaguchi-Cho	SSW	2.2 km	no
19	Firing range	SSW	3.0 km	no
20	Yoshijima airport	SSW	2.5 km	no
21	HgI and Sulphur at Engineering School	S	2.0 km	no
22	AgNO3 at high-school	SSE	2.0 km	no
23	Ujina 9-chome	SSE	4.0 km	no
24	Ujina 4-chome	SSE	4.5 km	no

Riken group

Dr Nishina of Riken arrived at Hiroshima in the evening of August 8, 1945 from Tokyo by plane as a member of the special investigating team of General Headquarters. He and his colleagues were involved in the Army project aimed at developing an atomic bomb. During the next day Dr Nishina took various samples in Hiroshima and sent them to his laboratory in Tokyo by plane. During the evening of August 10, Dr Kimura at the laboratory found radioactivity in a copper coil using a Lauritzen electroscope, the strength of which decreased to 40 % of the initial value the next morning. It was considered to be ^{64}Cu (half-life, 12.7 hr) produced through the ^{63}Cu(n,γ)^{64}Cu reaction (Kimura 1973).

On August 12, 1945 three members of the Riken laboratory (Kimura, Tamaki and Murachi) together with army officer Misonoo started their expedition trip to Hiroshima with two Lauritzen electroscopes. They arrived at Hiroshima in the morning of August 14 and stayed there until August 17, measuring radiation levels at various locations. The results are shown in Table 3 with later measurements by the Riken group (Kimura 1953). The measurements on August 17 indicated the distribution of radiation levels along a North (Misasa br. 1.5km N) – Centre (Kamita-cho, Yasuda Insurance) – South (Kokutaiji, Red Cross Hospital 1.4 km S) line. The measurement on September 4 was the radiation distribution along an East (Yanagi Br. 1.4 km E) – (Chuguku Newspaper 1.1 km E, Fukuya 0.8 km E) – Centre (Kamiya-cho, Torii) –

West (Tenma-cho 1.3 km W) line. These data are considered to indicate the radiation distribution due to neutron-induced radionuclides in soil materials at a very early stage after the bombing.

Table 3 Radiation survey in Hiroshima by Kimura et al of Riken

(August - October 1945 with the same Lauritzen)

Date	Place	Radioactivity (div/min) (minus BG)	Condition
Aug 17	Misasa Br.	～0	On truck
〃	Gokoku shrine. 40 m south from Torii	0.5	〃
〃	125 m south from Torii (Shima hospital)	0.4	〃
〃	Kamiya-cho intersection	0.26	〃
〃	West of Yasuda insurance	0.33	〃
〃	Kusunoki tree of Kokutaiji	0.08	〃
〃	In front of Red Cross Hospital	～0	〃
〃	40 m south of Torii	0.64	40cm above ground
Oct 2	40m south of Torii	0.36	Above ground
〃	125m south of Torii (Shima hospital)	0.32	〃
〃	Postal office	0.35	〃
Oct 20	West of Shima hospital	0.35	〃
〃	Several points	0.34 0.38	〃
Sep 4	Yanagi br.	～0	On car
〃	Chuguku Newspaper	0.06	〃
〃	Fukuya department store	0.04	〃
〃	Kamiya-cho	0.12	〃
〃	(North east) Torii	0.22	〃
〃	Saibunji telephone office	0.03	〃
〃	Tenma-cho	～0	〃

In October 1945, Miyazaki, Sasaki and Ikeda from the Riken group conducted a detailed radiation survey around the hypocenter using a Neher-type cosmic-ray meter. The obtained distribution is shown in Figure 2 (Miyazaki et al 1953).

From the data in Table 3 and Figure 2, it can be said that the effect of neutron-induced radionuclides was limited within a certain area around the hypocenter.

