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THE DEVELOPMENT OF THE ATOMIC BOMB-LOS ALAMOS

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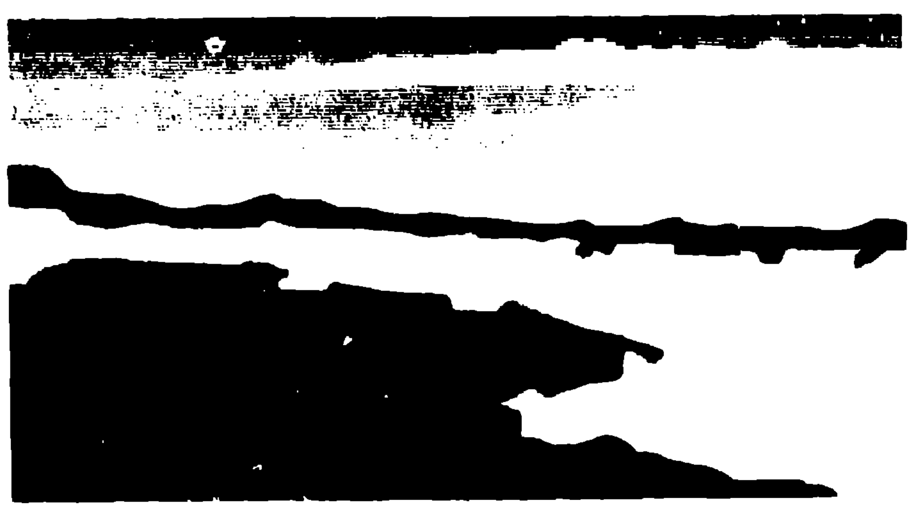

Los Alamos
NATIONAL LABORATORY

"The Development of the Atomic Bomb–Los Alamos"

Contributions of New Mexico to Victory in WWII

October 7, 1993

In November, 1942, four men traveled to Jemez Springs, New Mexico in search of a site for a top-secret laboratory to design the first nuclear weapons. Major John Dudley of the U. S. Army Corps of Engineers had recommended Jemez Springs after scouring the west for a remote place that would provide secrecy and safety from enemy attack, with a climate that permitted year-round construction, and yet would have adequate transportation, power, water, and fuel to complete its mission. To allow testing of high explosives and ballistics experiments, it would also have to be in a sparsely populated area. Dudley's boss, Manhattan Engineer District Commander General Leslie R. Groves, also wanted enough buildings to house a small research staff–of roughly 40 scientists and technicians.

Dudley had searched parts of California, Nevada, Utah, Arizona and New Mexico. His first choice for the laboratory site had been Oak City, Utah: "It was a delightful little oasis in south central Utah," he wrote. "The railroad was only 16 miles away over a nice, easy road. The airport was not too distant. The water supply was good. it was surrounded by hills, and beyond there was mostly desert. However, I noticed one thing: if we took over this area we would evict several dozen families and we would also take a large amount of farm acreage out of production." Had he chosen Oak City, New Mexico's contribution to World War II would have been quite different than it was.

Jemez Springs had a resort hotel and a number of empty buildings available for housing, but few people to be evicted and no farmland. It was surrounded by mountains and a small ridge could separate the technical area from the residential area. This provided a safety margin. Dudley recalled: "If the place blew up only the scientists would be involved and not all the families." Its road allowed the scientific equipment for the new laboratory to be hauled up from Albuquerque. A site study by members of the Albuquerque Office of the Corps of Engineers confirmed his choice

The November 16 visit was intended to ratify the selection of the site for the new laboratory on the western slopes of the Jemez Mountains of New Mexico.

University of California physicist J. Robert Oppenheimer took one look at the site, however, and told Groves that it would not do. While Dudley had been told to look for a site enclosed by hills, Oppenheimer wanted an expansive setting. While Dudley wanted good access roads, Oppenheimer only wanted one adequate to haul two heavy howitzers to the site. The fourth man in the team, University of California physicist Edwin M. McMillan, thought that there would not be room enough for the laboratory he and Oppenheimer had planned in the narrow valley. Groves asked Oppenheimer if he had a better location in mind. "Oppenheimer proposed Los Alamos as though it was a brand new idea," Dudley recalled, although the Army had surveyed it and found it had an inadequate water supply. Overruled by Groves and Oppenheimer, he drove them by jeep over primitive roads to the Los Alamos Ranch School.

