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WD-

OPERATION CASTLE

410634

A VERY PRELIMINARY REPORT

ON THE

RESULTS OF THE [redacted] SHOT

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Submitted by

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RG 326 US ATOMIC ENERGY COMMISSION

LANL

J-Div.

Of Castle, Prelim. Report

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[redacted]

INTRODUCTION

The [redacted] shot was detonated on Eninman Island of [redacted] The device was designed by the UCRL at Livermore to test a [redacted] than that used in the previously tested devices.

At the time of firing the atmospheric conditions with respect to fall-out and sampling criteria were satisfactory, but heavy showers in the area caused serious difficulties from the point of view of test instrumentation. Records show that the light transmission conditions were such as to automatically prevent firing of the shot from about 4 A.M. until about ten minutes before shot time. At shot time the transmission from Eninman to Enyu was sufficient to allow firing, but scattering of the light by fog or rain was such as to prevent proper photography. Thus no photographs of the fireball were obtained from any station, and the early "hot spot" photography also failed even though the instrumentation operated properly. However, enough data were obtained by other means (Radiochemistry, progress of reaction studies, threshold detectors, shock arrival times) to obtain a fair picture of what went on.

The times of arrival and overpressures on Airukiraru, Airukiiji and Eniirikku indicate a total energy release of some

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[redacted] DELETED with the lower number being perhaps more plausible in the light of the hydrodynamic yield. Observation of the total number of 14 Mev neutrons by means of threshold detectors suggest [redacted] DELETED

The first check in determining the cause of the unexpectedly [redacted] DELETED is to ascertain the operation of the [redacted] DELETED The initial alpha

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seem to bear this out.

[redacted] led, in general, to disappointing results from most of the effects experiments. However, there has long been interest in the crater that would be produced by a moderate size fission weapon detonated on the ground, and the crater produced by DELETED should be worth study when radioactive contamination levels permit. The crater is some 700 feet in diameter and about 35 feet deep at the center.

The project reports following are designed to give only a first scanning of the results, and all numbers are preliminary and subject to change. The results quoted are mainly the work of TU-12, TU-13, TU-1 and TU-7. The before and after pictures were taken by TU-9. Reports of the work of other task units will be issued separately.

Since no preliminary report will be issued on the [redacted] a few comments are perhaps in order here.

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Project 2.5a - FALLOUT DISTRIBUTION STUDIES

Project Officer - E. R. Tompkins

(E. R. Tompkins)

This report is confined to results obtained from the [redacted]tonation of [redacted]

Objectives

The following objectives were sought in this experiment:

Extent and time of arrival of fallout over the lagoon and atoll islands.

Physical nature of the fallout.

Instrumentation

All available stations in the lagoon and on the atoll islands were instrumented. For location of stations see Holmes and Narver Drawing 2225 AB-17.

Results

Collections were obtained at a number of lagoon stations and four island stations. No time of arrival samples were obtained. All field data are contained in Table 2.5a-1. Stations are identified by H & N reference numbers and by island names. Measurements were obtained with a T1B radiac in contact with the sample containers; background at time and location of measurements on atoll islands probably included some residual from previous detonations.

Little can be said at present concerning the apparent physical state of the contaminant upon arrival since heavy rains following the shot tended to dilute and obscure the original material.

[redacted]