Twenty eight soil samples were collected on August 9, 1945 and sent to the Riken laboratory. Dr Yamazaki measured these soils and wrote that strong radioactivity was found in the sample collected in the Koi area (Yamazaki 2007). Dr Yamazaki came to Hiroshima on August 30 and did a radiation survey around the Koi area using a Lauritzen electroscope (Figure 3) (Yamazaki 1953). A sample of gutter mud was taken from a house in the high radiation area and its contents were radiochemically analyzed in Tokyo. Dr Yamazaki found various fission products nuclides in the mud sample such as ^{140}Ba ^{89}Sr and ^{95}Zr, indicating radioactive fallout accompanying black rain.

At the end of January 1946, Miyazaki and Masuda of the Riken group began a radiation expedition in the wider area around Hiroshima in cooperation with US military officers who

provided a car for the radiation survey. The results for the area near Koi-Takasu where Yamazaki found strong contamination are shown in Figure 4 (Miyazaki and Masuda 1953). There still remained an increased radiation level in the hills behind the Koi-Takasu area.

Recently interesting material was found from the archive microfiche in the National Diet Library of Japan about the radiation survey at the beginning of 1946 by Masuda and Miyazaki (1946). They did a radiation survey in a wider area than that shown in Figure 4, including mountainous villages subjected to the strong black rain. Their results are reproduced in Figure 5, where Tomo and Yasu villages are in the strong black rain area. The radiation survey was carried out using a Neher-type cosmic-ray meter in cooperation with US military officers. It is noted that clear increase of radiation level was not observed along the road of Yasu, Tomo and Harada villages in January 27-Febraury 7, 1946. As shown later in Figure 7, however, considering physical decay of FP nuclides, it seems difficult to use these data to estimate the deposition level of local radioactive fallout from the Hiroshima bombing.

