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# **Fallout From Bravo**

## **The 1954 H-Bomb Test and Its Health Consequences**

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FALLOUT FROM BRAVO

The 1954 H-Bomb Test and Its Health Consequences\*

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BRAVO AND THE MARSHALLESE  
The 1954 H-Bomb Test and Its Consequences\*

**The Bravo shot**

In 1946 the United States chose Bikini atoll in the Marshall Islands as the best place in the world to test nuclear weapons—once the native Bikinians had been resettled. Yet Bikini was not the site when the Atomic Energy Commission established its Pacific Proving Ground in 1948. Instead the AEC displaced another Marshallese population, this time from the more remote atoll of Enewetak, 200 miles to the west and farther than Bikini from other inhabited islands. Bikini remained unused and deserted until well into the next decade, when H-bombs appeared on the scene.

Although the first full-fledged thermonuclear test took place at Enewetak in 1952, that atoll seemed too small if testing such powerful weapons were to become routine. This prospect restored Bikini to the test picture. Operation Castle, scheduled for early 1954, would test actual H-bomb designs, and the AEC slated Bravo, the first test in the series, for Bikini.

That meant, among other things, moving ground zero 200 miles closer to the nearest Marshallese population in the direction of the prevailing winds. The 82 inhabitants of Rongelap lived only 100 miles east of Bikini, and the AEC faced a dilemma. On the one hand, Rongelap seemed well beyond reach of any dangerous fallout. On the other, extending the declared danger area to Rongelap or other islands farther east would require resettling their inhabitants,

a choice even more controversial in 1954 than it had been in 1946 or 1948. So the AEC drew the new border west of the inhabited islands, but under Navy prodding agreed to track fallout past the formal danger area and to prepare evacuation plans against an unexpected fallout threat.

A military task force conducted Operation Castle. Not only would its ships help evacuate the Marshallese in an emergency, promised the task force commander, but "the impact of fall-out on populated islands will be one of the major factors in the . . . decision to shoot."<sup>1</sup> Major perhaps, but not primary. Although never ignored, the unlikely prospect of dangerously high fallout on distant populations played a relatively small part in Castle safety planning. Attention instead focused on close-in fallout, potential radiation hazards in the vicinity of Bikini that might affect the task force itself.

As Bravo day approached—Monday, the 1st of March 1954, at Bikini, but a day earlier the other side of the International Date Line in the U.S.—weather mattered most. It held for the most part, though Sunday night saw low altitude winds turn light and variable, which might affect close-in fallout. The task force took the precaution of shifting 20 miles farther out to sea, now 50 miles from Bikini. Even if winds did blow toward the nearest inhabited islands, predicted speeds and altitudes seemed to preclude any real danger; radioactive debris would reach Rongelap only after 12 hours or more, by then having decayed to safe levels.

Bravo went off as scheduled, at 6:45 a.m., but at 15 megatons more than doubled the predicted yield. It also produced heavier-than-expected fallout, forcing the returning task force to retreat. Within hours all efforts to retrieve data had to be suspended when the first survey of the atoll revealed

"wide spread fall-out of surprising intensity."<sup>2</sup> Preoccupied by this close-in fallout, radioactive debris that never reached high altitudes, task force members spared little concern for distant problems that might not even exist.

High altitude cloud tracking had begun with a B-29, the so-called Wilson 2, flying a holding pattern 50 miles west of Bikini to warn if fallout threatened base facilities at Enewetak. It should have left just before noon to follow the actual cloud moving east-northeast. Wilson 2 was late, though, and too far north; instrument problems added to the muddle. Apparently missing the main cloud, it measured radiation matching pretest forecasts in both range and bearing, so seeming to confirm the absence of threat to inhabited islands. A second plane tracking the cloud at lower altitude was contaminated early in the mission and had to be replaced, costing the task force another chance to obtain prompt and precise distant fallout data.