TABLE 2.5a-1

RADIOACTIVITY IN TOTAL COLLECTOR BOTTLES AND ON GUM PAPER COLLECTORS

Station	Date	Time	Gamma Field at Station (mr/hr)	Total Collector Reading (mr/hr)	Gum Paper Reading (mr/hr)	Remarks
[illegible].05	8 Apr	1630	120	300	600	Raft Station
[illegible].06	8 Apr	1555	10	50	- -	Raft Station
[illegible].07	8 Apr	1535	- -	150	- -	Buoy Station, #1 Collector
[illegible].07	8 Apr		- -	150	- -	Buoy Station, #2 Collector
[illegible].08	8 Apr	1510	- -	60	- -	Buoy Station, #1 Collector
[illegible].08	8 Apr			400		Buoy Station, #2 Collector
[illegible].09	8 Apr	1425	- -	- -	- -	Station Missing
[illegible].10	8 Apr	1410	- -	- -	- -	Station Missing
[illegible].11	8 Apr	1340	- -	- -	- -	Raft Overturned; Buoy Mast Destroyed
[illegible].12	8 Apr	1325	- -	- -	- -	Buoy Mast Destroyed
[illegible].13	8 Apr	1310	- -	- -	- -	Buoy Mast Destroyed
[illegible].14	8 Apr	1250	- -	2	- -	Four Bottle Array (one on each post of raft); all readings same
[illegible].15	8 Apr	1220	- -	2	10	Buoy Station, #1 Collector
[illegible].15	8 Apr		- -	2	- -	Buoy Station, #2 Collector
[illegible].16	8 Apr	1200	- -	100	- -	Buoy Station
[illegible].17	8 Apr	1140	100	1200	1000	Raft Station
[illegible].18	8 Apr	1115	40	150	- -	Raft Station
[illegible].18	8 Apr		- -	40	- -	Buoy Station, #1 Collector
[illegible].18	8 Apr		- -	100	- -	Buoy Station, #2 Collector
[illegible].19	8 Apr	1040	2	3	- -	Buoy Station, #1 Collector
[illegible].19	8 Apr		- -	8	- -	Buoy Station, #2 Collector
[illegible]	8 Apr	1030	1	4	- -	Raft Station
[illegible]	8 Apr	1000	2000	300	*400	Romurikku
[illegible]	8 Apr		600-300	0	0	Bikini
[illegible]	8 Apr		60-80	0	0	Rochikarai
[illegible]	8 Apr		30	0	0	Ourukaen
[illegible]	8 Apr	1440	2000(est.)	700	- -	

* Measured at 1 ft.

Project 2.5b - FALL-OUT DISTRIBUTION STUDIES

Project Officer - E. F. Wilsey

Objectives

The objectives of this project include the collection of fall-out samples for the documentation of the physical characteristics as a function of time and distance, and to provide samples for chemical and radio-chemical analysis for Project 2.6b.

Instrumentation

Two intermittent fall-out collectors were located together on each of the following islands: Uorikku, Romurikku, Aomoen, Rochikarai, Airukiji, Enriirikku, Rukoji, Chieerete, Gurukaen, and Bokororyuru. One of these instruments at each of the stations was set to sample at 30-minute intervals for a total sampling time of 12 hours. The second instrument at Airukiiji and Enriirikku was set to sample at 1-minute intervals for a total sampling time of 24 minutes; the second instrument at the other stations listed above was set to sample at 5-minute intervals for a total sampling time of 2 hours. One instrument was located on each of the following islands: Yurochi, Bikini, and Enyu. These collectors sampled at 30-minute intervals for a total sampling time of 12 hours.

Recovery

Instrument functioning was excellent; all instruments partially or completely operated except the Aomoen and Chieerete 30-minute instruments, and the Airukiraru and Eniirikku 1-minute

instruments. Recovery was begun on 8 April and completed on the morning of 9 April.

Results

Detectable amounts of fall-out were collected at the Yurochi, Uorikku, Romurikku, Aomoen, Bikini, and Enriirikku stations. Several 16 sq. in. tray samples at recovery read up to 200 mr/hr at 1 inch when surveyed with a AN/PDR-T1B instrument. (The background was 10-15 mr/hr) Most of the higher readings were found in the early time interval samples, however, detectable activity continued to be found in later samples from these stations. Ten samples were measured for early gross decay at Parry. The decay slopes ranged from -1.1 to -3.4 for the period M+3 to M+19 days. No trend in decay rate was exhibited for either the early or late fall-out. The remainder of the samples were returned to the Army Chemical Center for analysis.

