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THE WORLD'S FIRST ATOMIC BLAST AND HOW IT INTERACTED WITH THE JORNADA DEL MUERTO AND CHUPADERA MESA

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ABSTRACT—Because of the complexity of the implosion-assembled bomb developed at Los Alamos, a test was considered necessary. To preserve the secrecy of the atomic bomb mission and avoid claims against the Army, residents of New Mexico were not warned before the blast or informed of residual health hazards afterward, and no residents were evacuated. The device was detonated close to the ground, causing much soil to be drawn into the fireball. Some melted soil aggregated into larger droplets that became too heavy to remain suspended, fell to the shot crater, and formed puddles that cooled and became popular souvenirs known as trinitite or atomsite. Most material taken into the fireball eventually came to the surface as radioactive fallout. Exposure rates measured up to 15 or 20 R h⁻¹ in public areas about 20 mi northeast of ground zero. Field teams used instruments that were crude, ill suited to field use, and incapable of measuring about 4.8 kg of unfissioned plutonium that was dispersed. Vehicle shielding and contamination were not corrected for. Terrain and air flow patterns caused “hot spots” in and around Hoot Owl Canyon, which became known as “Hot Canyon,” and on Chupadera Mesa. Key residences were unknown to the Army and were not visited on test day. Ranchers reported that fallout “snowed down” for 4-5 d after the blast. Many residents collected rain water off their metal roofs into cisterns for drinking. It rained the night of test day, so fresh fallout was likely consumed. Most ranches had one or more dairy cows and a ranch near Hot Canyon maintained a herd of 200 goats. All evaluations of public exposures from Trinity published to date have been incomplete in that they have not reflected the internal doses that were received by residents from intakes of airborne radioactivity and contaminated water and foods. Too much remains undetermined about exposures from the Trinity test to put the event in perspective as a source of public radiation exposure or to defensibly address the extent to which people were harmed.

INTRODUCTION

The site selected in 1944 for the world's first atomic test, the Trinity test, was already part of the Alamogordo Bombing and Gunnery Range. As depicted in Figure 1, facilities at the test site included a 30.5 m (100 ft) steel tower shot tower placed at a location called “ground zero” (see Fig. 2). A Base Camp was built approximately 16 km (10 mi) to the south-southwest and heavily fortified shelters were built 9.14 km (10,000 yd) to the north, south, and west (Bainbridge, 1947, 1976).

There were approximately 63 ranches and three camps within 48 km (30 miles) of ground zero, not including ranches that were taken over by the government in 1942 when the bombing range was established. The closest occupied residence at the time of the blast was approximately 19 km (12 mi) north of ground zero.

The Trinity test device containing 6 kg of ²³⁹Pu as its sole fissile material (USDOE, 2001) was detonated on 16 July 1945 at 5:29:15 a.m. (Bainbridge, 1976; Hacker, 1987). The published yield of the Trinity blast was 21 kt of trinitrotoluene (TNT) equivalent (88 TJ) (USDOE, 2000). Physicist Otto Frisch described the blast as yielding “the light of a thousand suns” that dimmed into a fireball that looked like a huge oil well fire (Frisch, 1979). People as far away as Santa Fe and El Paso, Texas saw the light of the detonation (Maag and Rohrer, 1982). The fireball touched the earth, vaporizing perhaps 91 to 230 t (100-250 short tons) of sand that was sucked up into the ball of fire and later, as the blast started to cool, precipitated out in the form of a fine smoke that contained radioactivity from the blast (Hirschfelder and Magee, 1945).

During its ascent, the cloud was observed to break into three distinct portions—the lower one drifting north, the center one west, and the top one northeast (Hoffman, 1946). Men were stationed

at several searchlight stations to observe and plot the trajectory of the cloud from the blast, which was originally scheduled to take place before sunrise. One of the searchlight stations is shown in Figure 3. When driving on U.S. Route 380 toward Searchlight Station L-8 around 7:30 a.m., a monitoring team member reported that “the valley below [that contained the Trinity Site] was covered with a strata of sand-like dust...” (Hoffman, 1946). Having left his respirator at Searchlight Station L-8, he “immediately closed all the windows of the carryall and continued to L8 breathing through a slice of bread.” Searchlight Station L-8 crew members who were cooking steaks over an open fire buried the steaks and left the area around 8:35 a.m. after the steaks became “too much contaminated” and the exposure rate climbed to 2.0 R h⁻¹ (NTA, 1946).

