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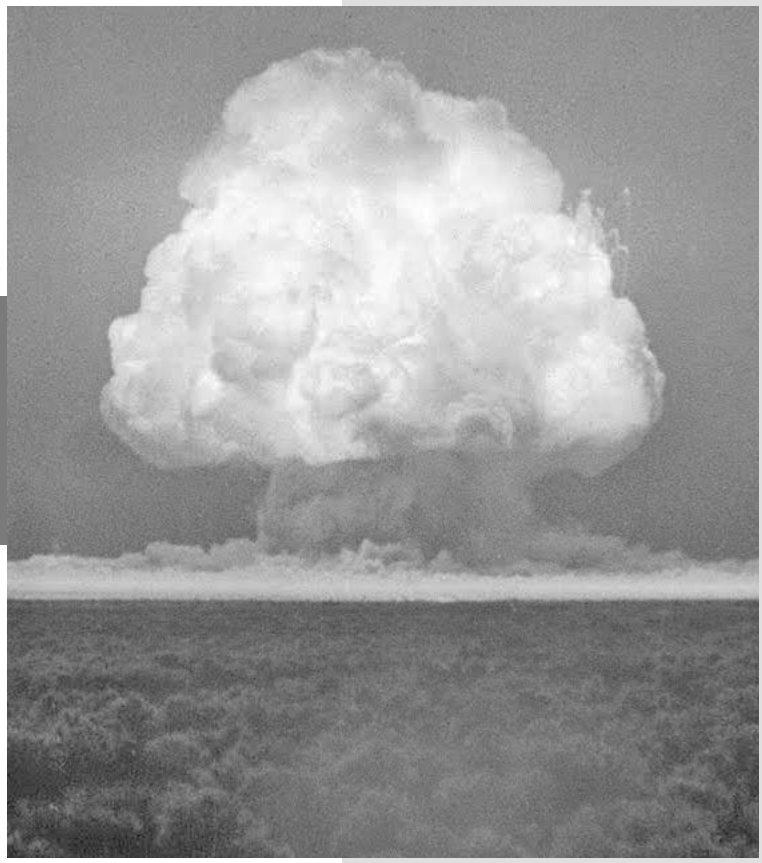
75 Years into the Atomic Age



The first atomic bomb exploded on July 16, 1945, near Alamogordo, New Mexico, heralding the start of the Atomic Age.

Credit: U.S. Department of Energy

75 years ago, the U.S. exploded its first atomic bomb, in the New Mexico desert. It was the culmination of 5 years of hurried development.

Throughout World War II, Germany hoped to use the incredible energy density of uranium and plutonium to build a devastating weapon.

To beat them to the bomb, the U.S. assembled teams across the country—130,000 staff and scientists, many of whom had fled Europe to avoid Nazi persecution.

In July 1945, team leaders gathered to watch that first detonation from 10 miles away. They were unsure whether it would detonate at all.

The blast vaporized the 100-foot tower that held the bomb, turned the desert sand to glass for a mile around, and broke windows more than 100 miles away. It exceeded the force the scientists had expected by 2 to 4 times.

To try to force Japan to surrender and end World War II, President Truman warned that the U.S. had created a weapon of "utter devastation." The Japanese emperor was unmoved.

Truman made the decision to drop a smaller uranium bomb, but Japan would still not capitulate. Three days later, the U.S. dropped a plutonium bomb like the one in the desert.

Together they killed nearly 200,000 people, and Japan surrendered.

Over the next 3 decades, America and other atomic powers developed more nuclear weapons. But they've never been used again in war, and let's hope they never will.

I'm Scott Tinker with a grim reminder of the power of science.

Bureau of Economic Geology

Background: 75 Years into the Atomic Age

Synopsis: Nearly 50 years after the discovery of radioactivity, the Atomic Age began on July 16, 1945, at 5:29:45 AM Mountain Time with the explosion of the world's first atomic bomb at the Trinity Site in the New Mexico desert. Just 3 weeks later, the United States dropped the infamous Hiroshima and Nagasaki bombs, heralding the termination of World War II. The technological leap made with that first successful test 75 years ago demonstrated the terrifying power of science, causing destruction on a scale that was previously unimaginable.