Dangerously high levels of radioactivity from distant fallout far more intense than expected in fact began reaching islands east of Bikini by early afternoon, several hours sooner than predicted. Unfortunately, task force headquarters on Kwajalein received only spotty information. First word came from a 28-man Air Force weather station on Rongerik, 135 miles from Bikini, but the 3 o'clock message was both terse and cryptic. It also coincided with a new wave of light fallout on the fleet, so sounding no alarm bells. According to the task force rad-safe officer, "It was generally believed that Rongerik and the task force ships were caught in a general pattern of finely divided . . . particles over a wide area" that posed little danger.<sup>3</sup>

A second message 5 hours later, at 8:15 that evening, conveyed only slightly greater urgency. Though still not greatly alarmed, the weather unit

commander decided to send his rad-safe officer on the morning supply flight to Rongerik for a first-hand look. To be on the safe side, he also radioed the weather team to cease work, take cover, and stand by their radio.

### **Evacuation and response**

Concern proved all too justified. Evacuation began soon after the morning flight landed, but that hardly ended the matter. Heavy fallout on Rongerik implied worse for Rongelap, 35 miles west and that much closer to ground zero. Returning to Kwajalein, the rad-safe officer warned that "High possibility exists that immediate steps must be taken to evacuate natives."<sup>4</sup> No one knew for certain, since the task force had neither person nor instrument on the spot. It did have its ongoing aerial radiation survey of the northern Marshalls, however, and Flight Able radioed the bad news Tuesday afternoon.

The task force promptly dispatched a destroyer. Monitors meanwhile flew to Rongelap for on-the-spot readings before dark; at 6:30 Tuesday evening, 36 hours after Bravo, they found radiation levels more than high enough to demand emergency action. Evacuation began early Wednesday morning, first from Rongelap, then from nearby Ailinginae where some islanders had gone fishing. A seaplane flew the 16 who seemed sickest to Kwajalein, the destroyer sailing with the other 66. Estimated doses ran up to 125 r, according to a task force official, and "many complained of stomach aches and headaches accompanied by vomiting on first day with similar symptoms to lesser degree on second day."<sup>5</sup>

Rongelap was not the only Marshallese atoll hit with fallout. Continuing on its Tuesday survey, Flight Able reported high readings just before 5 o'clock

at Utirik, 150 miles east of Rongerik. The next morning a destroyer sailed for that atoll with orders to begin evacuation at dawn next day; monitors landed to confirm the decision. Radiation survey results suggested that, by the time the 154 Utirik islanders boarded the destroyer the morning of 4 March, some of them may have received as much as 15 r.

Flight Able also recorded uncomfortably high fallout at Ailuk, south of Utirik. Ailuk posed a delicate problem. The atoll's 400 inhabitants almost doubled the combined population of Rongelap and Utirik, while the best guess of task force experts projected total exposure at 20 r—"less," as the task force rad-safe officer observed, "than the minimum standard used by the task force for its sampling aircraft crews. This was the major factor in the decision not to evacuate Ailuk."<sup>6</sup> No other islands became candidates for evacuation.

AEC Chairman Lewis Strauss wanted things kept quiet—no public release on fallout or evacuation. If outside pressure forced a statement, it would come from Washington. Nobody on the scene, he ordered, should "make anything public on these matters."<sup>7</sup>

Al Graves, one of those on the scene as head of Los Alamos test division, objected. In an "Eyes Only" message to Washington he described himself as "very much concerned [about] the recent decision not to make a release on evacuation of natives unless forced to do so." Graves deeply regretted that this could only create "the impression that we are being furtive in our actions with regard to these people."<sup>8</sup>

The guarded reply from Washington sought more details. From the AEC's viewpoint, a release looked ill-advised "until we know reasonably confidently whether or not serious illness or worse is going to result."

Evacuation as such had not greatly disturbed officials in Washington, but they did want to know how the Marshallese were exposed, why they had not been removed in advance, and what risks further testing might entail.<sup>9</sup>

The task force responded promptly. "The natives were not evacuated prior to detonation because, on the basis of information available to us, it was not considered necessary and no significant fall-out was expected on inhabited areas." Earlier tests had not shown "that radioactivity from high yield detonations can be carried hundreds of miles away from ground zero in intensities sufficient to become health hazards."<sup>10</sup> Criteria for wind and weather at time of firing simply became more stringent, the rest of the Castle series being completed without incident.

The victims meanwhile remained under observation at Kwajalein. Doses to those from Utirik appeared too low to pose any real threat; the Navy installed them on another island in Kwajalein atoll until Castle ended. Initially, doctors found no symptoms among the Rongelap islanders either, even among the 20 who were sick during the first 2 days.