Monitoring teams observed what they called “a definite skip distance of 15 miles [24 km] between zero and the regions of measurable gamma intensity” at ground level (Hoffman, 1947). Fallout was scattered over a wide area, with the highest deposition observed in a region about 160 km (100 mi) long and 48 km (30 mi) wide extending from ground zero to the northeast over Chupadera Mesa. William Wrye, whose ranch was just over 32 km (20 mi) northeast of ground zero, reported that “For four or five days after that [the blast], a white substance like flour settled on everything” (Calloway, 1995). Rancher M. C. Ratliff, whose home was about 31 km (19 mi) to the northeast of ground zero, reported that “the ground immediately after the shot appeared covered with light snow,” adding that for several days afterward “the ground and fence posts had the appearance ... of being frosted” (Hacker, 1987; Hempelmann, 1947).

The highest levels of radiation in public areas were found around Searchlight Station L-8 and in rugged areas to its southeast. About 3.2 km (2 mi) east from the junction of Routes 161 and 146, Route 146 runs through a gorge named Hoot Owl Canyon

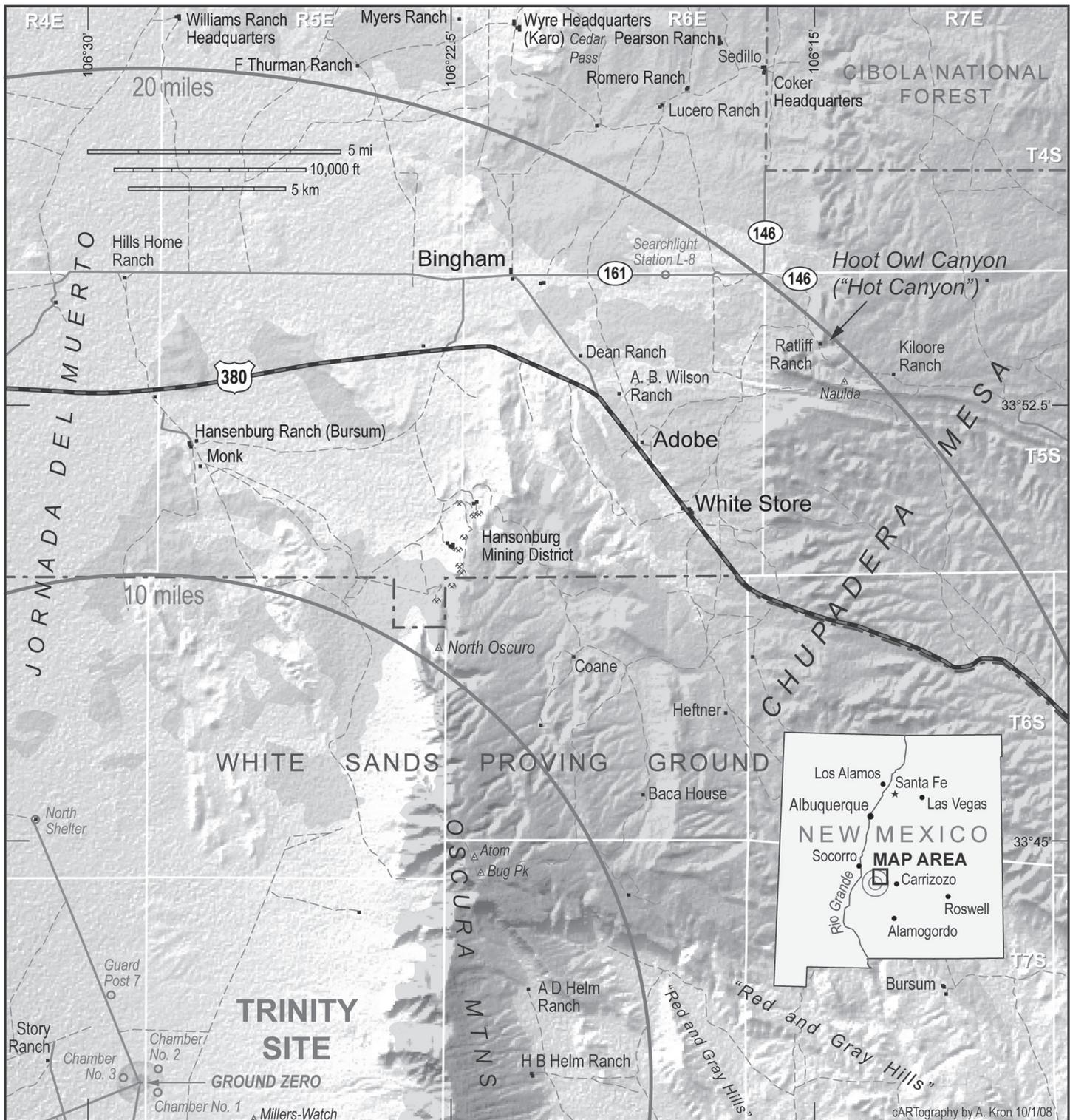


FIGURE 1. The area to the northeast of the Trinity test site, where the highest deposition of radioactive fallout occurred near the town of Bingham, Hoot Owl Canyon, and on Chupadera Mesa. All ranches within 16 km of ground zero were vacated when the proving ground was established.

