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CASTLE

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Final Report Project 4.1

STUDY OF RESPONSE OF HUMAN LUNGS ACCIDENTALLY EXPOSED TO SIGNIFICANT FALLOUT RADIATION

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HEADQUARTERS FIELD COMMAND, ARMED FORCES SPECIAL WEAPONS PROJECT
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Report to the Scientific Director

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OPERATION CASTLE — FINAL REPORT PROJECT 4.1

Study of Response of Human Beings Accidentally Exposed to Significant Fallout Radiation

by

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ABSTRACT

Following the detonation of Shot 1 on Bikini Atoll on 1 March 1954, 28 Americans and 239 Marshallese were exposed to fallout. One hundred fifty-seven of the Marshallese were on Utirik Atoll, 64 were on Rongelap Atoll, and 18 were on the neighboring atoll of Ailinginae. The 28 Americans were on Rongerik Atoll. The presence of significant fallout on these atolls was first determined by a recording dosimeter, located on Rongerik, when this device went off scale at 100 mr/hr shortly after the detonation. Emergency surveys detected radiation on the inhabited atolls, and evacuation of inhabitants to the Naval Station at Kwajalein was promptly carried out. The dose of radiation to which the individuals were exposed was calculated from the intensities found on the islands and the decay exponent of the fallout material. The individuals on Rongelap received approximately 175 r, those on Ailinginae received approximately 69 r, and the Americans on Rongerik received an average calculated dose of 78 r. The Marshallese on Utirik received approximately 14 r. The fallout on Rongelap, Ailinginae, and to a lesser extent on Rongerik was distinctly visible. No fallout was observed on Utirik. A significant number of individuals on Rongelap suffered from mild nausea and one or two individuals vomited on the day of the exposure. With the exception of nausea in one Ailinginae individual, there were no other definite gastrointestinal symptoms in the other Marshallese or the Americans. The Marshallese on Rongelap and Ailinginae, and the Americans experienced to a varying degree burning of the eyes and itching of the skin from 1 to 3 days. Later, signs of radiation injury included definite epilation in the Rongelap and Ailinginae groups, and the development of spotty, superficial, hyperpigmented skin lesions that desquamated from the center of the lesions outwards. In some cases the skin damage was sufficient to result in raw, weeping lesions. There was no full thickness necrosis of the skin. The Americans developed only minor skin lesions without ulceration. There were no skin lesions in the Utirik natives. All lesions healed rapidly with no further breakdown of the skin noted during the period of observation. Microscopic examination of biopsies of the lesions showed changes usually associated with radiation injury. Fully clothed individuals and those remaining inside of buildings or huts were protected to varying degrees from development of lesions. Hematologic changes were definite in the Rongelap, Ailinginae, and the American groups. Lymphopenia appeared promptly and was persistent for a prolonged period of time. Neutropenia occurred in all of the individuals with initial minimum values occurring around the 11th day followed by an increase in the counts and a secondary minimum around the 40th to 45th day. The most consistent hematologic change was the depression in the platelet counts. Platelets were below normal when first counted on the 10th day of post-exposure and progressively decreased attaining a minimum between the 25th and 30th day. Although recovery commenced following this minimum, the platelet counts had not returned to normal by the completion of the initial study on the 76th post-exposure day. The incidence of various respiratory and cutaneous infections was identical in all exposure groups and bore no relationship to the hematologic changes.

Urinary excretion of radioisotopes was studied. Small amounts of radioactive material were found. Estimates of total body burden indicate that there is no long term hazard and that ingestion and inhalation of isotopes did not contribute significantly to the initial radiation exposure.

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PREFACE

Operation CASTLE did not include a biomedical program. The participants in Project 4.1 were drawn from various laboratories and were totally unprepared for a field program when the joint DOD-AEC Medical Research Team was organized after the operation had begun.

Dr. John C. Bugher, Director, Division of Biology and Medicine, AEC, and Lt Col L. E. Browning, MC, USA, Surgeon of the Armed Forces Special Weapons Project, selected the project officer and requested that the selection of technical and professional personnel be commenced immediately. Rear Admiral Clarence Brown, Deputy Surgeon General, Medical Department, USN, gave immediate and complete support of all naval medical research activities and assigned responsibility to CAPT Van Tipton, MC, USN, and CDR Harry Etter, MC, USN, of the Atomic Defense Division, Bureau of Medicine and Surgery, USN, for the implementation of the project.