Project 2.6a - CHEMICAL, PHYSICAL AND RADIOCHEMICAL ANALYSIS OF SURFACE CONTAMINATION

Project Officer - E. R. Tompkins

(R. Cole)

Objective

To determine the chemical and physical state of the gross fallout essential to a knowledge of its contamination-decontamination potentialities.

Instrumentation

Sampling instrumentation is described in the Project 2.5a Pre-Operation Report. Laboratory instrumentation consisted of ultra-filters, ion exchange columns and associated counting-rate circuitry, standard chemical laboratory equipment, gamma scintillation counters, beta proportional counters, and a ten-channel gamma analyzer.

Results

Seven useful samples of fallout from the detonation of [DELETED] were recovered. These consisted of 6 lagoon station samples and one island station sample. The samples were received at Parry Island on the morning of 10 April 1954. The samples were aliquoted into three parts: (1) Treatment on site, (2) Radiochemical analysis at NRDL, (3) Chemical Analysis at NRDL. All the useful samples contained large volumes of liquid (350 - 1850 ml). This is the result of heavy rainfall on both the day of the shot and the next day. These samples all consisted of a suspension of a grayish solid similar in

[redacted]

appearance to that in the [redacted] fallout, namely, like slaked lime. The one island sample contained a solid which was somewhat more sandy in appearance, indicating extraneous solids blown in by the wind.

The following quantities were determined for some or all of the samples: (1) Gross beta and gamma decay of all samples, (2) Aluminum and lead absorption curves for a few of the samples, (3) Gamma spectra for some of the samples and fractions thereof, (4) Oxidation state and approximate percentage of neptunium, (5) Oxidation state of iodine, (6) Fractionation of gamma activity into solid, ionic and colloidal constituents using centrifugation and ultra-filtration. In addition, work was continued on development of methods for the determination of induced and fission product activities of interest.

TABLE 2.6a-1
GROSS ANALYSIS OF FALLOUT MATERIAL

Sample (Station)	Total Volume (ml)	Total Gamma Activity 4/14/54 (7.31 days) (counts per min)	Total Beta Activity 4/14/54 (7.33 days) (counts per min)
TC(1) Coca Head	355.	5.31×10^8	8.21×10^8
3 C(2) Coca Head	498.	1.00×10^8	1.60×10^8
TC(1) 250.05 Buoy	1365.	3.06×10^8	4.80×10^8
TC(1) 250.05 Raft	1822.	3.14×10^8	4.85×10^8
TC(1) 250.07 Raft(3)	2715.	4.29×10^8	6.55×10^8
TC(1) 250.09 Raft(4)	1020.	3.57×10^8	5.56×10^8
TC(1) 251.02 Island	1160.	3.68×10^8	5.78×10^8

(1) TC = total collector bottle.
(2) 3C = triple collector-combination of three bottles.
(3) Combination of two bottles.
(4) One bottle (Number 2)

[redacted]

[redacted]

Physical State Measurements

These were made on one lagoon sample (Coca TC) and one island sample (251.02 TC). The gamma activity breakdown is given in Table 2.6a-2. For both samples the liquid fraction activity ran 96-97 percent ionic, exactly as in the fallout [redacted] The percent of gamma activity in the solid was in good agreement with that from [redacted] where it was never less than 90 percent.

TABLE 2.6a-2
GAMMA ACTIVITY IN PHYSICAL STATE FRACTIONS

	Sample Coca TC	Sample 251.02 TC
Date Fractionated	4/10/54	4/12/54
Date Counted	4/11/54	4/12/54
pH	10. - 11.	11.15
% Gamma c/min(1) in Solid	70.2 - 92.4	91.6 - 93.2
% Gamma c/min(1) in Ionic	6.28 - 7.33	5.35 - 5.60
% Gamma c/min(1) in Colloidal	0.23 - 0.23	0.23 - 0.23

(1) The first figure of each pair represents the percentage actually recovered. The second represents the limiting value of the percentage, based upon known sources of loss in the separation procedures.

