PAPER II

Studies on the Properties and Size of the Radioactive Ashes Obtained from the No. 5 Fukuryu Maru

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INTRODUCTION

In consequence of the hydrogen bomb test at Bikini Atoll on March 1st, 1954, some Japanese fishermen, who were working on board the No. 5 Fukuryu Maru about 90 miles from Bikini have suffered from radiation sickness due to the radioactive ashes, which had happened to fall on the boat. Since a small amount of the radioactive ashes in a relatively pure state obtained from the No. 5 Fukuryu Maru was given to us by the courtesy of Prof. T. Shiokawa, Faculty of Science, Shizuoka University, and Dr. T. Maekawa, Chief of Sanitation Division of Shizuoka Prefecture, the properties of the ashes, especially the size of the particles and its relation to the radioactivity have been investigated in our laboratory.

MATERIALS

The radioactive ashes used for our investigation were collected by one of the crew of the No. 5 Fukuryu Maru and preserved in a lead container at Shizuoka University. The ashes were wrapped up by a sheet of white paper and seemed to be in a relatively pure state. A small amount of the ashes was transferred into a glass tube and brought to our laboratory.

METHODS

The size of the ashes was measured one by one under the microscope with an ocular micrometer, which had been calibrated by the ruling of a counting chamber. Both the ocular micrometer and counting chamber employed were ordinary ones made by Carl Zeiss for counting purposes of blood corpuscles. The maximum and minimum diameters of each particle were measured and the size of the particle was expressed by the mean value of the two diameters. The ratio of the minimum diameter to the maximum diameter was also calculated. An end-window type Geiger-Mueller counter with a thin mica window (3 mg./cm^2.) and a "100" scaler were used for the measurement of the radioactivity of the ashes. The intensity of the radioactivity was compared with that of a known radioactive isotope.

RESULTS

1) General aspect of the ashes (Figs. 3~5).

The ashes, when observed in a glass tube, consisted of small dry particles, which looked like white sands rather than ashes. According to the crew of the No. 5 Fukuryu Maru the ashes fell down on the deck with a faint noise. The ashes, when taken on a glass slide and observed under the microscope, consisted of dark particles, and minute irregularities were seen on their surface. When observed by side illumination, the particles appeared white, and there were several points, from which the reflection was particularly intense. Although there was some unevenness on the surface of the particles, they looked smooth as a whole and looked like semi-transparent glass. By closer observation several black spot-like grains 2 to 3 μ in size were seen on the surface of the particles. The number of black grains on one particle ranged from 2 to 4. When the white particles were placed on a glass slide and pricked by a needle, they were easily broken and revealed coarse cut surfaces.

2) Size of the particle.

The maximum and minimum diameters of 200 particles are shown in Table 1. The distribution of the mean diameter is shown in Table 2 and Fig. 1. The mean diameter ranged mostly from 100 to 400 μ, averaging 257 μ, although there were a few particles with a mean diameter less than 100 μ or larger than 400 μ. The ratio of the minimum diameter to the maximum diameter ranged from 1.0 to 0.3, averaging 0.74 (Table 3 and Fig. 2).

Table 1 (a). Size of the particle (1)

Minimum diameter μ	Maximum diameter μ	Ratio	Mean diameter μ	Minimum diameter μ	Maximum diameter μ	Ratio	Mean diameter μ
290	364	0.80	327	190	260	0.73	225
230	240	0.96	235	24	16	0.67	20
280	340	0.82	310	300	390	0.77	345
162	252	0.64	207	202	260	0.78	231
280	340	0.82	310	220	242	0.91	231
220	230	0.93	225	40	60	0.67	50
320	338	0.95	329	410	420	0.98	415
300	390	0.77	345	210	220	0.95	215
210	300	0.70	255	370	442	0.84	406
120	240	0.50	180	252	370	0.68	311
24	28	0.86	26	310	340	0.91	325
10	20	0.50	15	270	356	0.76	313
230	300	0.77	265	300	340	0.88	320
330	400	0.83	365	270	330	0.82	300
182	240	0.76	211	200	400	0.50	300
260	280	0.93	270	296	402	0.73	349
210	290	0.72	250	340	340	1.00	340
280	520	0.54	400	310	400	0.78	355
230	260	0.88	245	280	300	0.93	290
164	200	0.82	182	230	350	0.66	290
340	420	0.81	380	140	150	0.93	145
340	362	0.94	351	284	350	0.81	317
240	300	0.80	270	320	420	0.76	370
292	302	0.97	297	320	400	0.80	360
172	340	0.51	256	300	310	0.97	305