- In the early 1940's, around the time World War II broke out in Europe, the U.S. launched a top-secret program called the "Manhattan Project."
  - American scientists, many of whom were recent refugees from Europe, knew the U.S. was trailing Germany in the race to develop atomic power. They advocated for the development of nuclear fission for military purposes.
  - Early research on the concepts of nuclear power had taken place at Columbia University in New York City, leading to the code name "Manhattan Project." The goal of the program was to beat the Germans in the race to build the world's first atomic bomb.
  - More than 130,000 people from 30 institutions collaborated on the project across three nuclear research laboratories in Los Alamos, New Mexico; Oak Ridge, Tennessee; and Richland, Washington.
  - The scientists were more confident in their enriched uranium-235 bomb and did not know if their newly designed plutonium bomb would explode or simply fizzle out. They needed to test it to be sure it was viable.
  - Three years of planning and research culminated in the first secret test of an atomic bomb on July 16, 1945.
- Observing from observation huts as far as 10 mi (16 km) away, U.S. scientists and military staff conducted the Trinity test—the first successful detonation of a plutonium atomic bomb.
  - Originally scheduled for 4:00 AM, the test was delayed to 5:30 AM because of a light rain. The actual detonation occurred at 05:29:45 Mountain Time.
  - With a deafening blast, the plutonium bomb instantly vaporized the 100-ft tower that was holding it. The heat generated could be felt 10 mi away and at its source was many times hotter than the sun's surface.
  - Within 2 seconds, the brilliant fireball expanded to 2000 ft in diameter, turning the sand and asphalt below it into glass.
  - The mushroom cloud grew to 40,000 ft (12,200 m) in diameter and blew upward to a height of 5–7 mi (8–11 km).
  - The Department of Energy estimated the bomb was equivalent in power to about 21,000 tons (21 kilotons) of TNT—2 to 4 times what scientists expected.
- The Atomic Age was born.
  - Having witnessed the explosion from afar, Brigadier General Thomas Farrell—who was on the staff of Major General Leslie Groves, the Manhattan Project's military commander—wrote: "The effects could well be called unprecedented, magnificent, beautiful, stupendous, and terrifying. No man-made phenomenon of such tremendous power had ever occurred before. The lighting effects beggared description. The whole country was lighted by a searing light with the intensity many times that of the midday sun."
  - After observing the blast, Dr. J. Robert Oppenheimer, director of Los Alamos Laboratory where the bomb was developed, completely understood the gravity of what they had created and quoted from the *Bhagavad Gita*: "If the radiance of a thousand suns were to burst at once into the sky, that would be like the splendor of the mighty one. Now I am become Death, destroyer of worlds."

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Dawn of the Atomic Era | DOE
16 July 1945—'Trinity': World's First Nuclear Test | CTBTO
A Visit to Trinity Turns Up Radiation Still | Washington Post
Nuclear-bomb Carbon Unmasks Luxury Whiskey | Nature
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- The aftermath of the explosion was astounding.
  - The shockwave of the bomb was felt up to 160 mi (257 km) away and broke windows as far as 120 mi (193 km) away in Albuquerque. When asked by residents about the sound and light, the government stated that "a remotely located ammunitions magazine containing a considerable amount of high explosives and pyrotechnics" had exploded and that "there was no loss of life or limb to anyone."
  - The explosion made a small crater, just 340 ft (105 m) across. Most eyewitnesses describe it as more of a small depression than a crater. A stone obelisk was built in the crater at the location of the 100-ft tower that held the bomb suspended above the ground before ignition.
  - The heat of the blast vaporized the tower and melted the desert sand, turning it into a green glassy material called trinitite, which has been found as far as 1 mi (1.6 km) from the site.
    - This glass covered the site until the Nuclear Energy Commission filled the crater and removed much of the trinitite in the 1950's.
    - You can still see trinitite in a preserved section of the crater that has been covered by a low roof on the west side of the obelisk. Trinitite can also be found in anthills when the insects bring spherical beads of the glass to the surface.
    - Had the trinitite melted on the ground, it would have formed layers, not spherical beads, meaning the sand must have melted while swirling in midair.
  - Most of the initial fallout was within 1200 yd (1.1 km) of "ground zero," but the huge mushroom cloud contained most of the radioactivity.
  - As it dispersed north-northwest, it dropped fission products in a 30-mi-wide (48 km) band estimated to be up to 90 mi (145 km) long. Once plutonium atoms rupture by fission, they produce many types of radioactive daughter products. Some decay quickly, but others stay around for a long time. One has a half-life of 24,100 years.
  - Although the military did a survey for residents within 20 mi of the site, it missed some families on remote ranches that were exposed to the blast. The humans did not show much external injury at the time, but the livestock exhibited bleeding, skin burns, and hair loss. These families are known as the "downwinders" and still meet twice each year to protest nuclear testing.
  - Some ranchers reported that their farms, which had been productive with good crops in the spring of 1945, did not produce in the summer and fall after the test. They suspected that the explosion killed all the pollinating insects. There were reports that the daily sounds of buzzing insects stopped completely after the blast.
- But that isn't the end of the story. The Trinity test was just a dry run for the second of the two bombs dropped on Japan just three weeks later—the "Fat Man."
  - The June 1945 invasion of the Japanese island of Okinawa, considered a dress rehearsal for the invasion of the Japanese home islands, resulted in 50,000 American casualties and the deaths of 90,000 defending troops and 100,000 Japanese civilians.
  - U.S. President Harry S. Truman joined other Allied leaders in issuing the Potsdam Declaration to Japanese leaders on July 26, 1945. It called for Japan to immediately surrender or face "prompt and utter destruction." The declaration did not mention the atomic bomb.
  - On behalf of the emperor, Japanese Prime Minister Kantaro Suzuki and his cabinet released the Potsdam Declaration to the Japanese media with an announcement that Japan's policy would be one of *mokusatsu*.