Decay curves of the various fractions showed differences as pronounced as those from [redacted] and in the same direction. Gamma spectra were obtained for the various fractions and these also indicated fractionation, but have not been completely analyzed.

Decay of the Gross Sample

The decay of all the samples was the same within

[redacted]

[redacted]

experimental error. This agrees with results from [redacted] Composite decay data for beta and gamma activity are given in Table 2.6a-3. Zero time was taken as 0620, 7 April 1954. The beta and gamma decays are almost identical, the beta decay being only slightly slower. In general, the gamma decay is similar to that of [redacted]. Over various time ranges, the decay rates are as follows:

3.5 to 5.0 days . . . $t^{-1.17}$

6 to 11 days . . . . $t^{-1.85}$

10 to 17.5 days . . . $t^{-2.27}$.

TABLE 2.6a-3
GROSS SAMPLE DECAY

Time Elapsed (days)	% Gamma Activity(1)	% Beta Activity(1)
3.6	190.	188.
4.1	167.	165.
4.5	149.	145.
5.1	128.	127.
6.1	100.	100.
7.3	74.	78.
8.2	62.	64.
9.1	49.	50.
10.1	40.	41.
12.1	27.	29.

(1) Average of seven samples. Normalize to 100 percent at 6.1 days.

Iodine Activity

At D + 3 days 7 percent of the iodine gamma activity was in soluble form, the rest being associated with the solid

[redacted]

fraction (Coca TC). The oxidation state was found to be predominantly -1 (iodide). Analysis of gamma spectra indicated that the iodine gamma activity was due mainly to I^{130}, I^{131} and I^{132}. Roughly 5 percent of the gross gamma activity at D+3 days was contributed by iodine.

Neptunium Activity

Two samples were subjected to extraction procedures with the following results:

Coca TC at D+4 days: NpIV:-66 percent; NpV-VI:-34 percent.

251.02 TC at D+6 days: NpIV:-80 percent; NpV-VI:-20 percent.

Ion exchange procedures yielded the same types of [redacted] Because of lack of time, the complete analysis of the decay curve for percentage of Np and of fission products, as described in the [redacted] report, was not repeated. However, because of the close similarity of

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fission products were present, the decay should go as $t^{-1.2}$. The discrepancy can be explained by the presence of U^{237} ($t_{\frac{1}{2}}$ = 6.7 days). Graphical methods similar to those described

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Project 2.6b - RADIOCHEMICAL ANALYSIS OF SURFACE CONTAMINATION

Project Officer - R. C. Tompkins

Objectives

The objectives of this work were to study the distribution of certain nuclides within fall-out particles and to determine some of the differences in radiochemical properties between liquid and solid fall-out.

Instrumentation

Total fall-out collectors were set up on Enyu, Rukoji, Arriikan, and Bokororyuru Islands. On account of a failure in the timing circuit, the collector on Bokororyuru operated before the shot. The collector on Enyu did not operate properly. Collectors on Rukoji and Arriikan operated properly.

Results

Since the yield [redacted] the samples recovered were too small to size-grade. Comparisons of the aqueous and solid phases were made, however, as shown in Table 2.6b-1. Additional data will be covered in later reports.

TABLE 2.6b-1

COMPARISON OF LIQUID VS SOLID FALL-OUT

Location	Mo^{99} Aqueous/Solid Ratio
Rukoji	0.303
Arriikan	0.74

A sample of coral sand was scooped up from the ground on Aomoen Island for leaching studies to determine distribution of activities within the fall-out particles. The sample was leached once with water and then with successive portions of dilute hydrochloric acid. Data are given in Table 2.6b-2. Weight of total sample was 2.1453 g.