Oppenheimer knew the area from visits to northern New Mexico in the 1920s and 1930s. He had purchased a cabin near Cowles in the Pecos, and often road horseback on the Pajarito Plateau, where Los Alamos is today. It had long been his ambition to combine "physics and desert country." Los Alamos offered an opportunity to do so in an beautiful setting. To the west, the rim of the Valle Caldera cast its rugged shadow across the plateau in the late afternoon. To the east, the Sangre de Cristo thrust snow-capped peaks against a sky that was still clear blue. Such thoughts may have occupied his mind as the four men drove into the Ranch School, even though the Jemez had clouded over that day.

As they arrived, a light snow was falling, but the students and their teachers of the Ranch School were on their playing fields in shorts. Their rugged curriculum combined college preparation with outdoor conditioning, and the cost of tuition, room and board was a princely $2400, about $20,000 in 1993 dollars. Almost a year after Pearl Harbor, the school was losing faculty, if not students, to the war effort. Soon, it would lose its campus.

The visitors saw that the school's 42 buildings would do for housing the laboratory's scientists. Groves noted that access to the Mesa could easily be controlled by shutting off the main road. That road could also be widened to accommodate trucks and heavy machinery Canyons surrounding the site could be used for explosives and ballistics tests. Although the water supply was marginal, Groves thought it might do for the few score scientists and technicians he believed would be needed. At dinner in Santa Fe that evening, he decided to acquire the site.

Within two weeks Leslie Groves had arranged to acquire the Ranch School, over the protests of Ranch School Director A. J. Connell, who had to rush his term to completion in January. The Army also acquired 54,000 acres of semiarid forest and grazing land controlled by the Federal Government, and purchased 8900 acres from homesteaders and ranchers. The total cost for all private land was approximately $4 million in 1993 dollars[1]. This takeover, which Connell called "the Big Invasion," displaced few New Mexicans, although some of them, like Peggy Pond Church, the daughter of the Ranch School's founder and wife of one of its teachers, were subsequently very vocal about their discommodation. It was the first of many sacrifices made at Los Alamos.

Of course, no New Mexican then knew the purpose of the new Army installation at Los Alamos, although a few of the Ranch School students recognized Ernest Lawrence when he reconnoitered the site with Oppenheimer and McMillan a week after their first trip. Since Lawrence had won the Nobel Prize for work on nuclear physics with his cyclotron, it did not take them long to figure out that the project must have something to do with atomic energy. They could not have guessed that the object was a bomb. Even the Army's contractor for the laboratory, the University of California, was unaware of that for at least a year.

Although its purpose was concealed for the next 33 months, Los Alamos scientists fired a shot heard round the world, whose reverberations are still with us, in August, 1945. Let me tell you, briefly, how they came to do that. The story begins with the discovery of fission of Otto Hahn and Fritz Strassman in 1938 in the Kaiser Wilhelm Institute for Chemistry in Berlin, Germany.

1. Vincent Jones, *Manhattan: The Army and the Atomic Bomb* (Washington, D.C.: U.S. Army Center for Military History, 1985), p. 328-330.

Historical Background

The discovery capped a half-dozen years of rapid progress in the new field of nuclear physics. Fortunately, Americans, who had long followed the lead of Europe in the sciences, had managed to come abreast of their foreign colleagues in this field, where particle accelerators like Lawrence's cyclotron and Robert J. Van de Graaff's electrostatic generator allowed them to apply the national genius for technology to the solution of physical problems. At the same time, thanks to the immigration of Europeans like Albert Einstein, Hans Bethe, and Enrico Fermi and the efforts of native-born theorists like J. Robert Oppenheimer, Americans had also matured in theoretical physics, where thought experiments supplanted "atom-smashing." Within a year after the discovery of fission, over 100 articles appeared on the subject, many describing the work of native of adopted Americans.