Table 1 (b). Size of the particle (2)

Minimum diameter μ	Maximum diameter μ	Ratio	Mean diameter μ	Minimum diameter μ	Maximum diameter μ	Ratio	Mean diameter μ
126	200	0.63	163	210	360	0.58	285
280	340	0.82	310	200	290	0.69	245
270	344	0.78	307	220	290	0.76	255
30	122	0.25	76	290	450	0.64	370
272	350	0.78	311	260	370	0.70	315
290	362	0.80	326	160	180	0.89	170
320	350	0.90	335	220	370	0.59	295
210	220	0.95	215	150	210	0.71	180
220	340	0.65	280	280	370	0.76	320
200	330	0.61	265	180	250	0.72	215
360	420	0.86	390	200	270	0.74	235
230	280	0.82	255	150	390	0.38	270
270	340	0.79	305	170	270	0.63	220
310	350	0.89	330	120	270	0.44	195
280	400	0.70	340	90	140	0.64	115
300	340	0.88	320	200	210	0.95	205
230	360	0.64	295	160	270	0.59	215
320	390	0.82	355	170	370	0.46	270
220	240	0.92	230	140	170	0.82	155
220	350	0.63	285	200	360	0.56	280
260	320	0.81	290	110	210	0.52	160
360	420	0.86	390	140	170	0.82	155
230	260	0.88	245	240	370	0.64	305
210	240	0.88	225	170	340	0.50	255
160	380	0.42	270	150	200	0.75	175

Table 1 (c). Size of the particle (3)

Minimum diameter μ	Maximum diameter μ	Ratio	Mean diameter μ	Minimum diameter μ	Maximum diameter μ	Ratio	Mean diameter μ
320	340	0.94	330	150	230	0.65	190
240	340	0.71	290	260	390	0.67	325
300	380	0.79	340	290	320	0.91	305
262	300	0.87	281	210	520	0.40	365
220	340	0.65	280	280	330	0.85	305
160	180	0.89	170	190	370	0.51	280
280	340	0.82	310	190	220	0.86	205
282	380	0.74	331	190	360	0.53	275
252	460	0.55	356	240	260	0.92	250
240	360	0.67	300	300	330	0.91	315
380	400	0.95	370	190	190	1.00	190
150	210	0.71	180	260	290	0.90	275
220	270	0.81	245	250	270	0.93	260
230	400	0.58	315	220	290	0.76	255
220	300	0.73	260	50	140	0.36	95
230	650	0.35	440	280	330	0.85	305
220	480	0.46	350	200	350	0.57	275
210	230	0.91	220	180	410	0.44	295
260	340	0.76	300	190	220	0.86	205
160	400	0.40	280	180	340	0.53	260
200	300	0.67	250	140	210	0.67	175
170	460	0.37	315	230	260	0.88	245
240	310	0.77	275	140	270	0.52	205
170	252	0.67	211	110	200	0.55	155
320	420	0.76	370	150	190	0.79	170

Table 1 (d). Size of the particle (4)

Minimum diameter μ	Maximum diameter μ	Ratio	Mean diameter μ	Minimum diameter μ	Maximum diameter μ	Ratio	Mean diameter μ
90	210	0.43	150	160	160	1.00	160
180	220	0.82	200	160	180	0.89	170
250	380	0.66	315	200	230	0.87	215
220	240	0.92	230	140	310	0.45	225
240	290	0.83	265	250	260	0.96	255
180	290	0.62	235	170	230	0.74	200
200	230	0.87	215	130	140	0.93	135
190	230	0.83	210	110	110	1.00	110
160	290	0.55	225	170	200	0.85	185
220	220	1.00	220	310	320	0.97	315
150	170	0.88	160	160	180	0.89	170
200	200	1.00	200	130	174	0.75	152
240	340	0.71	290	140	430	0.33	285
270	200	0.74	235	190	290	0.66	240
150	200	0.75	175	130	190	0.68	160
150	220	0.68	185	140	170	0.82	155
260	270	0.96	265	240	360	0.67	300
330	380	0.87	355	200	240	0.83	220
20	24	0.83	22	230	250	0.92	240
300	304	0.99	302	300	340	0.88	320
300	320	0.94	310	130	370	0.35	250
140	424	0.33	282	280	500	0.56	390
230	310	0.74	270	140	290	0.48	215
190	250	0.76	220	190	240	0.79	215
90	220	0.41	155	210	210	1.00	210