TABLE 2.6b-2
ACTIVITY REMOVED FROM AOMOEN SAND BY LEACHING
CORRECTED TO K+12.2 DAYS

Leach No.	Weight Dissolved (mg)	Specific Activity of Solution (c/min/mg)			Mo^{99}/Zr^{95} at Zero Time
		Gross F.P.'s	Mo^{99}	Zr^{95}	
1	2.4	1.40×10^4	1.7×10^3	4.8×10^2	63
2	88.9	6.41×10^3	6.1×10^1	6.2×10^1	18
3	98.4	2.12×10^3	2.8×10^1	1.0×10^1	50
4	97.3	9.15×10^2	9.4	5.7	30
5	91.0	5.61×10^2	Not Determined		
6	187.3	2.73×10^2	Not Determined		
7	187.8	1.57×10^2	9.0×10^{-2}	5.1×10^{-1}	3.2
8	378.5	3.84×10^2	6.4×10^{-1}	2.0	6.0
9	179.0	4.07×10^2	Undetectable	4.8×10^{-1}	Very Low
10-14	Data not yet available				

R-factor calibration data for this operation are not available at this time. However, some indication can be obtained from the fact that a Mo^{99}/Zr^{95} ratio of about 23 is usually obtained in the home laboratory for a thermal bombardment of U^{235}.

Conclusions

The data of Table 2.6b-2 appear to confirm the evidence from Operation Ivy that for the detonation of a thermonuclear device on a coral surface Mo^{99} tends to concentrate on the surfaces of fall-out particles, while Zr^{95} does not. Further work is in progress.

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Project 11.2 - CLOUD SAMPLING (H. Plank)

Because of gear trouble and accidental decompression the RB-36 sampling control aircraft was replaced by the back-up control B-36 with back-up control personnel. The back-up arrived in the shot area at approximately H+15 minutes with a clear view of the cloud lying above a solid cirrus layer, the top of which lay between 37 and 38 thousand feet. In addition to an opportunity to use the back-up control system, this shot also afforded the chance to try an emergency recovery of an F84G sample from the Bikini airstrip.

Although restricted from very high altitudes by the presence of the back-up control personnel, the secondary control B-36 (comprised by one of the high altitude B-36's) collected a sample at 45,000 feet after completing its control function. Blue Flight was prevented from collecting samples because of mechanical aircraft difficulties in one plane of each element. The number of fissions collected by each aircraft is shown in Table 11.2-1.

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Although the number of fissions collected is about a factor of ten less than in previous shots on Castle, fractionwise the present samples are similar. The high altitude B-36,

Floyd 1, was in the topmost layers of the cloud at 55,000 feet absolute altitude and had to come down several thousand feet to conduct sampling. A private communication from Jere Knight indicates that the topmost section of the cloud had a calcium to fission ratio approximately 1% of that at lower altitudes.

A picture of the cloud taken from the control airplane soon after shot time is shown in Fig. 11.2-1 lying above the cirrus cover. In the original print dark portions suggest that a considerable portion of the cloud lay below the cirrus in the natural weather existing up to 37 - 38 thousand feet. Figs. 11.2-2 and 11.2-3 show the cloud at later times after burst when the wind shear effects can be seen from upwind and cross-wind views respectively. The long streamer seen in Fig. 11.2-3 is the result of a wind velocity at 55,000 feet (absolute) which is approximately 17 knots slower than at the cirrus level and is an illustration that negative as well as positive velocity shear can produce the same relative effects. A dimensional analysis of this photograph shows that the length of the streamer is commensurate with this velocity shear. A notable characteristic of this cloud was that the radiation intensities observed were a factor of from five to nine lower than for previous clouds at the same altitudes and times after burst.