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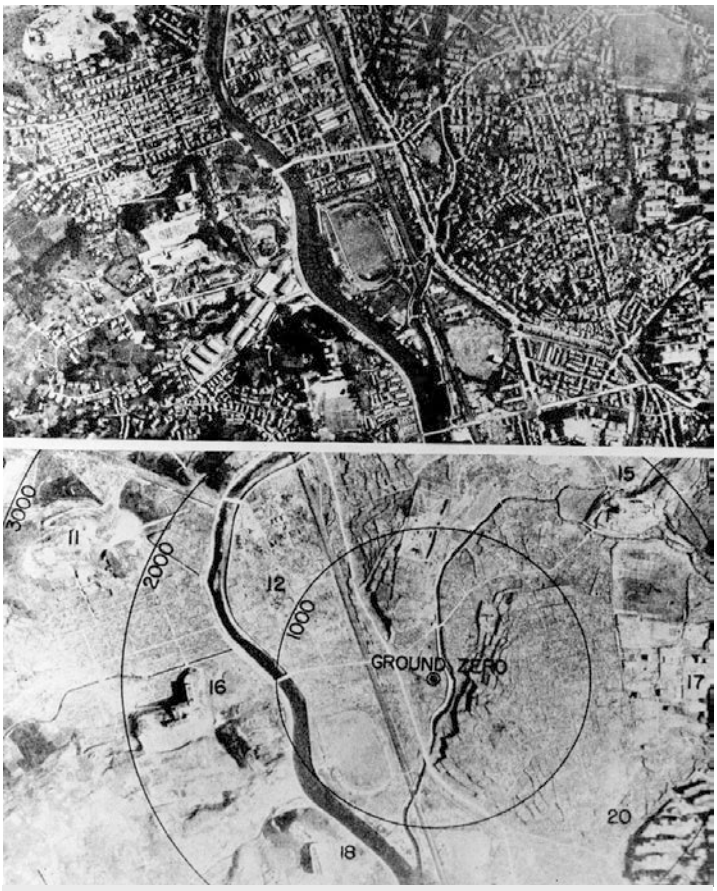

Nagasaki, 1945. Arial photographs before (top) and after (bottom) the Fat Man bomb exploded.

Credit: U.S. National Archives

- The word *mokusatsu*—literally "killing silence"—can be interpreted several ways. It is likely that the Prime Minister meant it as an equivalent of "no comment." However, Western media and even some Japanese sources took his remark to mean "rejection by dismissal."
- Interpreting Prime Minister Suzuki's remarks as Japan's rejection of the call for surrender, and faced with the possibility of huge American and Japanese casualties in the event of an invasion, President Truman made the decision to accelerate the end of the war by dropping atomic bombs on Japan.

