Test of Nuclear Explosive in China Viewed from Muncie

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Introduction

On October 16, 1980, at 12:30 a.m. E.D.T., the People's Republic of China detonated a nuclear weapon to celebrate the 16th anniversary of their first detonation of a nuclear explosive. The burst in the atmosphere above the Lop Nor region in China was estimated at 200 kilotons to one megaton of T.N.T. in accounts published in the United States.

Two types of nuclear reactions are used in nuclear weapons, namely fission and fusion. The fission process occurs when a neutron enters the nucleus of a fissionable atom, ^{235}U or ^{239}Pu, and causes the nucleus to split into two smaller parts. More than 100 unstable, primary isotopes are produced during fission reactions. The fragments are generally unstable and undergo an average of three decays before reaching a stable state. Their half-lives vary from a fraction of a second to many years.

Fusion is the process of uniting a pair of light nuclei to form a nucleus of a heavier atom. Two isotopes of hydrogen, deuterium and tritium, are used extensively in the fusion process. Nuclear fusion explosions are triggered by very high temperatures produced by critical fission reactions. Fusion reactions between deuterium and tritium liberate high energy neutrons. These neutrons cause fission in isotopes of uranium or plutonium, which do not fission when they absorb slow neutrons. Thus, an explosive device using ^{235}U to trigger a thermonuclear explosion can be surrounded by a casing of plutonium or uranium to increase its explosive yield. Eighty percent of the explosive intensity may result from the final fissioning of the blanket of uranium or plutonium.

The characteristics of the fallout produced by a nuclear explosion depend on the type of weapon used and the test conditions. Depending on the height of the burst and type of terrain below, varying amounts of debris will be sucked into the center of the blast. In this central region, all the material vaporizes and a cloud is formed from the debris, casing, and explosive itself. As expansion takes place, cooling begins, and the vapor condenses to form a radioactive cloud containing many particles. The speed at which the radioactive cloud descends depends upon the meteorological conditions and the energy yield of the weapon. Some of the particles will fall out within the first 100 miles of the burst. Thus prompt fallout is extremely radioactive and will cause most deaths. The remaining particles in the cloud flow with global air currents and continue to fall from the cloud as it passes over the earth (2).

Experimental Details

Sampling began on October 18, 1980, just two days after the explosion. Air samples were collected using a high-volume air sampler which was mounted on the roof of Cooper Science Complex at Ball State University, Muncie, Indiana. Sampling was conducted from October 18th to 27th. The air filter was removed from the sampler every 24 hours and examined within the following week for gamma activity using a lithium-drifted germanium detector. Each filter was weighed before and

after sampling and each sample contained approximately 20,000 mg of particulates. Spectra were recorded in a Nuclear Data 4410 multichannel analyzer and then transfered to the Dec System 10 computer for editing, plotting, and making corrections for the efficiencies of the detector. Relative gamma activities were computed from the areas under the gamma peaks.

The following fission fragments and heavy elements were clearly identified in the gamma-ray spectra: ^{95}Zr, ^{111}Ag, ^{207}Bi, ^{208}Tl, ^{214}Bi. Table 1 lists activities of three isotopes as a function of time when the samples were collected. (Only statistical errors are shown in the table.).

The initial data on the fallout, which demonstrated the passage of the cloud over Muncie, were troubled with high laboratory background. A later run, also collected from the roof of Cooper, contained a larger sample and produced a spectrum with less background. This spectrum was recorded on January 10, 1981, 86 days after the published date of the detonation. Four gamma peaks were identified as the activity due to fission fragments. The counts contained in each of these peaks were corrected for branching ratios to represent relative activity due to each isotope at the time of the explosion.

Results and Conclusion

The experimental data indicate that the fallout cloud reached Muncie, Indiana, on October 23rd. This is consistent with a report in the Muncie Star on October 19th, which indicated the cloud should be over the west coast that day and with the date observed by Lewellyn et. al. (3) in 1976 for a similar Chinese test. On October 23rd and 24th, the main center of the cloud appeared. A heavy rain on the 24th accounts for the increase of activity on that day and its subsequent decline. Sampling was halted on the 27th of October because of equipment failure.

In order to verify that the observed activity was indeed due to the Chinese test, the ratio of activity observed for ^{95}Nb to the activity of its parent ^{95}Zr was computed for the cleaner spectrum recorded in January. The ratio was used to calculate the time elapsed since the detonation. This calculation yielded 82 days ± 8 days, which is in agreement with the time known to have elapsed since the explosion. The quoted uncertainty includes errors in the efficiency calibration of the detector and the branching ratios.

The time elapsed since the detonation was then used to calculate the relative initial abundance of the, isotopes ^{95}Zr, ^{103}Ru and ^{141}Ce. No attempt was made to compute absolute yields from the fallout data, since they depend on weather condi-

TABLE 1 *Activities in counts per hour of three isotopes*

DATE	^{95}Zr	^{208}Tl	^{207}Bi
Oct 18-19			1837 ± 15
Oct 19-20			
Oct 20-21	706 ± 87		1479 ± 15
Oct 21-22	397 ± 60	163 ± 51	1750 ± 13
Oct 22-23	106 ± 57	118 ± 47	1332 ± 13
Oct 23-24	583 ± 74	352 ± 83	2394 ± 14
Oct 24-25			1863 ± 14
Oct 25-26			1721 ± 14
Oct 26-27			1463 ± 13

TABLE 2 *Relative Abundance of Fission Fragments for Different Fission Processes*

	^{235}U	^{239}Pu	Exp
$^{95}Zr/^{103}Ru$	2.09	1.02	1.88 ± .27
$^{141}Ce/^{95}Zr$	.97	.88	.21 ± .03
$^{141}Ce/^{103}Ru$	2.00	.90	.39 ± .06

tions and other unknown factors, such as the height of the burst. The ratio of ^{95}Zr to ^{103}Ru provides an indication of the particular material which fissioned in the test (1). Table 2 shows the results of this study compared to the isotopic ratios expected for the fission of ^{235}U and ^{239}Pu, respectively. This information leads one to conclude that the current Chinese explosion relied on the fission of ^{235}U. This is in agreement with the results found by Smith, Ward and Wesick, of Indiana University, for a bomb detonated by the Chinese at Lop Nor China on November 17, 1976 (4). A marked depletion of ^{141}Ce relative to ^{95}Zr and ^{103}Ru is noted in the fallout. This depletion is expected since ^{141}Ce is the end product of a decay chain involving ^{141}Xe, a noble gas, and ^{141}Cs which is volatile. Both of these nuclides live long enough for particles in the fallout to condense from the test cloud. Since the gas and the volatile element would not condense, the fallout particles would be expected to be deficient in these isotopes and their daughter ^{141}Ce.

In conclusion it is believed that the bomb detonation observed in this study was not pure fission since it was so large. A fission-fusion bomb would not have yielded the heavy elements that were observed and so it must have been a fission-fusion-fission explosion with the majority of the fission due to ^{235}U.

According to data released by the National Radiological Protection Board, fallout from nuclear testing increases background radiation by about 1%. This test produced tracer additions to the normal background on the order of another percent which present no significant health hazard, as long as the Chinese only test every 16 years.

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