TABLE 11.2-1
SAMPLING RESULTS FOR [redacted] SHOT

Aircraft Code	Type Aircraft and Number	Avg. Sampling Time (Hrs. after Burst)
Red 1	F-84G 030	2:40
Red 2	F-84G 037	2:30
Red 3	F-84G 033	2:30
Red 4	F-84G 051	2:55
White 1	F-84G 046	3:40
White 2	F-84G 053	3:40
White 3	F-84G 038	3:55
White 4	F-84G 049	3:50
Blue 1	Abort	
Blue 2	Abort	
Blue 3	Abort	
Blue 4	Abort	
Floyd 1	FB-36 1086	4:35
Floyd 2	FB-36 1083	5:15
Wilson 1	WB-29 7269	3:10

DELETED

PAGES 94-124 WERE JUDGED
IRRELEVANT AND WERE NOT COPIED

PART III

TASK UNIT 7

[redacted]

TASK UNIT 7 - J. D. Servis, Maj, USA

RADIOLOGICAL SAFETY

(J. D. Servis)

A partial Rad-Safe survey was conducted on [redacted] day with incomplete atoll results. Results of this survey did indicate that Bokobyaadaa, Namu, Enirikku, Bikini, and the Yurochi - Aomoen chain were materially contaminated. Reentry and recovery were accomplished to a large degree on shot day. No secondary fall-out was detected as having resulted from this shot.

Lagoon contamination was restricted to a V shape pattern with apex at Eninman and tips covering the Bokobyaadaa - Aomoen area. A reading of 100 mr/hr was obtained over the Eninman anchorage at H+4 hours. Enyu anchorage was clear of contamination while Bikini anchorage showed traces of contamination at H+4 hours.

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[redacted]

[redacted]

TABLE TU-7-1

[redacted] SUMMARY (r/hr)

Island	H+4 hrs Extrapolated	D+1 day	D+7 days	Pre-shot Background
Enyu	.03	.03	.03	.03
Bikini	5.0	.67	.07	.10
Aomoen	20.0	2.5	1.6	.35
Romurikku	10.0	1.6	.80	.50
Uorikku	5.0	1.0	.60	.47
Yurochi	5.2	1.0	.60	.45
Namu	250.	30.0	16.0	1.5
Bokobyaadaa	600.		16.0	9.0
Ourukaen	.60	.08	.02	.012
Arriikan	.50	.07	.01	.008
Eniirikku	210.0	2.4 T	1.8	.008
Eninman			.02	.010
Airukiiji	.02	.02	.02	.018
Crater	5000.	50.*	60.	

T - Reading at 100 feet

* - Reading at 200 feet

Underlined islands indicate islands contaminated by [redacted] shot.

[redacted]

Task Unit 15 - TIMING AND FIRING (H. Grier)

(H. Grier)

World Time

The world time as measured by the world time clock on [redacted] 1954. This figure is not corrected for transit time from the signal generators in Hawaii to the receiver at Station 70.

Timing System

The operation of the timing system including radio signals was normal.

TABLE A-1
WEATHER (BIKINI ATOLL) AT 0420M, 7 APRIL 1954

Surface Pressure 1009.7 mb
Surface Temperature 81°F
Surface Humidity 82%

Altitude (ft)	Wind Direction (degrees)	Velocity (knots)	Pressure (mb)	Temp. (°C)	Dew Pt. (°C)	Relative Humidity
Surface	040	20	1009.7	81	75	79
1000	070	17	973	23.5	22.0	
1500			958	22.4	21.2	
2000	060	16	940.	21.1	20.4	82
3000	090	08	909	19.7	19.0	
4000	120	07	878	18.4	17.5	80
5000	150	08	848	17.1	16.2	
6000	170	12	819	15.8	14.9	78
7000	170	17	789	14.3	13.5	
8000	190	14	760	12.7	12.2	
9000	200	14	733	11.2	10.9	
10,000	210	14	705	9.6	9.5	75
12,000	180	17	655	6.5	5.6	
14,000	200	08	608	3.0	-0.9	69
16,000	190	10	563	-0.3	-10.4	67
18,000	200	10	522	-3.8	-12.9	64
20,000	220	04	483	-7.8	-23.6	24
25,000	190	20	396	-18.0	-29.6	24
30,000	210	22	322	-27.5	-32.9	42
35,000	210	28	253	-39.3		
40,000	230	34	206	-51.8		
45,000	280	24	161	-63.8		
50,000	240	35				
53,000	230	39				