Yet all too soon they displayed classic symptoms of high exposure. In his official report, the task force commander noted: "From a blood picture standpoint, the Rongelap natives corresponded very well with the Japanese who were about 1.5 miles from ground zero at Hiroshima and Nagasaki. In this group two to three per cent lost some hair, ten per cent had sore mouths, and five per cent experienced hemorrhages under the skin."<sup>11</sup>

They clearly warranted further study, and a joint AEC-Department of Defense medical research team was on its way even before written orders could be cut. Reaching Kwajalein on 8 March, a week after Bravo, the 21-man team

headed by Eugene Cronkite of the Naval Medical Research Institute promptly began to gather data: photos, case histories, blood counts, urinalyses, physical exams. This effort became Operation Castle Project 4.1, "Study of Response of Human Beings Exposed to Significant Beta and Gamma Radiation Due to Fall-Out from High-Yield Weapons."<sup>12</sup> Such an ill-chosen label in a secrecy-shrouded program—Cronkite's instructions explicitly enjoined secrecy—may help explain later charges that the AEC deliberately exposed Marshallese to observe the effects.

Secrecy in fact proved a fleeting hope. On 11 March, a Cincinnati newspaper quoted a Marine's letter to his mother from Kwajalein. Dated 6 days earlier, it mentioned "two destroyers that pulled in here today bearing natives . . . . They were suffering from various burns and radio activity."<sup>13</sup> The resulting furor forced the AEC to issue a brief statement.

During the course of routine atomic tests in the Marshall Islands, 28 U.S. personnel and 236 residents were transported from neighboring atolls to Kwajalein island according to plan as a precautionary measure. These individuals were unexpectedly exposed to some radioactivity. There were no burns. All are reported well. After completion of the atomic tests, they will be returned to their homes.<sup>14</sup>

This release arrived from Washington with an order: "There will be no elaboration of the above statement."<sup>15</sup> And for good reason.

The carefully worded release nowhere lied outright, but was misleading and disingenuous throughout. "Routine atomic tests" stretches words to the limit when the subject is the first trial of a deliverable H-bomb hundreds of

times more powerful than the A-bombs known to the public. "According to plan" scarcely suggests resort to emergency evacuation in a crisis compounded of poor wind forecasts, an unexpectedly large blast, and misjudged fallout phenomena. "Some radioactivity" hardly conveys doses high enough to invite comparison with Hiroshima and Nagasaki. There were, indeed, "no burns"—yet. But a day or two later the first signs of severe beta burns surprised no expert. That all "are reported well" was true 10 days after Bravo, but omitted mention of symptoms they had when evacuated, significant blood changes already observed, other symptoms anxiously awaited, and as yet uncertain prognoses for the hapless victims. "After completion of the atomic tests" gave no hint that months, or even years, might elapse before all the Marshallese went home. Elaborating on such statements very likely would lead quickly into treacherous waters.

### **Repercussions and studies**

Rongelap evacuees began losing hair two weeks after Bravo, children first, then adults. Abnormal blood counts, depigmented skin spots, and small skin lesions were other symptoms. None seemed life-threatening. The task force staff medical officer felt "the possibility of extensive hospitalization or serious illness remains but the likelihood is lessening."<sup>16</sup> Cronkite's daily reports supported the same conclusion. Urine samples showed traces of plutonium and radioiodine, but nothing then judged serious.

By early April the worst appeared over. For the first time, Cronkite reported positively on at least short-term prospects for the exposed Marshallese: "Since hematologic picture appears stabilized," since a cold epidemic had no

"serious complications and since skin is healing rapidly a favorable prognosis for the immediate future can be given."<sup>17</sup> But he also urged they be followed medically for the rest of their lives. The AEC agreed. Acknowledging that Bravo victims might face future health problems, the Commission included medical care in plans for long-term studies.

Despite some minor puzzles, concern now shifted toward how soon they might return home. Surveys of Rongelap and Utirik in late April 1954 yielded mixed results. Utirik could be reoccupied as soon as Castle ended in June, but not Rongelap. Not only had fallout badly contaminated the home island, but the atoll's northern islands, the main source of food, had received ten times more. For the time being—more than 3 years, as it turned out—the AEC moved the Rongelap islanders to a newly built village on Majuro atoll.