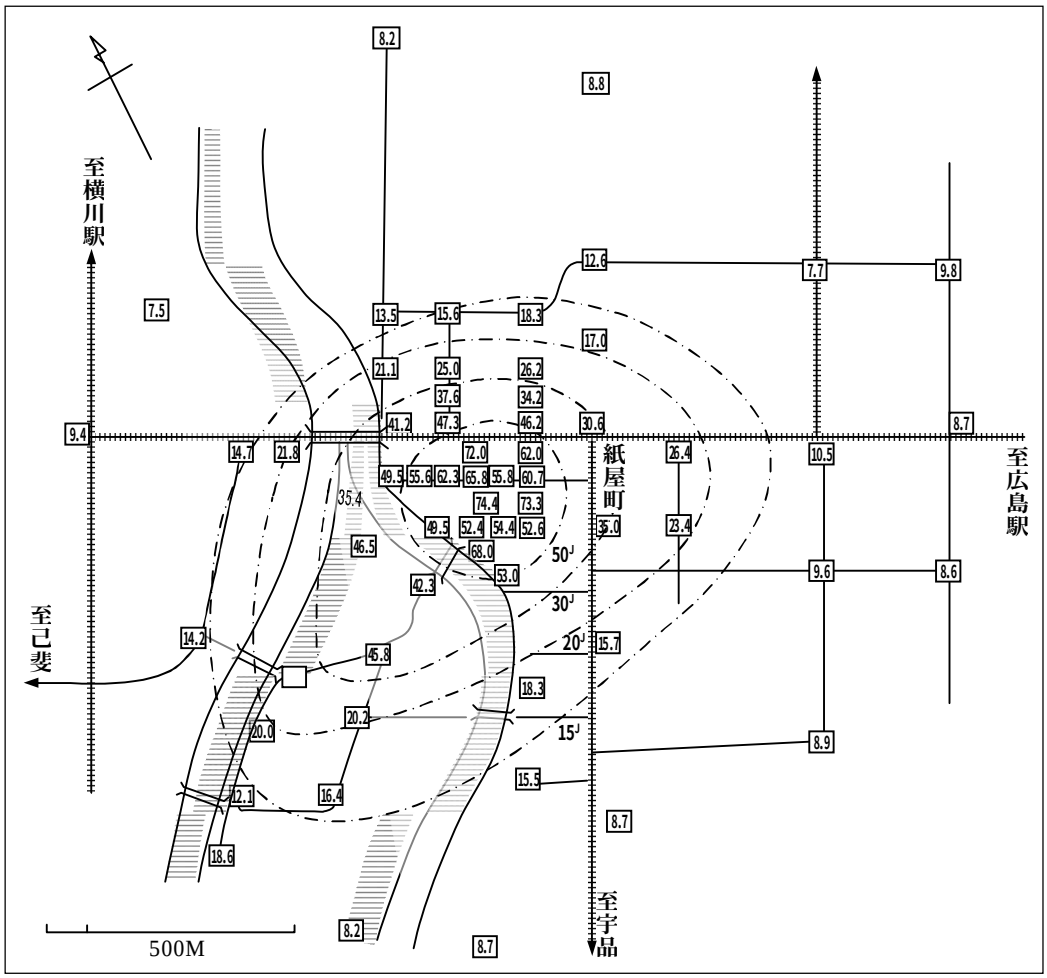

Figure 2 Radiation distribution around the hypocenter by Miyazaki et al. with Neher cosmic-ray meter. October 1-22, 1945. Unit: Joule

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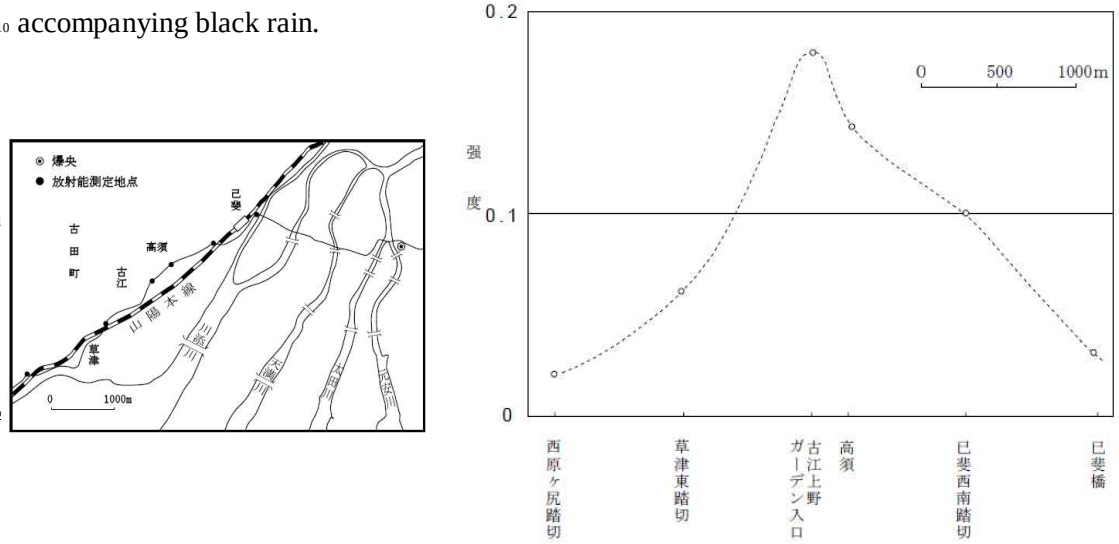

Figure 3 Radiation survey along the road by Yamazaki et al on September 3-4. Relative intensity after BG subtraction