The most famous of these new citizens, Albert Einstein, warned Franklin D. Roosevelt of the possibility of nuclear weapons in October, 1939. During the three years which separated his warning from the birth of Los Alamos, American scientists had invented means of producing fissile materials like uranium 235 and plutonium, a transuranic element discovered at the University of California Radiation Laboratory in 1941. Oppenheimer's 1942 summer study of the theory of the nuclear bomb, also at the University of California, had revealed the possibility of a thermonuclear bomb of much greater destructive capacity than the fission weapon. As Americans, and their British allies learned more about these possibilities, they became more apprehensive about the lead Nazi Germany might have in the secret race to the bomb.

Just 51 years ago today that the two founders of Los Alamos, J. Robert Oppenheimer and General Leslie R. Groves, first met at Lawrence's Radiation Laboratory. There, for the first time, Groves heard Oppenheimer's idea for a centralized laboratory to design a nuclear weapon. Scattered experiments at a variety of universities in support of the theoretical design of the atomic bomb had proved impossible to coordinate under security regulations that prohibited telephone calls, publications, and other normal forms of scientific communication. Moreover, the differences in enrichment of uranium samples, measuring instruments, and experimental techniques led to duplication of effort and incommensurable results. [1]

Groves' plutonium and uranium plants, which would furnish the raw materials for that weapon, were not yet built. He agreed to build the laboratory so that their production requirements could be determined as quickly as possible. He also appointed Oppenheimer to lead it over the objections of his security officers, who were concerned about Oppenheimer's left-wing associations, and those of a number of senior scientists involved in the Manhattan Project. Unlike them, Oppenheimer did not possess a Nobel Prize, nor would he ever win one. Unlike them, he had never led a major physics laboratory. While his University of California colleague, Ernest Lawrence, had won funds to build larger and larger cyclotrons in the Radiation Laboratory at Berkeley in the 1930s, Oppenheimer had been lucky to get pencils. Nevertheless, Groves gave this dreamer millions to build and operate Los Alamos, and that gamble, which rose to over $2 billion once the other facilities of the Manhattan Project were accounted for, paid off because Oppenheimer made Los Alamos work.

The race for the atomic bomb was run not only in Los Alamos, but also in other "secret cities," like Oak Ridge, Tennessee, and Hanford, Washington, where hundreds of millions of dollars were spent to build the production plants that made the uranium and the plutonium that went into the nuclear weapons designed and built at Los Alamos. Like all of the efforts we celebrate here today, the effort at Los Alamos was part of a larger national effort in which New Mexico played a role far greater than one might have expected from the 47th state. Indeed, it was an international effort, for the emigrès from fascism joined a British mission led by James Chadwick at Los Alamos.

The Wartime Accomplishment of Los Alamos

The "secret city" in New Mexico, known only as "Project Y" (Hanford was W and Oak Ridge was X), was built rapidly in the winter of 1942-43, before Oppenheimer and his staff began work in April. The Sundt Construction Company modified the Ranch School buildings, and,

1. John Manley, "A New Laboratory is Born," in Lawrence Badash, *et al., Reminiscences of Wartime Los Alamos* (New York: D. Reidel, 1980), p. 25.

added soldiers' barracks, a mess hall, officers quarters, an administration building, a theater, and an infirmary, as well as apartments, a bachelor dormitory, laboratory technical buildings and utilities for civilian scientists designed by Willard C. Kruger and Associates of Santa Fe,. These plans changed constantly as Oppenheimer visited Kruger every other week.

For the Albuquerque Corps of Engineers, the project became known as the "Buck Rogers Project," since no one had any idea what was going on. The engineers there had been told that it was to be a "heavy bombardment range," a claim made patently false by the plans. Actually, Van de Graaff accelerators from the University of Wisconsin, a Cockcroft-Walton machine and a betatron from the University of Illinois, and a cyclotron from Harvard, machines that bombarded atoms, were the project's principal armamentarium in the early months.