Since little detailed information was available about dose and initial symptomatology, the research team was organized to include the following talents for the constitution of the emergency medical team: internal medicine, hematology, radiation technology and radiobiology. In the selection of personnel the emphasis was placed on past experience in biomedical research in the field with atomic weapons. In addition, provisions were made for a second echelon of specialized personnel in case they were needed. Accordingly, a preventive medicine unit of the Commander-in-Chief, Pacific Fleet, was alerted for possible bacteriologic studies; blood bank personnel, and additional clinicians and nurses were notified in case conditions justified their services in the Kwajalein area. Rear Admiral Bartholomew Hogan, MC, USN, Pacific Fleet Medical Officer, immediately made any needed medical facilities of the Pacific Fleet available.

Personnel were obtained within the Continental limits of the U. S. for the research team as follows:

Naval Medical Research Institute (NMRI)
- 4 medical officers (E. P. Cronkite, project officer, R. A. Conard, N. R. Shulman, and R. S. Farr)
- 2 medical service corps officers (W. H. Chapman and R. Sharp)
- 6 enlisted men (C. R. Sipe, P. K. Schork, C. P. A. Strome, W. C. Clutter, R. E. Hansell, J. S. Hamby)

U. S. Naval Radiological Defense Laboratory (NRDL)
- 1 civilian M.D. (V. P. Bond)
- 1 medical service corps officer (L. J. Smith)
- 4 enlisted men (W. H. Gibbs, J. C Hendrie, W. S. Argonza, J. Flanagan)

Division of Biology and Medicine, AEC
- 2 civilian M.D.'s (C. L. Dunham and G. V. LeRoy)

Armed Forces Special Weapons Project (AFSWP)
- 1 Army Medical Officer (L. E. Browning)

Preliminary studies had been made by CDR W. S. Hall, MC, USN, Station Medical Officer and his staff, and decontamination of the individuals was well underway when Project 4.1 person-

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nel arrived in the field. Preliminary hematologic studies indicated that the individuals probably had not received acutely fatal doses of radiation. The primary responsibilities within the project group were delegated as follows:

Clinical observations and care — LT N. R. Shulman, MC, USN
Organization and operation of laboratory — LT R. S. Farr, MC, USN
Compilation and daily analysis of all data — Dr. V. P. Bond
Decontamination and radiation measurement — LT (jg) R. Sharp, MSC, USN
Senior Petty Officer in charge of laboratory — P. K. Schork, HMC, USN

As the clinical picture developed, a further breakdown in responsibility was necessary. Commander R. A. Conard, MC, USN, and Lt Col L. E Browning, MC, USA, were made responsible for a daily survey of skin lesions, and Dr. S. H. Cohn was made responsible for studying the problems concerned with the excretion of radioisotopes and the estimates of body burdens in the exposed individuals.

The project officer commends all of the professional and technical members of the group for their excellent motivation, initiative, and voluntary long hours of extra work that were essential for the accomplishment of the clinical and research objectives, and for the rapid collection of the preliminary data in the field. It is emphasized that the work was a cooperative endeavor in which all were mutually dependent upon each other. The willing efforts of all concerned constituted a remarkable example of team-work and sacrifice of personal ambitions and desires for the good of the project at large.

The authors wish to express their gratitude and indebtedness to Dr. John C. Bugher, CAPT Van Tipton, and CDR Harry Etter; CAPT W. E. Kellum, MC, USN, and CAPT T. L. Willmon, Commanding and Executive Officers, respectively, NMRI, CAPT R. A. Hinners, USN, Director, NRDL, and CAPT A. R. Behnke, MC, USN, Associate Director, NRDL; all of whom gave unlimited support and reduced administrative procedures to a bare minimum, thus making it possible for the unit to be assembled and underway in a matter of hours.

On arrival at Kwajalein, RADM R. S. Clarke, USN, Commanding Officer, U. S. Naval Station, Kwajalein, supported Project 4.1 with all the facilities at his disposal. As a result, a laboratory and clinic was established and operating within 24 hours after arrival of the project personnel.

Project personnel also wish to acknowledge the outstanding contributions of Col C. S. Maupin, MC, USA, Field Command, AFSWP, CAPT H. H. Haight, MC, USN, Division of Military Application, AEC; Col K. Houghton, MC, USAF, Special Weapons Center; CAPT Donald Dement, MC, USN, CINCPAC Fleet; Drs. T. L. Shipman, T. White, and P. Harris of Los Alamos Scientific Laboratory; Dr. Gordon Dunning, Division of Biology and Medicine, AEC, and Dr. G. V. LeRoy, University of Chicago. During all phases of the early care of the exposed individuals, the foregoing participated as much as their other primary duties would permit. In addition the authors wish to thank them for the extensive and complete data which they collected in the atolls or their home laboratories and kindly furnished to the project personnel.