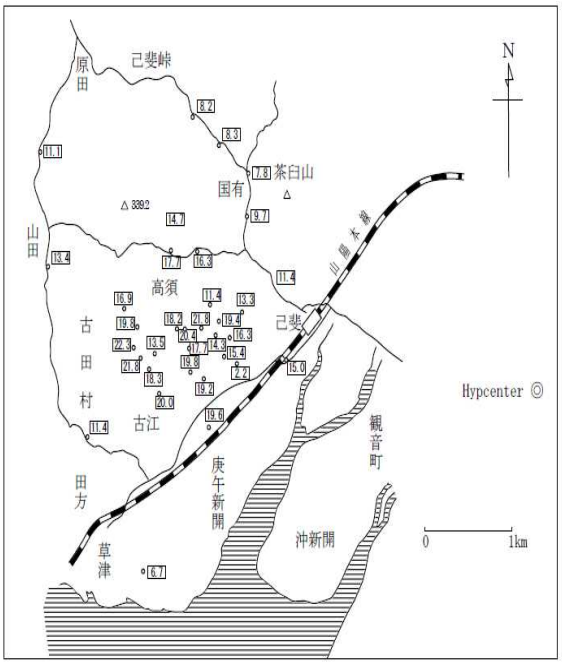

Figure 4 Radiation survey in Koi-Takasu area with Neher-type cosmic-ray meter by Miyazaki et al. January 27 – February 7, 1946. Unit: Joule.

At the end of January 1946, Miyazaki and Masuda of the Riken group began a radiation expedition in the wider area around Hiroshima in cooperation with US military officers who provided a car for the radiation survey. The results for the area near Koi-Takasu where Yamazaki found strong contamination are shown in Figure 4 (Miyazaki and Masuda 1953). There still remained an increased radiation level in the hills behind the Koi-Takasu area.

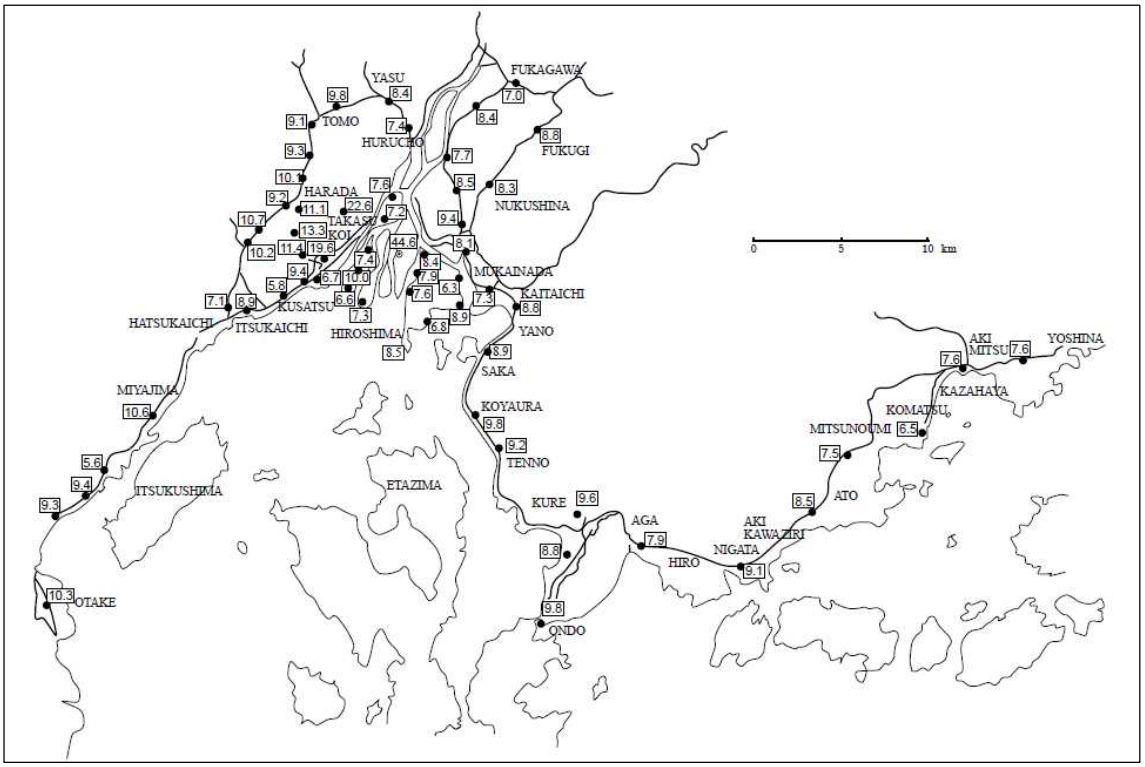

Figure 5 Radiation survey data by Masuda and Miyazaki recently found from the National Diet Library. January 27 - February 7, 1946 with Neher-type cosmic-ray meter. Unit: Joule.