Table 2. Distribution of the mean diameter of the particle

Mean diameter μ	%	Mean diameter μ	%
0- 19	0.5	240-259	9.0
20- 39	1.5	260-279	8.5
40- 59	0.5	280-299	9.5
60- 79	0.5	300-319	14.0
80- 99	0.5	320-339	6.5
100-119	1.0	340-359	6.0
120-139	0.5	360-379	3.0
140-159	4.0	380-399	2.5
160-179	6.5	400-419	1.5
180-199	4.5	420-439	0.0
200-219	10.0	440-459	0.5
220-239	9.0	460-	0.0

Average of the mean diameter 257 μ

Table 3. Distribution of the ratio of the minimum diameter to the maximum diameter of the particle

Ratio	%
1.00-0.91	19.5
0.90-0.81	24.0
0.80-0.71	21.0
0.70-0.61	15.5
0.60-0.51	8.5
0.50-0.41	6.5
0.40-0.31	4.5
0.30-0.21	0.5
0.20-0.11	0.0
0.10-0.00	0.0

Average ratio 0.74

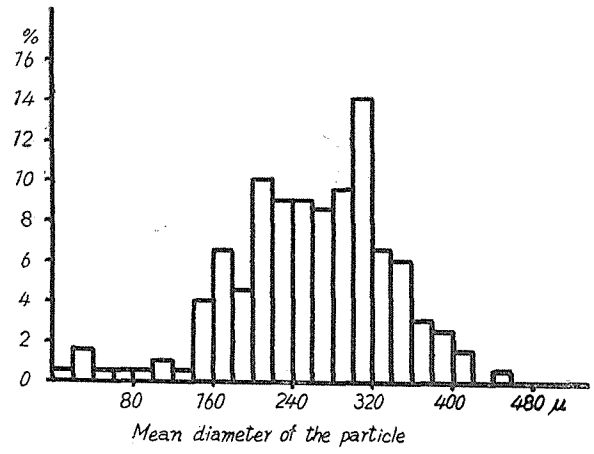

Fig. 1. Distribution of the mean diameter of the particle.

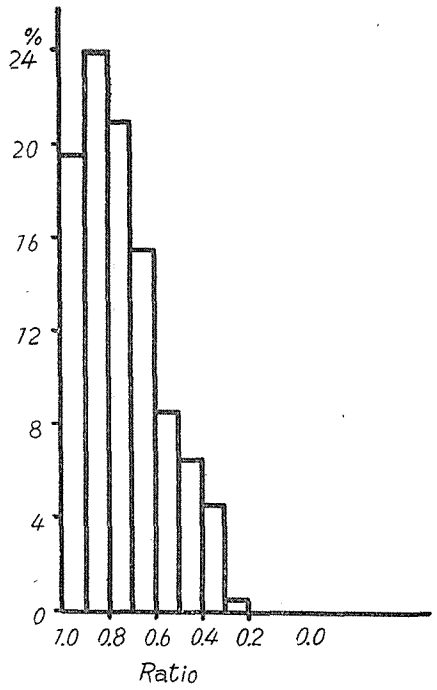

Fig. 2. Distribution of the ratio of the minimum diameter to the maximum diameter of the particle.

3) Radioactivity.

Each particle was placed on a glass slide, and after the measurement of the size the radioactivity was measured by the Geiger-Mueller counter (Table 4).