- On August 6, 1945, the United States dropped a bomb called "Little Boy" on the center of the city of Hiroshima, Japan.
  - The bomb was a gun-type design carrying enriched uranium-235 produced at the Oak Ridge, Tennessee, facility with the energy equivalent of about 16 kilotons of TNT.
  - The bomb detonated about 2000 ft (600 m) above the flat ground of Hiroshima without leaving a crater.
  - Little Boy killed 90,000–146,000 people over the next 4 months, half of them on the first day. The blast and fireball wiped out 2 mi^2 (5.2 km^2) of central Hiroshima.
- On August 9, 1945, the United States dropped a second bomb called "Fat Man" on Nagasaki, Japan.
  - Fat Man was carrying a much more efficient fuel—plutonium. The plutonium was produced at the Hanford Lab in Washington state and was the same type used for the Trinity test.
  - An implosion-type bomb, Fat Man used TNT to compress plutonium atoms, setting off reactions that then split plutonium atoms, triggering a chain reaction with the energy equivalent of 21 kilotons of TNT (similar to the Trinity test).
  - The original target—Kokura, Japan—was cloaked in clouds and smoke because a neighboring city, Yahata, had been firebombed the night before. With orders to drop the bomb visually, the bomber flew to its secondary target, Nagasaki, and found a hole in the clouds. Due to limited visibility, the bomb missed the city center by about 2 mi (3.2 km).
  - Fat Man detonated about 1650 ft (500 m) above a valley, which served to somewhat contain the blast. Like Little Boy, it decimated about 2 mi^2 (5.2 km^2). It killed 60–80,000 people over the following 2 to 4 months; about half died on the first day.

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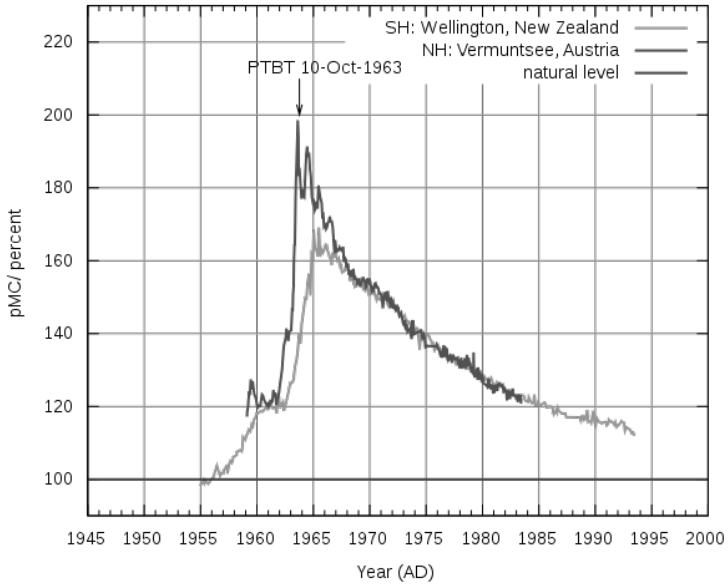

The concentration of atmospheric carbon-14 from 1945 into the late 20th century illustrates the global impact of nuclear weapons testing.

Credit: Hokanomono / Public domain

- Proliferation of nuclear testing ensued, culminating in 22 tests equivalent to more than 1.4 megatons in 1962. 1.4 megatons, or 1.4 million tons, is about 67 times larger than the Trinity test or Fat Man.
  - You can see the long-term effects of nuclear testing on the atmosphere by observing concentrations of carbon-14. At sites in Austria and New Zealand, concentration spikes in 1963, then slowly decreases.
  - By the late 1990's, global carbon-14 concentrations were still twice the natural background level from before 1955.
  - Interestingly enough, the 1963 spike can be used to establish the ages of humans, tooth enamel, water, wine, and whiskey through carbon dating. Forgeries of antique whiskeys and wines have been foiled using this technique.
- The Trinity Site was selected because of its extremely remote location, but it is open to visitors on the first Saturday in April and October—no reservations required. The site sees about 4000 visitors each year.
  - It is at the north end of the 3,200-mi^2 White Sands Missile Range. The site is about 120 mi south of Albuquerque and just 15 mi due south of U.S. Highway 380 between the towns of Socorro and Carrizozo, New Mexico.
  - Once at the site, visitors can caravan with a military escort for the desolate 170-mi round trip drive from the southern Tularosa gate. Visitors can also view the crater and the Schmidt/McDonald Ranch house where the plutonium core of the bomb was assembled
  - Geiger counters register 0.5–1.0 millirem of radiation per hour at the site, or about 10 times the background radiation of the region. For comparison, a flight from the east coast to the west coast of the United States exposes passengers to about 3.5 millirem of radiation.
- After witnessing the destruction of his laboratory's creations, Dr. Oppenheimer resigned from his post at Los Alamos soon after the Trinity test and went on to argue against further atomic development. Toward the end of his life, he had this to say: "As for how we used it, I understand why it happened and appreciate with what nobility those men with whom I'd worked made their decision. But I do not have the feeling that it was done right. The ultimatum to Japan was full of pious platitudes... Our government should have acted with more foresight and clarity in telling the world and Japan what the bomb meant."

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