Recently interesting material was found from the archive microfiche in the National Diet Library of Japan about the radiation survey at the beginning of 1946 by Masuda and Miyazaki (1946). They did a radiation survey in a wider area than that shown in Figure 4, including mountainous villages subjected to the strong black rain. Their results are reproduced in Figure 5, where Tomo and Yasu villages are in the strong black rain area. The radiation survey was carried out using a Neher-type cosmic-ray meter in cooperation with US military officers. It is noted that clear increase of radiation level was not observed along the road of Yasu, Tomo and Harada villages in January 27 - Febraury 7, 1946. As shown later in Figure 7, however, considering physical decay of FP nuclides, it seems difficult to use these data to estimate the deposition level of local radioactive fallout from the Hiroshima bombing.

Hiroshima Bunri University group

Dr Fujiwara and colleagues of Hiroshima Bunri University began a radiation survey in September 1945, using a Lauritzen electroscope belonging to the Riken group. In 1948, they carried out a radiation survey in the mountainous area known to be a ‘strong black rain area’ extending to the north-west direction from the hypocenter. There results are shown in Figure 6 together with measurements in September 1945 by Sugimoto of Riken (Fujiwara and Takeyama 1953). It is interesting to note that high ratio values of 2.5 and 1.5 were found in Tomo-village

about 8 km NW from the hypocenter.

General decreasing tendency of radiation level with time due to physical decay of fission radionuclides was calculated based on a method developed by the author (Imanaka et al 2010) and is shown in Figure 7 for a case of 40 μR/hr on Oct 6, 1945. The radiation level in Figure 6 were due to radioactive fallout with black rain. from fallout became less than the natural background in the first part of 1946 and became negligible in 1948. So, it is difficult to accept that several high values observed in Tomo-village