Table 4. Radioactivity of each particle (May 16th, 1954)

Size μ	c.p.m.	Size μ	c.p.m.
240×380	688	3× 6	15
320×360	215	120×130	39
260×320	1334	20×400	362
340×440	53	290×300	84
300×400	140	310×329	109
320×480	404	250×320	136
360×400	38	200×230	61
200×250	14	250×320	103
7× 15	109	200×230	63
10× 11 2× 3	115	100×140	30

Distance between the sample and G-M counter : 2 mm.
Mica window : 3mg./cm².
Co^{60} 0.2 μc. : 17500 c.p.m.

Table 5. Radioactivity of the ashes (May 5th, 1954)

Sample	Counts per minute
Ashes 1.0 mg.	4218
Co^{60} 0.4 μc. (1)	7359 } 7475
〃 〃 (2)	7590 }

Background : 20 c.p.m.
Distance between the sample and G-M counter : 3.5 cm.

There was no direct correlation between the size of the particle and its radioactivity. Some of the particles showed very weak radioactivity at the time of our investigation (May 16 th, 1954, 77 days after the fall). It seemed that the particles with black grains showed strong radioactivity. When measured by the Geiger-Mueller counter, 1.0 mg. of the ashes showed 4218 counts per minute. Under the same conditions 0.4 μc. of Co^{60} showed 7475 counts per minute (Table 5).

DISCUSSION

It has been shown by our investigation that the radioactive ashes collected from the No. 5 Fukuryu Maru consisted of particles ranging from 100 to 400 μ in mean diameter. It is a question, however, whether the distribution of the size of the particles reported in this paper represented that of the whole sample or not. Our sample was a part of the original one preserved at Shizuoka University, and the possibility cannot be denied that, when transferring from the original container to the other, large particles were more easily transferred than small ones. There was also a possibility that the particles of great specific gravity might have remained in the original container. Nevertheless, our results might give some information about the properties of the radioactive ashes. According to the report of Prof. K. Kimura[1] the main constituent of the radioactive ashes collected from the No. 5 Fukuryu Maru was calcium carbonate and it has been suggested that the ashes consisted of the fragments of the atoll, which were scattered by the explosion. Our observation that there was no direct correlation between the size of the particle and its radioactivity might suggest that the distribution of radioactivity in the particles was not uniform, and that the fission products were carried on the fragments of the atoll.

SUMMARY

1) The size and radioactivity of the ashes collected from the No. 5 Fukuryu Maru have been measured.

2) The ashes consisted of particles, which appeared dark, when observed through the microscope. When observed by side illumination, the particles appeared white and several black spots were seen on their surface.

3) The mean diameter of the particle was 257 μ on an average. The average ratio of the minimum diameter to the maximum diameter was 0.74.

4) There was no direct correlation between the size of the particle and its radioactivity.

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investigation. This work was supported by a special research grant from the Ministry of Education.

REFERENCE

1) Kimura, K. : On the radioactive ashes which fell on the No. 5 Fukuryu Maru. Kagaku, **24**, 300-302, 1954 (In Japanese).

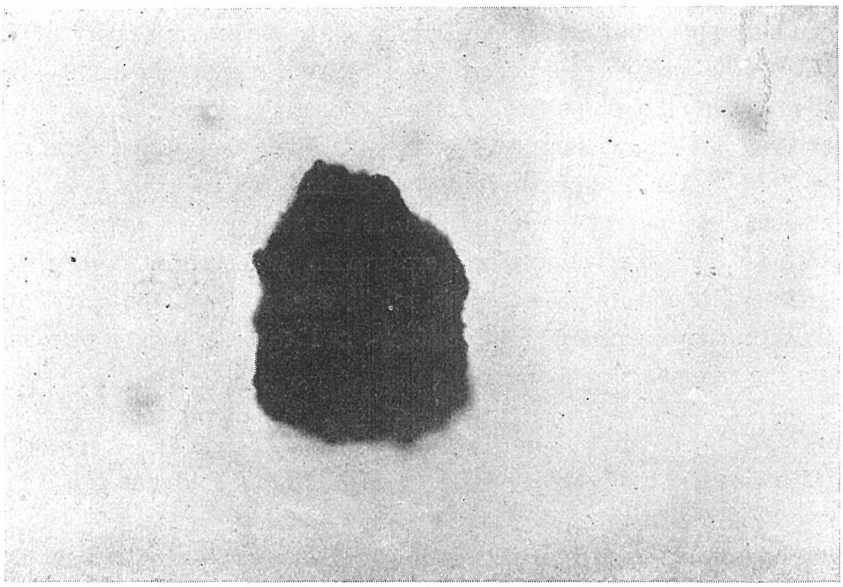

Fig. 3. Photomicrograph of a particle of the radioactive ashes (×150).