The continuous help and cooperation of Trust Territory representatives and their aid in obtaining necessary control data on native Marshallese at Majuro is hereby acknowledged. The authors are particularly indebted to Mr. John Tobin. His help as an interpreter and his extensive knowledge of the Marshallese language and habits were invaluable. Lieutenant J S. Thompson, MC, USN, furnished his records on the exposed individuals decontaminated by the radiation group of the VP-29 squadron stationed at Kwajalein.

The authors wish especially to express their admiration for the excellent job done by the medical personnel of the U. S. Naval Dispensary, Kwajalein, in completing the extensive laboratory examinations that were required to obtain a prompt initial evaluation of the severity of the radiation injury.

The authors are deeply grateful to Dr. David A. Wood of the University of California Hospital, San Francisco, and Dr. Edward L. Alpen and Miss Pat Roan of NRDL, for invaluable aid in carrying out the histopathological evaluation of skin lesions. The extensive contributions of Mr. H. H Hechter in the statistical analyses of the data, and of Mr C. A. Sonchaus of the NRDL in dosage calculations are gratefully acknowledged.

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CHAPTER 1

INTRODUCTION

1.1 OBJECTIVES

Project 4.1 was organized with the following specific objectives:

(1) To evaluate the severity of the radiation injury in the human beings exposed to the fallout radiation.

(2) To provide for all necessary medical care for these individuals.

(3) To conduct a scientific study of radiation injury in human beings.

1.2 GENERAL DESCRIPTION OF THE EXPOSED GROUPS

Shot 1 of Operation CASTLE was detonated on 1 March 1954. Following the detonation significant amounts of radioactive materials fell on the following populated neighboring atolls: (1) Rongelap, (2) Ailinginae, (3) Rongerik, and (4) Utirik. Exposure groups are identified according to their geographical location at the time of exposure. The numbers of individuals involved, their location, the distance of the atoll on which they were located from the site of the detonation on Bikini, the calculated dose of radiation, the probable time of beginning of the fallout and its duration are tabulated in Table 1.1. The Rongelap group received the highest calculated dose. These individuals were living under relatively primitive conditions in lightly constructed palm houses (Fig. 1.1). The Ailinginae people were a part of the Rongelap group who were on their Ailinginae farms from the time the fallout began to the time of evacuation. Their calculated dose was smaller than that of the other members of their group that had remained on Rongelap. The third and largest group of Marshallese, inhabitants of the atoll of Utirik, received the smallest dose of radiation.

The American military personnel exposed on Rongerik were aware of the significance of fallout and promptly put on additional clothing to protect the skin. As far as duties would permit, they remained inside of Butler-type buildings. In contrast, most of the native Marshallese remained out of doors and thus were more heavily contaminated by the material falling on the atolls. Some of the Marshallese, however, went swimming during the fallout and many of the children waded in the water; thus washing a considerable amount of the material from their skins.

1.3 EVACUATION AND EARLY CARE OF THE EXPOSED GROUPS

The American military personnel were evacuated to Kwajalein via air in two groups on 2 March. The native Marshallese were evacuated by a combination of air and surface trans-

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portation. Since a survey of all individuals showed that there was significant contamination of skin and clothes, prompt decontamination was instituted. Clothes were removed and laundered. Their skin and hair were washed repeatedly with fresh water and soap. In many individuals, particularly in the Marshallese, it was difficult to wash the radioactive material from the hair because of the heavy coconut-oil hair dressing used by these people.

Table 1.1 EXPOSED AND CONTROL UNEXPOSED GROUPS

Group Designation	Total Number in Group	Distance from Bikini (Naut. Miles)	Approximate Effective Time of Fallout	Time of Evacuation	Instrument Readings Used in Dose Calculations	Best Estimate of Total Gamma Dose in Air(r)*
Americans, Exposed Rongerik	28	135	H + 6.8 hr	H + 28.5 hr (8 men) H + 34 hr (20 men)	280 mr/hr H + 9 days	78
Americans, Control Kwaj-American	105					
Marshallese, Exposed Rongelap	64	105	H + 4 hr	H + 50 hr (16 people) H + 51 hr (48 people)	375 mr/hr H + 7 days	175
Ailinginae	18	83	H + 4 hr	H + 58 hr	100 mr/hr H + 9 days	69
Utirik	157	270	H + 22 hr	Started at H + 55 hr Completed at H + 78 hr	40 mr/hr H + 8 days	14
Marshallese, Control Majuro Group	117					
Total Exposed – 267 Total Controls – 222						

* See Section 1.4.3.