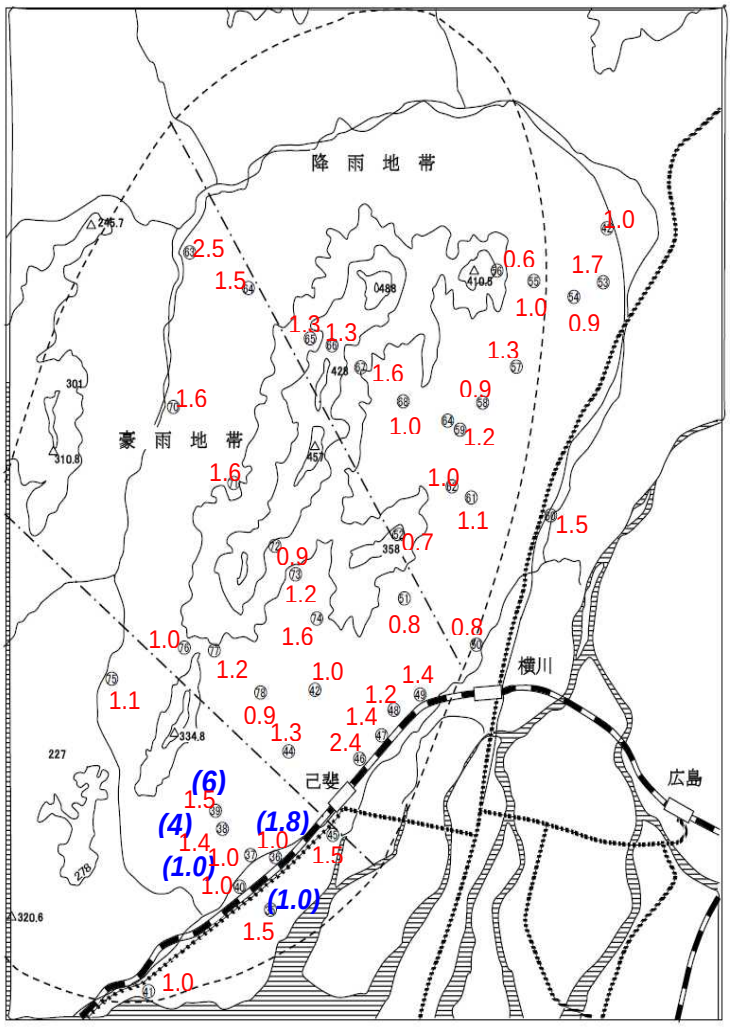

Figure 6 Survey locations by Fujiwara et al. in 1948. Values indicate ratios of the survey point to BG. ( ) are measurements in September 1945 by Sugimoto of Riken.

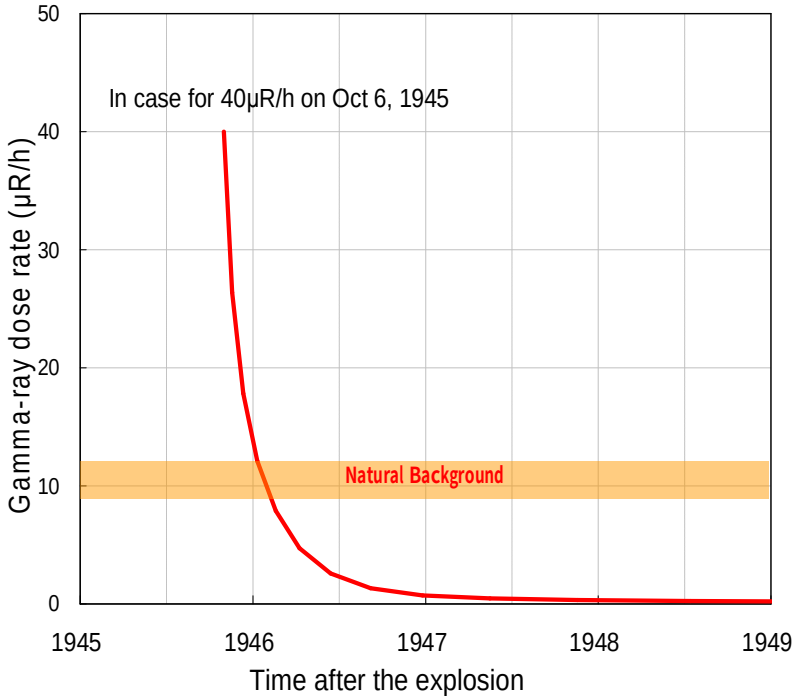

Figure 7 Decreasing tendency of radiation level from deposited fission products on the ground, given an example of 40 μR/hr on October 6, 1945.

US military radiation survey teams

A radiation investigation team from the Manhattan Engineering District (MED) visited Hiroshima from October 3 to 7, 1945 (Tybout 1946). This team used two Lauritzen electroscopes and two GM counters. Meanwhile, Pace and Smith from the US Naval Medical Institute (NMRI) stayed in Hiroshima, November 1-2, 1945 with a GM counter (Pace and Smith 1959). Both teams compiled their own contour map of residual radiation in Hiroshima, both of which are shown in Figure 8 (DNA 1980).

At a workshop on the black rain issue in 2010 at Hiroshima University, Dr Kamada referred to a significant difference of contour maps between MED and NMRI. He insisted the effect of radioactive fallout with black rain was seen in the north direction in the MED map. After the workshop the author managed to find the original data, the measurements used to make the MED contour map (Tybout 1946). Their values are indicated in the contour map (Figure 9).

Radiation levels due to neutron-induced radionuclides for various distances from the hypocenter are shown in Figure 10 (Imanaka 2008). Considering that the radiation level at a distance more than 1 km becomes smaller by more than two orders of magnitude than that near the hypocenter, the high value of radiation at two kilometres north from the hypocenter (Figure 8) can not be explained by neutron-induced radionuclides, suggesting a significant level of radioactive fallout with black rain. To the regret of the author, the original data that were used to make the NMRI contour map could not be found although it was recorded that about 100 locations were measured during their stay in Hiroshima.