that rises 183 m (600 ft) above its floor (see Fig. 4). The highest gamma intensities were found in that gorge, which led to its being referred to as "Hot Canyon" thereafter by project staff. Monitoring in the area of the canyon found gamma intensities up to "the

vicinity of 20 R/hr" at 8:30 a.m. that dropped off to 6.0 R h⁻¹ by 1:30 p.m. and 3.8 R h⁻¹ by 1:57 p.m. (Hoffman, 1946; Hoffman, 1947; NTA, 1946). Puzzled by the high readings reported from Hot Canyon, Los Alamos and Manhattan Project medical group



FIGURE 2. The shot tower that held the Trinity device.

leaders went to that area on the day after the shot and discovered an adobe house hidden from the road, about 1.6 km (1 mi) east of where the highest readings had been taken (Hacker, 1987). In this home on the Ratliff ranch, an elderly couple lived with a young grandson, several dogs, and assorted livestock (Hacker, 1987; Hempelmann, 1947; Hoffman, 1947). Overlooked by the Army, the Ratliff residence was not on the maps that monitoring crews were given. A second ranch unknown to the Army was discovered later. A couple with the last name of Wilson lived near

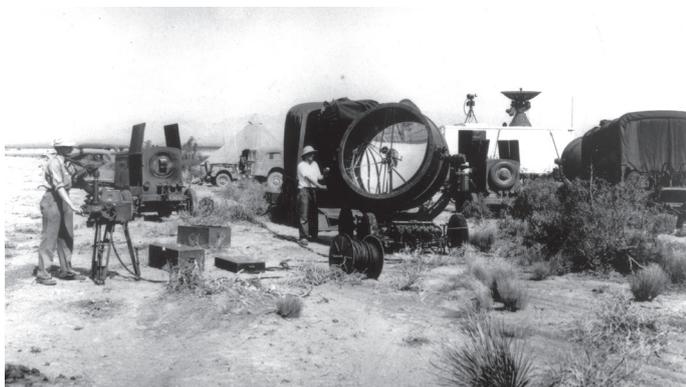


FIGURE 3. One of the searchlight stations manned around the Trinity Site to track the radioactive cloud from the 16 July 1945 test. Some of the highest radiation levels in public areas were measured around Searchlight Station L-8.

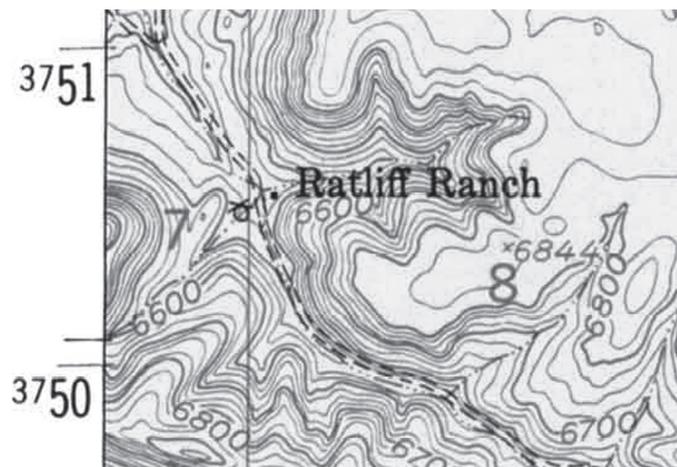


FIGURE 4. USGS Topographic map excerpt showing the “Hot Canyon” area around the Ratliff Ranch (Broken Back Crater, N. Mex., 15 minute series, 1948. Contour interval = 25 feet).

the Ratliffs, and project personnel did not clarify that they were separate residences until months after the blast (Hacker, 1987; Hempelmann, 1947; Hoffman, 1947).

The Trinity test led to an appreciation of how local terrain and air flow patterns can create “hot spots” when radioactive clouds disperse, with the potential for particularly high exposures of workers and members of the public. Terrain features such as mountain ridges were believed to create significant turbulence in the radioactive cloud as it moved over the ridge, causing increased fallout on the downwind side (Larson and Neel, 1960). The Oscura Mountains and air flow patterns on the day of the Trinity blast appear to have resulted in the creation of hot spots around Hoot Owl Canyon and particularly high deposition there and on Chupadera Mesa.