1.4 ESTIMATION OF WHOLE BODY EXTERNAL DOSE

The estimated values of external dose given in Table 1.1 were based on readings of AN/PDR-39 field instruments. Averages of a number of dose rate measurements on each island at a given time were used. The readings were taken in air, approximately 3 feet above ground, several days after the inhabitants were evacuated. Before this time, adequate surveys with well calibrated instruments had not been possible.

Several variables which influence the results are indicated below. These will be discussed in greater detail in an addendum report on external dose, which will contain the data, methods and calculations by which the external dose analysis was made.

1.4.1 Energy Distribution of the Fallout Gamma Radiation, Its Variation With Time, the Response of the Meter in Each Energy Region and Its Correction Factor for the Total Dose Spectrum

Fallout deposited as an effectively infinite plane source resulted in the dose-energy histogram shown in Fig. 1.2. Its energy distribution was the result of degradation of the original

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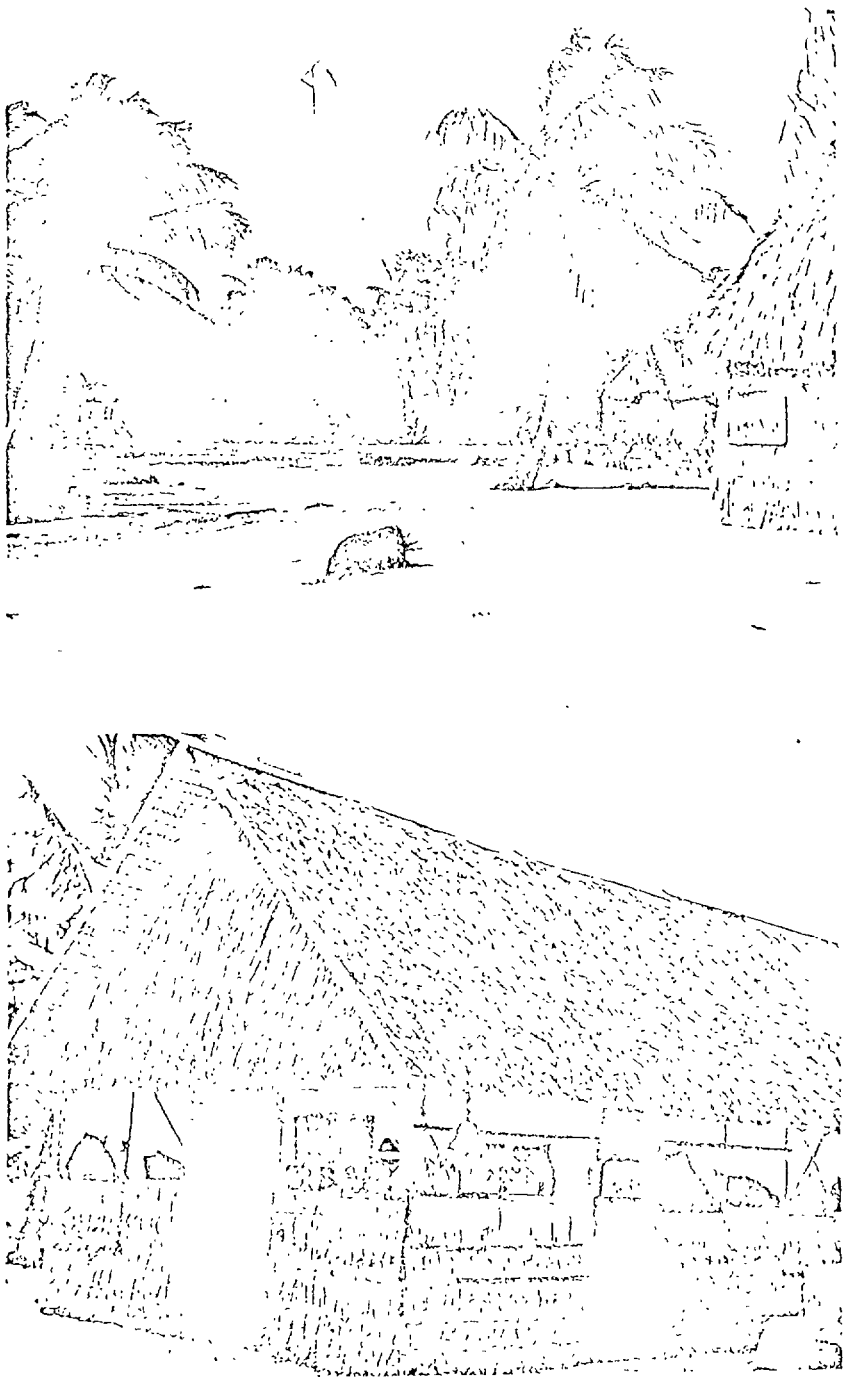

