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Artificial Radiocarbon as an Indicator of Recent Origin of Organic Remains in Forensic Cases

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ABSTRACT: From 1950 to 1963 atmospheric testing of thermonuclear devices produced elevated levels of artificial carbon-14 in the atmosphere. Terrestrial organic material from that time period displays carbon-14 activity nearly twice the pre-1950 levels. Measurement of the carbon-14 activity within organic specimens from forensic cases can reveal if the material dates before or after about 1955. Such information can prove important in some cases in determining if the material is sufficiently recent to be of forensic concern. Application of this technique to an unidentified human skeleton from the American southwest is discussed.

KEYWORDS: forensic science, radiocarbon, antiquity, skeleton

An important contribution of forensic anthropology to the process of human identification consists of determining if recovered remains are of relatively recent origin and thus of forensic interest. Usually this process involves judging the extent of preservation of remains, context and/or associated cultural information that might suggest they originate from archeological features or some other source too ancient to merit continued forensic interest. In some cases, factors are present greatly facilitating this process, allowing determinations to be made with great confidence. In others, these factors may be absent or diminished to the extent that such determinations can not be made reliably. In such situations, radiocarbon analysis may prove useful.

Radiocarbon dating has long been recognized as a powerful research tool to determine antiquity. Introduced by Willard F. Libby and colleagues in 1949, the technique recognizes that living plants and animals maintain concentrations of the radioactive carbon isotope, carbon-14 which approximate atmospheric levels. When death occurs, the quantity of carbon-14 begins a gradual decline with a half-life of about 5730 years (1). Radiocarbon dating methods can reliably measure the amount of radiocarbon remaining in the individual and calculate back to the approximate time of death (i.e., the last point of equilibrium between the individual and the atmosphere). The date is derived using the half life. Radiocarbon dating is most accurate for materials which are more than 300 years old. Recent large scale fluctuations in the atmospheric radiocarbon content over the last 300 years limit the ability to declare more than "it died between 50 and 300 years ago." However, very recent events (within the last 50 years) can be distinguished from events of antiquity.

One of the variables affecting radiocarbon dating of relatively recent samples is the presence of artificial or so-called "bomb" carbon-14. Between 1950 and 1963 atmospheric testing of thermonuclear devices introduced artificially high levels of carbon-14 which nearly doubled carbon-14 activity in terrestrial organisms (2). This sudden introduction of artificial carbon-14 allows organic material predating nuclear testing to be distinguished from the more recent organics. Since the dates of the testing between 38 and 51 years ago approach the limits of contemporary forensic interest in organic evidence, the elevated carbon-14 levels, or the lack of them may provide key information for interpretation.

Figure 1 (modified from Taylor (2), 1987, Fig. 2.14) expresses the relationship between the quantity of radiocarbon recorded in trees rings from 1900 to 1950 and in the atmosphere between 1950 and 1983. The data are expressed as the percentage of carbon 14 relative to the contemporary standard (2). The curve clearly indicates that a radiocarbon measurement in excess of 1950 standards documents that the specimen is more recent than 1950. Dating within the post-1950 period would depend on the precise measurement and interpretation if a particular value represents a date during the period of rapid increase (about 1950 to 1963), or during the subsequent period of decline.

An Example from the American Southwest

In 1992, human skeletal remains were submitted for analysis to the Federal Bureau of Investigation from a law enforcement agency in the southwestern region of the United States. The remains had been found associated with an eroded river bed in an area with a temperate semi-arid environment. Although the remains were generally well preserved, they lacked soft tissue and odor. These and other taphonomical indicators suggested the remains were likely at least several years old but antiquity of many decades could not be ruled out using the morphological indicators.

Analysis revealed that the skeleton was relatively complete and consistent with a single individual. Many indicators, especially those of the pelvis suggested female sex.

The extent of dental formation and epiphyseal union suggested an age at death between 16 and 21 years.

Pathological conditions consisted of marked asymmetry of the bones of the cranium (possible torticollis) and many skeletal lesions distributed throughout the skeleton suggestive of tuberculosis (3). The diagnosis of tuberculosis was confirmed through molecular analysis. Mycobacterium tuberculosis DNA was isolated and identified from a section of the right seventh rib which displayed characteristic lesions. The nested PCR technique based