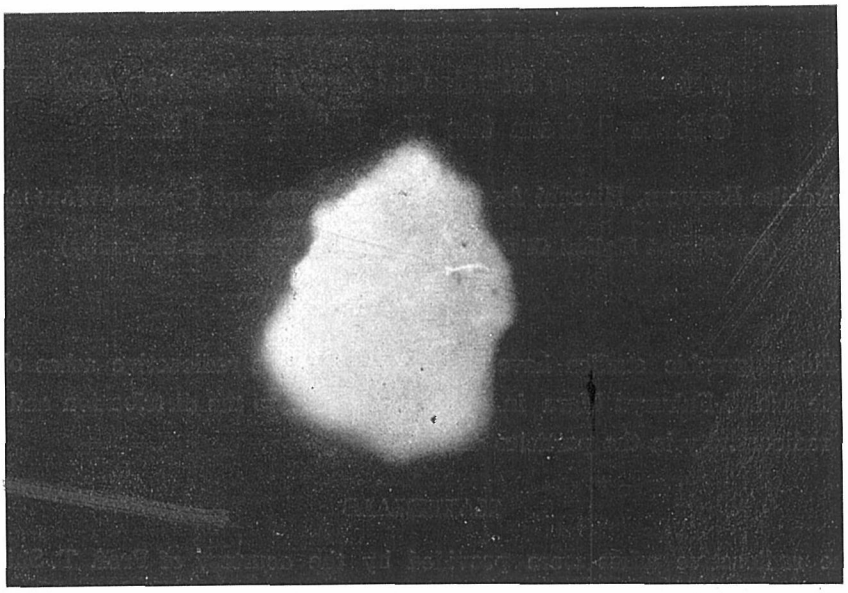

Fig. 4. Photomicrograph of a particle of the radioactive ashes taken by side illumination (×150).

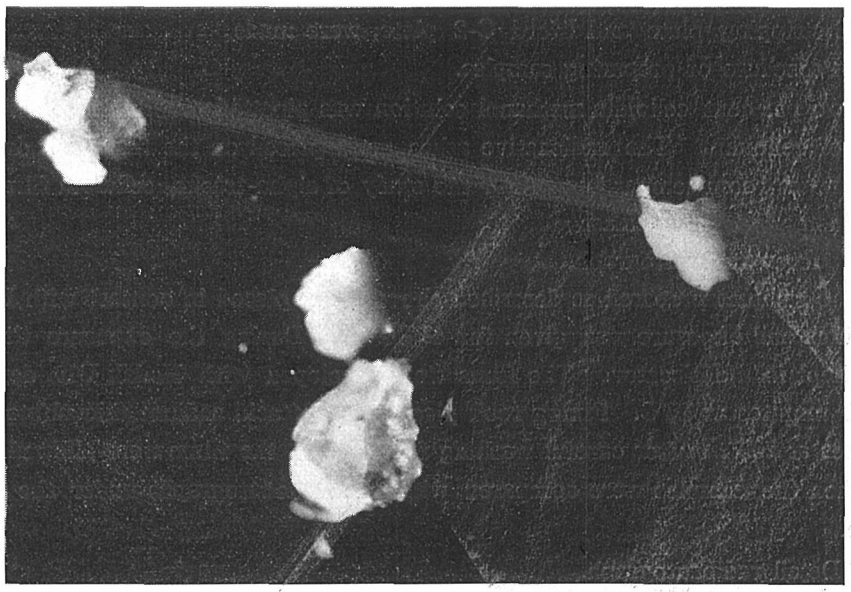

Fig. 5. Photomicrograph of broken particles of the radioactive ashes (×150).