Oppenheimer's plans for the original "technical complex" included an administrative building which also housed theoretical physics, since he hoped to lead both efforts, chemistry and physics laboratories bracketed by the Van de Graaff and Cockcroft Walton accelerators, shops, a cryogenic laboratory to investigate liquid deuterium and tritium for the super bomb, and the cyclotron building. It was sufficient, the planners felt, for about 100 scientists, the number Oppenheimer then anticipated would staff the Laboratory. You can see pictures of some of these buildings in our display outside.

By March 24, 1943, forty-two apartment buildings, Officers' Quarters, six barracks, a PX, the chemistry and physics laboratories, the cyclotron and the other main technical buildings were completed.[1] The construction continued at much the same pace throughout the war. No sooner had they completed construction of main technical area and the Anchor Ranch test site, then the Army demanded 290 more apartments, twelve civilian dormitories, six more military barracks, warehouses, service, recreation and messing facilities, hospitals, and security facilities. These were finished on November 30, 1943.[2] Then Oppenheimer decided to build a new site to make high-explosives on December 1. And so it went.

1. Marjorie Bell Chambers. "Technically Sweet Los Alamos, the development of a federally sponsored scientific community." (Albuquerque: University of New Mexico. Thesis. 1974). p. 86.
2. Chambers, "Technically Sweet," 110-111.

All of this construction was accomplished by southwestern firms with local labor under Army supervision. By the time the first scientists arrived on March 15, three thousand construction workers had been at work for three months. The work was far from perfect, and the morale of the workers, who had been building for three months without any idea of what they were working on, was low. They did not welcome the scientist/critics with enthusiasm. They could not have known they were building the largest physics laboratory in the world, and that it would eventually produce the weapon that would end World War II. Even so, they were "sworn to never reveal what they didn't know anyway, for the rest of their lifetime"[1]. The population of the laboratory doubled in its first nine months and each nine months thereafter as it was continually reborn to meet the new challenges. The final cost of the facilities exceeded $430 million in today's dollars. Of course, the replacement value of the Laboratory today exceeds ten times that amount.

Technical problems forced this constant growth. To construct a new weapon, using materials that were only then becoming available in milligram quantities, whose properties were largely unknown, to be produced in kilogram quantities in gigantic plants still being designed, using an unproven fast-neutron fission process dependent on behavior of neutrons that remained to be determined seemed formidable enough in April 1943. Almost immediately however, more problems were posed by the Manhattan Engineer District's scientific reviewers.

An expanded ordnance program to design "guns" that would assemble these materials into a supercritical mass required Laboratory and range facilities for 200 ordnance experts. A chemistry and metallurgy research program to purify and cast uranium 235 and plutonium into metal required a new chemistry laboratory which was dust-proof, air-conditioned, and ventilated so as to contain these materials. The staff reduced the light element impurities in plutonium that might have caused the bomb to pre-detonate to acceptable levels for a gun-assembled weapon. However, the discovery of a heavier isotope of plutonium, plutonium-240, which could not be chemically separated from plutonium-239, and which spontaneously fissioned, made much of this effort superfluous. Groves, who was building two separate plants to separate uranium-235 in Oak

1. according to the *New Mexican*.

Ridge and two production piles to produce plutonium at Hanford, did not count the cost. Time, not money, was the object, and plutonium-240 threatened the success of the whole enterprise.

Implosion, which had been proposed as early as 1942 and pursued as a backup to gun assembly at Los Alamos, was the only feasible method of assembling plutonium fast enough to avoid the predetonation of the atomic bomb that spontaneous fission in plutonium-240 might cause. In order to perfect it, S-site was created to make the high-explosives that could uniformly compress plutonium and the whole Laboratory was reorganized in the summer of 1944 to design an implosion device. Never in human history had high-explosives been made to do what they had to do to use plutonium in a nuclear weapon. Had Los Alamos scientists failed, all of the investment that went into the Hanford production reactors, some $350 million dollars, would have been wasted. Only a test of the device would tell the tale.

