The Surprising Silver Lining of the Atomic Age Nuclear Tests

By: Patrick J. Kiger | Oct 18, 2022

The "Baker" explosion, part of Operation Crossroads, a nuclear weapon test by the United States military at Bikini Atoll, Micronesia, July 25, 1946. UNITED STATES DEPARTMENT OF DEFENSE

Crazy as it might seem, there was a time when the U.S., the Soviet Union, and other countries tested nuclear weapons by exploding them in the atmosphere. From 1945 to 1963, when such tests finally were banned by an international treaty, more than 500 nuclear bombs were detonated, releasing radioactive fallout that spread far and wide across the planet, causing harm to the environment and human health.

For example, everyone born in the U.S. after 1951 has been exposed to nuclear fallout, and for some, it's resulted in an increased risk of thyroid cancer, according to the U.S. Centers for Disease Control and Prevention (CDC).

But for scientists that fallout also has provided an important measuring tool. The tests caused what's known as the **14C bomb pulse** because of the spike in the atmospheric concentration of carbon-14, a carbon isotope that also occurs naturally. The excess carbon-14 was distributed throughout Earth's atmosphere, peaking in 1963 when the test ban went into effect.

That radioactivity, which has gradually been declining since the 1960s, has been absorbed by plants, animals and people, creating a sort of time stamp that's enabled researchers to measure when things occur — from the longevity of white sharks to the growth of human knee cartilage and even brain cells. It's also enabled forensic investigators to estimate the age and year of death for human remains with much greater precision than previously possible.

How Radiocarbon Dating Works

Using the bomb pulse is an advance upon conventional radiocarbon dating that uses naturally occurring 14C, according to Thomas D. Holland. He's a research professor and director of the Forensic Institute for Research and Education at Middle Tennessee State University.

"Radiocarbon dating has long been a mainstay of archaeologists," Holland explains via email. "All living things absorb carbon during life. This includes the most-common form of the atom — carbon-12 (12C) — as well as the radioactive form carbon-14 (14C)."

Both of these isotopic forms exist in a known ratio, which is reflected in the carbon in organic tissues. When an organism dies, it stops taking in carbon and the unstable carbon-14 atoms start to decay at the known half-life of approximately 5,700 years. "This results in the ratio of unstable 14C carbon to stable 12C declining at a predictable rate," Holland says, "and this declining ratio allows organic substances to be 'dated' with some accuracy."

The big limitation of radiocarbon dating always has been the error range, according to Holland. "Estimated dates, derived from the radioactive decay of 14C, have a plus-minus error range based on the size and quality of the sample," he says. "Generally, error ranges for a good sample are no more than a few hundred years, which for most archaeological purposes is insignificant, rendering carbon dating a valuable tool in the archaeological toolkit."

This error-range problem, however, presents a real limitation when the material being dated may be less than 100 years old — for example, human remains found buried somewhere or recovered from a lake.

"A skeleton found buried in the woods may be a recent murder victim, or they may represent an early settler to the area," Holland says. "Traditional radiocarbon dating may allow for a point estimate of the person's year-of-death, but if it is accompanied by a plus-minus error range of 200 years, it renders the estimate of little use — at least in forensic contexts."

That's because the naturally occurring 14C in the atmosphere occurs in a relative constant amount, since the cosmic radiation striking the atmosphere to create the isotope is relatively constant.

The Bomb Pulse Changed Radiocarbon Dating

The bomb pulse, though, isn't constant.

"In the 13 years that above-ground [nuclear bomb] tests were conducted, the relative amount of 14C in the atmosphere almost doubled the normal level," Holland explains. "Viewed on a longitudinal chart, the total amount of 14C present in the atmosphere shows a dramatic pulse in late 1963, followed by a gradual decline of approximately 4 percent a year as the 'artificial' bomb-created 14C is absorbed out of the atmosphere by living things and the ocean."

That means if that skeleton found in the woods doesn't show the presence of large amounts of carbon-14, that's a pretty good indication that it dates *before* 1950. But if there's evidence of the bomb pulse's effects, it's possible for forensic scientists to determine that the bones belong to a person who died sometime between 1950 and the present.

"Additionally, because the graph of atmospheric 14C shows a sharp, upward slope, beginning with the first [nuclear bomb] test in 1950, peaking in late 1963 (when the test ban treaty was signed), and then a more gradual absorption curve continuing into the present, it may be possible to 'fine-tune' the date of death for individuals who died post-1950," Holland says.

Since banning the above ground testing of nuclear bombs, carbon-14 levels have been declining and are expected to eventually return to baseline levels.
HARVARD UNIVERSITY

By examining organic tissues with different growth and "turnover" rates, such as fingernails and hair relative to bone, scientists can estimate where on the bomb pulse downward slope the sample falls and speculate an age.

"Tissues that remodel slowly, such as bone, which may take years to turnover, will reflect a higher concentration of bomb 14C than will tissues, such as hair, which will reflect 14C absorbed closer to the time of death, and therefore lower on the declining slope," Holland says. "This can result in estimates of year-of-death within one to five years."

Carbon-14 levels in fingernails, for example, can help scientists determine the year of death with 91 percent accuracy, according to a 2022 study published in Journal of Forensic and Legal Medicine.

What Else Can Scientists Date Using the Bomb Pulse?

Scientists used the bomb pulse to date elephant tusks in a large investigation on the ivory trade. Nearly all of the ivory the group analyzed had a lag time of around two to three years, suggesting that it was not from old sources, but rather the ivory was likely from recently poached elephants. PROFESSOR BENEZETH MUTAYOBA, SOKOINE UNIVERSITY OF AGRICULTURE, TANZANIA

But the bomb pulse isn't just useful for dating human bodies. Thure E. Cerling, chair of the department of geology and geophysics and a distinguished professor in both biological sciences and geology and physics at the University of Utah, used the bomb pulse in this 2016 study on poaching in the ivory trade.

"We found most ivory seized by customs officials in that study were killed less than three years before seizure, so these were not longtime storage samples, and therefore almost all the ivory being confiscated (and presumably also in the ivory trade) was from animals killed very recently," Cerling explains via email. "This is not 'antique ivory.'"

Cerling notes that one of his University of Utah colleagues, James R. Ehleringer, has used 14C to measure the time period between when coca leaf is harvested in South America and the cocaine made from it is seized in the U.S. And oceanographers have used 14C to determine how the oceans are absorbing CO2, he says.

The main problem for scientists is that the bomb pulse will only be useful for tracking dates within a narrow time window. "In fact, the bomb pulse will run its course by approximately 2030 and 14C levels will return to their pre-1950 level," Holland says. And some studies show burning fossil fuels could only speed up this deadline.

Now That's Interesting

As Science reported in 2021, nuclear fallout from 1950s and 1960s nuclear bomb tests is showing up in honey produced in the U.S.

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