All evaluations of public exposures from the Trinity blast that have been published to date have been incomplete in that they have not reflected the internal doses that were received by residents from intakes of airborne radioactivity and contaminated water and foods. Some unique characteristics of the Trinity event amplified the significance of those omissions. The Trinity device was not 100% efficient—approximately 4.8 kg of plutonium from the device remained unfissioned and was dispersed in the environment [the 21 kt yield of the blast (USDOE, 2000) corresponds, at 1.45×10^{23} fissions per kiloton (Glasstone and Dolan, 1977), to 3.05×10^{24} atoms or 1.21 kg of ^{239}Pu fissioned. That left 4.79 kg of ^{239}Pu unfissioned]. Because the “Fat Man” device was detonated so close to the ground, members of the public lived less than 32 km (20 mi) downwind and were not relocated, terrain features and wind patterns caused “hot spots” of radioactive fallout, and lifestyles of local ranchers led to intakes of radioactivity via consumption of water, milk, and homegrown vegetables, it appears that internal radiation doses could have posed significant health risks for individuals exposed after the blast.

Monitoring records and interviews clearly indicate that members of the public took radioactivity into their bodies by inhalation and by consumption of water and food products that were contaminated. Like many local ranchers, for example, the Ratliff

home in Hot Canyon used its metal roof to collect water into a cistern that served as the family's drinking water supply. Figure 5 shows a ranch house from near the Trinity Site that is outfitted with a water collection system. There was rain in the area the night after the shot, which means that deposited radioactivity was carried into their drinking water (Hoffman, 1947; Hubbard, 1945).

Trinitite, the thin layer of glassy fused earth in the shot crater, was one of the long-lasting effects of the bomb and one of the most popular souvenirs from the Trinity test (see Fig. 6). Although not intensely radioactive, the pieces could cause radiation burns when worn in jewelry next to the skin (Hoddeson et al., 2004). Until recently, trinitite was thought to be formed from sand melted by temperatures of 5,000 F and then cooled. Robert Hermes and William Strickfaden recently published the results of their investigation of the formation of trinitite (Hermes and Strickfaden, 2005). Their calculations showed that the atomic fireball was not around long enough to form glass in the thicknesses found on site. They also observed spheroids within pieces of trinitite that looked like droplets, which suggested that the sand was first scooped up into the fireball and aggregated into larger droplets that became too heavy to remain suspended and fell as a rain of molten glass. The molten glass collected on the hot sand to form the observed puddles of trinitite. The top surface of the trinitite layer was still heated somewhat by the fireball and developed a smooth surface (Hermes and Strickfaden, 2005). Figure 6 contains photographs of trinitite in several formations that have been found (Hermes et al., 2006).

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FIGURE 5. System for collection of water off the roof of a residence on the Black Hills Ranch, formerly the Nalda Ranch, east-northeast of the Trinity Site. The cistern to the left, which was damaged by the Trinity blast and then repaired, is still in use today.

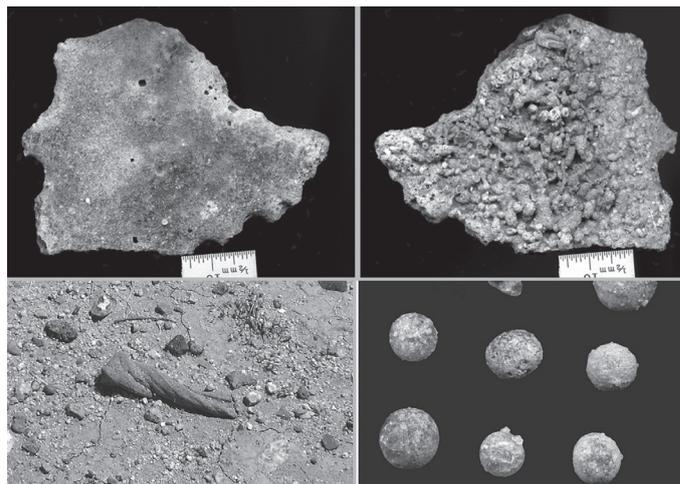


FIGURE 6. Specimens of trinitite, also known as atomsite, formed from the July 1945 Trinity blast. The top photos show formations that are flat. The lower left photo shows a rope-like formation of trinitite, and the lower right photo shows trinitite in spherical or droplet forms. Photographs courtesy of Hermes et al. 2006.

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