Similar efforts were required to fashion a weapon using uranium–235. Since this isotope formed less than 1% of natural uranium, and had only been discovered in 1935, it was largely unknown to science. Eventually, three huge separation plants were built at Oak Ridge to make enough of it for one bomb. Since only milligrams of uranium-235 were available when the work began, the problem seems simple only in comparison to that faced with plutonium.

Six-day weeks of 16-hour days were required to complete the design of these two nuclear weapons, and although such effort was not unusual in wartime, it placed heavy demands upon theoretical physicists, who used IBM punched-card calculators as brain-saving devices, and experimentalists who had to build and use both nuclear accelerators and the world's fourth nuclear reactor to get the data needed to design the bombs. Theorists were distinguished from experimentalists, by their wives, as those who knew what was the matter with a defective door bell and those who knew how to fix it. The wives could not be confident that the doorbell would be fixed, because of what one of them called the "hectivity" of wartime.[1]

It would be impossible to characterize that "hectivity" in the short time allotted today. For those who have an interest in the details of the technical work at Los Alamos during the war, I can

1. Bernice Brode, "Tales of Los Alamos," *LASL Community News* (July 20, 1960) p. 7.

recommend Lillian Hoddeson's *Critical Assembly,* which appeared from Cambridge University press this June, and which is likely to be the fullest account of the work that will be declassified for some time.

Suffice it to say that after the Laboratory reorganized to make the implosion, it required less than six months for the theoretical physicists to develop a design, and a little over nine months for Luis Alvarez's group to develop the detonators, Robert Brode's group to develop fusing and firing techniques, and Kistiakowsky's division to perfect the high explosive lenses required. The uranium gun-type device was perfected in the same period. By the summer of 1945, Los Alamos scientists were certain enough that a gun-assembled weapon using uranium 235 would work that they saw no need for a test.

The principal factor that slowed the work was the availability of uranium-235 and plutonium from Oak Ridge and Hanford. Because of the value of the plutonium produced at Hanford, Groves ordered up a containment vessel that would capture the valuable plutonium if the implosion "gadget" failed to work. This vessel, called Jumbo, was designed with the help of the University of California at Berkeley, manufactured by Babcock and Wilcox in Ohio, and three trestles on the railroads between Ohio and New Mexico had to be rebuilt to support the train that carried it. It was the largest item that had ever been shipped by rail.

The Trinity Test

A search for a test site for the implosion "gadget" led Kenneth Bainbridge to select a location in the barren Jornada del Muerto north of Alamogordo, where Jumbo was shipped in April, 1945. For the final thirty miles, it was pulled by three Caterpillar tractors and followed by another to prevent it getting away. By the time it arrived, Groves and Oppenheimer had decided not to use it, because it would interfere with measurements they wished to make of the "gadget's" performance. The 214 tons of iron it contained would double the size of the fireball and increase the radioactive fallout. The rate of plutonium production at Hanford had, by that time, reached higher levels and Los Alamos scientists were more confident it would work.

Trinity, which was named by Oppenheimer after the three gods of his favorite Sanskrit text, the Bhavgad-Ghita, was part of the White Sands Bombing Range, and we will hear more about its history later today from General Fulwyler. Other sites were also considered, including the Malpais south of grants and an area southwest of Cuba, New Mexico. Only the Jornada del Muerto, appropriately named, combined the convenience and isolation desired. If the test worked, it would mean the end of that journey of death called World War II.

Contractor Ted Brown of Albuquerque was brought in by the Corps of Engineers to build the site with a crew of 200 New Mexicans who worked dawn to dusk, seven days a week, for thirty straight days, took a break, worked another stretch, rested again, and yet another before the bunkers, towers, and roads at the site were complete.

They built two test towers at Trinity. The first 25 feet high, and surrounded by a 150-yard fire break.[1] On May 7, the explosion of one hundred tons of high explosives on that tower provided a scale model of the later test of the atomic bomb. It was the largest controlled explosion up to that time and included fission products from the Hanford Reactors to test theories of fallout as well as the instruments that would be used by the physicists to monitor the final test.

A second, 100-foot tower was built for the test of the "gadget." The July test was scheduled to provide information to the new President, Harry Truman, at the Potsdam Conference with Great Britain and the Soviet Union. Truman delayed the meeting in order to be sure that hew would have the atomic bomb in his hip pocket, but there was still a scramble to get the test done.