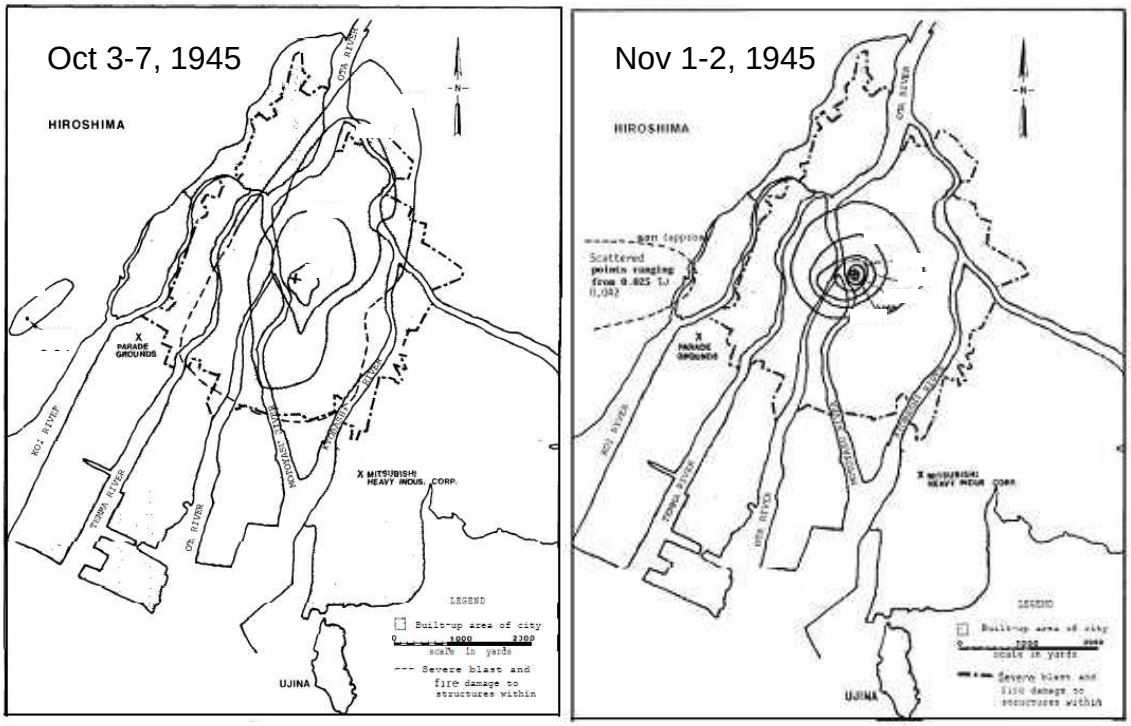

Figure 8 Radiation contour map by MED (left) and NMRI (right). Unit, mR/h.