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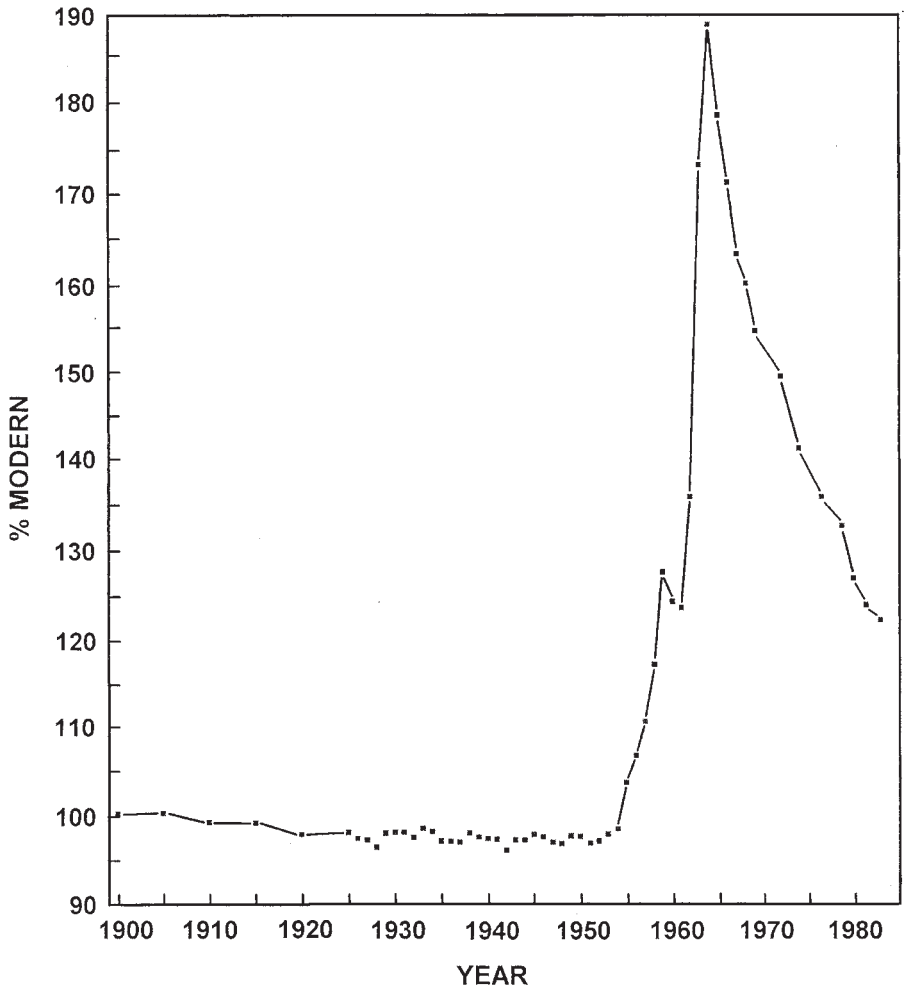

FIG. 1—*Correlation of carbon-14 activity with dates ranging from 1900 to 1983 (modified from Taylor (2), 1987, page 37, Fig. 2.14). The vertical axis is the percentage of carbon-14 measured in a living sample relative to the NIST modern reference standard, defined as AD 1950 and equaling 100%. Values greater than 100% indicate the presence of atomic bomb generated carbon, and suggest the material was "alive" within the last 50 years, since the onset of atomic bomb testing.*

on the 123 base pair sequence of IS6110 (4) was employed to identify the disease organism (5).

Antiquity represented a key problem for interpretation of this case. As noted above, the morphological indicators suggested the remains were not extremely recent. However, in recognition of the variables involved, it could not be determined without further testing if the remains were sufficiently recent to be of forensic interest or if they were of great antiquity.

In an attempt to resolve this problem, a sample of bone from the skeleton weighing approximately 5.5 g was submitted to Beta Analytic Inc. in Miami Florida for radiocarbon analysis using accelerator mass spectrometry. Using standard procedures, bone collagen was extracted from the sample and analyzed. The measured carbon-14 age was essentially 0 years, derived from a measured radiocarbon activity approximately equal to the contemporary standard (~100%). Stable carbon isotopes (13C/12C) were then measured and used to correct for fractionation effects and resulted in a "Conventional Radiocarbon Age" of 150+/−30 years before present (present being AD 1950). This age expressed as relative percentage to the contemporary standard was 98.4/−0.4% of the activity measured in the AD 1950 reference standard. Since this percentage value was below 100%, it indicated a "prebomb era" death of the individual (i.e., prior to ~ AD 1950). Calibration of the result to calendar years provides a range of AD 1670 to 1955 (95% probability) for the death of the individual.

Additional important information was provided by the stable carbon isotope ratio. Such a ratio reveals information on aspects of the diet of the individual represented, in particular, the consumption of C_3 and C_4 plants and/or the herbivores which consume these plants. Plants with a C_3 photosynthetic pathway include most leafy plants, trees, and shrubs which grow in temperate climates. Plants with a C_4 photosynthetic pathway include a much more limited number of plants such as maize, millet, and sugarcane. Humans who consume largely C_3 plants have carbon isotope ratios of about −20 plus or minus 1%. Less negative ratios reflect consumption of C_4 plants and also marine foods (6–8).

The measured value of −13.1% in the skeleton from the southwestern area of the United States strongly suggests that the individual was consuming marine foods and/or C_4 plants. The value is consistent with a diet largely based on corn.

Summary

Although chemical analysis of carbon isotopes is usually thought of as a procedure for dating organic material of archaeological origin, it also can provide key information in assessing similar material in a forensic context. Analysis of radioactive carbon-14 activity in association with other information can establish if the specimen dates before or during the post 1950 period of elevated carbon-14 levels. This assessment can help investigators decide if recovered remains represent individuals of medical-legal concern or archaeological resources.

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