Fig. 1.1 The Living Area on Rongelap Island, Indicating the Light, Open-type of Construction

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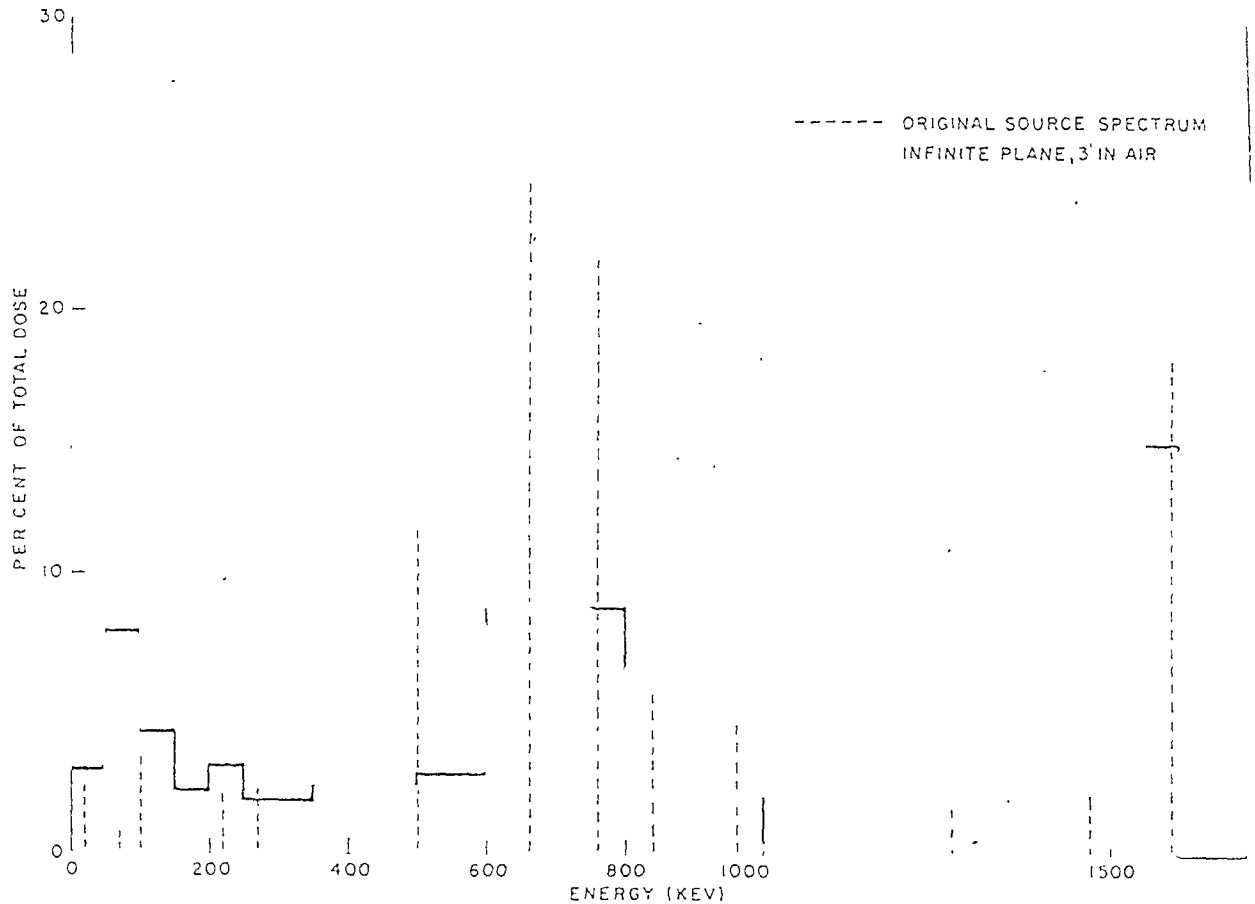

Fig. 1.2 Histogram of Proportion of Total Dose Contributed by Various Energy Regions from the Fallout Radiation