On the whole, acute symptoms passed quickly, and all seemed well with the Marshallese. After a decade the Brookhaven team in charge of the major long-term study noted "few findings . . . that could be related to radiation exposure."<sup>18</sup> Such effects as were observed seemed both slight and ambiguous; statistical analysis in so small a population provided little help. Miscarriages and stillbirths doubled among exposed Rongelap women during the first 5 post-Bravo years, then returned to normal. Despite signs of impaired growth and development, especially among younger children, no clear-cut pattern emerged. Persistent blood chromosome abnormalities left the question of genetic damage open, but children of exposed parents showed no other effects.

The 2nd decade was another story. A boy 1 year old when Bravo fallout hit Rongelap died at 19 of a form of leukemia that radiation might cause. As with all such long-delayed effects, no one could know for certain

whether or not radiation caused his specific disease, though it seemed likely. Other cases of cancer appeared unrelated to radiation exposure.

About the cause of one affliction, however, no doubt existed. The Rongelap islanders not only received external gamma doses up to 190 r, but also estimated doses as high as 1,400 r to the thyroid from radioiodine breathed and swallowed. A decade after Bravo the results began to show in thyroid tumors, benign and malignant, as well as cases of hypothyroidism and retarded growth among those who were children at the time.

Thyroid problems caught the experts by surprise. Though aware of radioiodine's potential hazard, they had seen no early evidence of damage. Calculated thyroid doses fell well below what 1954 believed to be tumor-causing levels. Even 5 years later, one review of the islanders' medical status failed to mention radioiodine among the fission products that might have added to their body burdens. This was less a failure of data than of perception.

Radioiodines had been measured, only to be dismissed as insignificant: Although radioactive isotopes of iodine probably delivered substantial doses, concluded a 1959 report, "absorption . . . was too small to result in any acute effects," or long-term effects, either.<sup>19</sup> But the experts then assumed that only iodine-131 mattered because it had by far the longest half-life, 8 days. As the Marshallese revealed, the shorter lived and therefore more highly active radioisotopes of iodine mattered too.

Children suffered disproportionately, at least in part because their smaller thyroid glands received relatively higher doses. By 1974 almost a third of those exposed had developed thyroid neoplasms. Fortunately, the thyroid is a very radio-resistant organ and thyroid cancer is seldom fatal; none of those

afflicted had died of this disease. Although reduced hormone levels from damaged thyroids might cause later trouble, that question remains unresolved. Thyroid injury and its consequences, concluded the Brookhaven medical team 20 years after Bravo, had become "the most serious late result of the fallout exposure in the Marshallese people."<sup>20</sup>

The United States has never admitted legal liability for injured Marshall islanders, though it has accepted a degree of moral responsibility, as reflected both in ongoing medical care and, from 1964 onwards, in *ex gratia* payments. The 1983 Compact of Free Association between the United States and the Republic of the Marshall Islands created a \$150,000,000 trust fund for health-related purposes. That offer had a catch. Acceptance of compact and compensation meant renouncing all future claims on the United States, despite suits totaling nearly six billion dollars still pending.

The AEC in March 1954 had quickly decided that data from the accidentally exposed Marshallese could be of immense medical and military value. Immediate action centered on evacuating, decontaminating, and medically treating them. But also promptly launched were the studies of human response to exposure from fallout that became project 4.1 in the Castle experimental program. Like the American radium-dial painters of the 1920s and the Japanese of Hiroshima and Nagasaki in 1945, the Marshallese of 1954 inadvertently provided otherwise unobtainable data on the human consequences of high radiation exposures. But such contributions to knowledge are costly, and like those earlier victims, the victims of Bravo themselves paid most heavily.

## NOTES

\*An earlier version of this paper was presented at the annual meeting of the History of Science Society, Washington 1992. It draws chiefly on my research for *Elements of Controversy: The Atomic Energy Commission and Radiation Safety in Nuclear Weapons Testing, 1947-1974* (Berkeley: Univ. of California Press, forthcoming), which provides more details and fuller documentation.

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