Many scientific instruments were devised to measure the blast, radiation, and damage of the "gadget." As one measure of the device's power, Jumbo was suspended a quarter of a mile away from the tower. It emerged unscathed, unlike a number of scientific instruments placed too close to the tower. Many techniques were used to determine the effectiveness of the device, but the most important result was that it worked.

Robert Oppenheimer's response was relief mixed with apprehension for the future. He recalled the words of the third member of the Hindu trinity, Vishnu: "I am become Death, the destroyer of worlds." Most were elated and overwhelmed at their success. After twenty-seven

1. Ferenc Szasz, *The Day the Sun Rose Twice*, (Albuquerque: UNM Press, 1984), chapter two.

months of hard work, a weapon that every nation in the world but Britain and the United States had thought could not be built in time to have an effect upon the war, was ready.

A World Destroyed

Armed with the results of Trinity, Truman faced Stalin with "an entirely new feeling of confidence" at Potsdam, but he did not tell him more than that the United States had just tested a new and powerful weapon," to which Stalin responded that he hoped Truman would make "good use of it against the Japanese."[1] Truman, like all the rest of those caught up in the process of developing the first atomic bombs, could hardly have done otherwise. Indeed the Interim Committee which he had set up to consider the future of atomic energy and the scientific committee which advised it could not think of any alternative to a military demonstration that was likely to achieve the unconditional surrender of Japan.

The Manhattan Engineers recognized this at once. At Trinity, Thomas Farrell, Groves' Deputy, saw the test and declared, "The War is over." "Yes," Groves replied, "It is over as soon as we drop one or two on Japan." And so it was. The gun-assembled uranium weapon, "Little Boy" was dropped on Hiroshima on August 6. After Fat Man was dropped on Nagasaki on August 9, the Japanese unconditionally surrendered.

President Harry S. Truman deemed the making of the atomic bomb "the greatest achievement of organized science in history." Oppenheimer worried that if "atomic bombs are to be added as new weapons to the arsenals of a warring world, or to the arsenals of the nations preparing for war, then the time will come when mankind will curse the names of Los Alamos and Hiroshima." The Santa Fe *New Mexican* heralded the "Deadliest Weapons in World's History, Made in Santa Fe['s] Vicinity," and hoped they would be the "Tool To End Wars."

Since World War II, all of these statements have been in some measure ratified by events. No contribution of organized science has yet eclipsed the atomic bomb in the eyes of mankind. Atomic bombs have been added to the arsenals of many nations, and the names of Los Alamos

1. Ferenc Szasz, *The Day the Sun Rose Twice*, 146-147.

and Hiroshima have been cursed by at least some of mankind. And, although atomic bombs and their successors, hydrogen bombs, have not ended all war, they have, perhaps, prevented World War III.

Historians may dispute whether atomic bombs were essential to victory in World War II. They cannot dispute that they contributed to victory in World War II. The Japanese did not surrender until they were convinced that we had more than one such weapon in our arsenal. Thus, they did not surrender after Russia's declaration of War on August 8, but awaited the second bomb on Nagasaki as the Secretary of War and Leslie Groves anticipated that they would. For those who were preparing for the invasion of Japan in the Pacific, whether the bomb saved 40,000, or 400,000 or 4 million lives is merely a numbers game played by academia's equivalent of Monday morning quarterbacks. As soldier-historian Paul Fussell wrote, "The degree to which Americans register shock and extraordinary shame about the Hiroshima bomb correlates closely with lack of information about the war."[1] Symposia such as this, which remind us of the sacrifices Americans in general, and New Mexicans in particular, made in that war, can serve as a useful corrective to what he calls a "historian's tidy hindsight". As a historian, a member of the staff of the Los Alamos National Laboratory, and a fourth-generation New Mexican, I appreciate the opportunity to open this symposium which honors those who sacrificed time, talent, and even their lives to make it possible for us to be here today. Thank you very much.

1 Fussell, "Hiroshima: A Soldier's View"