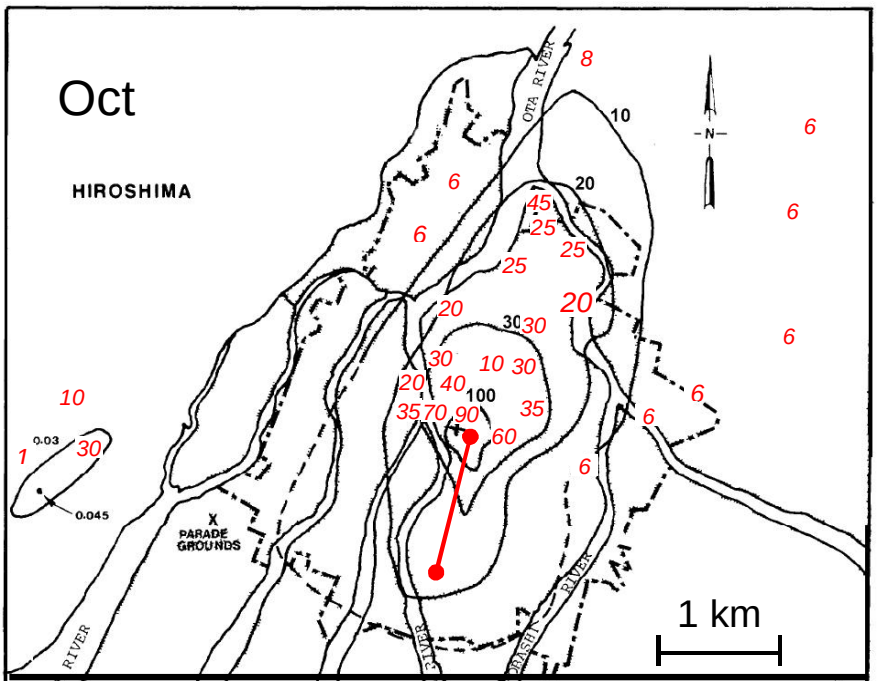

Figure 9 MED original data on the contour map. Unit: μR/h. GM counter made by Victoreen. Along the line from the hypocenter to south direction, measured data were reported from every 150 yard, which decreased from 100 near the hypocenter to 20 at the south edge.

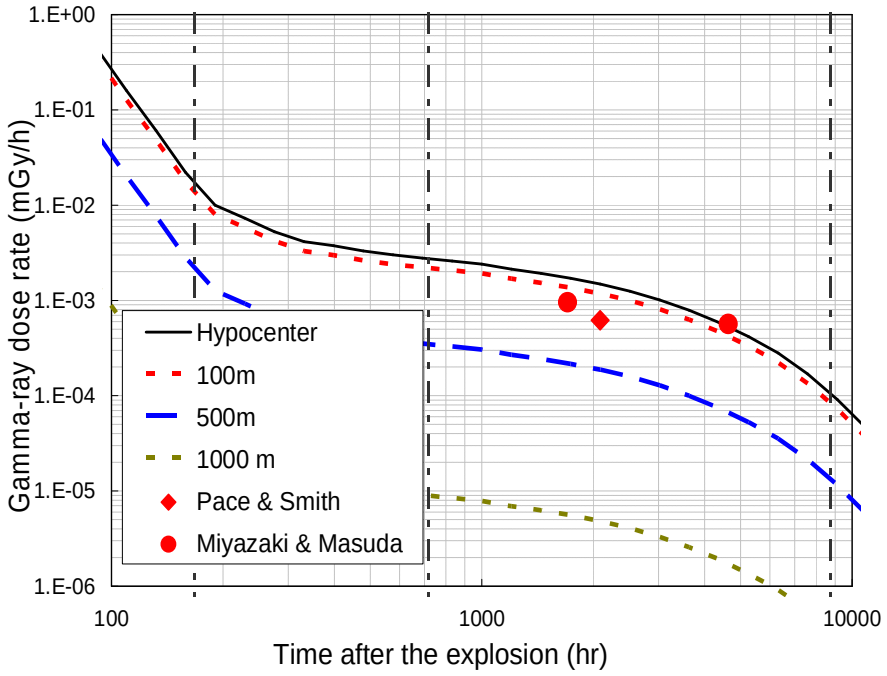

Figure 10 Temporary change of radiation level due to neutron-induced radionuclides in soil in Hiroshima . Pace & Smith and Miyazaki & Masuda are measurements near the hypocenter.

Summary

- Detailed radiation surveys were conducted after the bombing in Hiroshima both by Japanese and US military groups. Clear residual radiation was reported near the hypocenter due to neutron-induced radioactivity as well as the Koi-Takasu area due to radioactive fallout with black rain.
- Significant radioactive fallout was supposed to have occurred in the north direction, which seemed inhomogeneous and spotty.
- Radiation survey in the mountainous area where strong black rain was reported was sparse and insufficient.

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