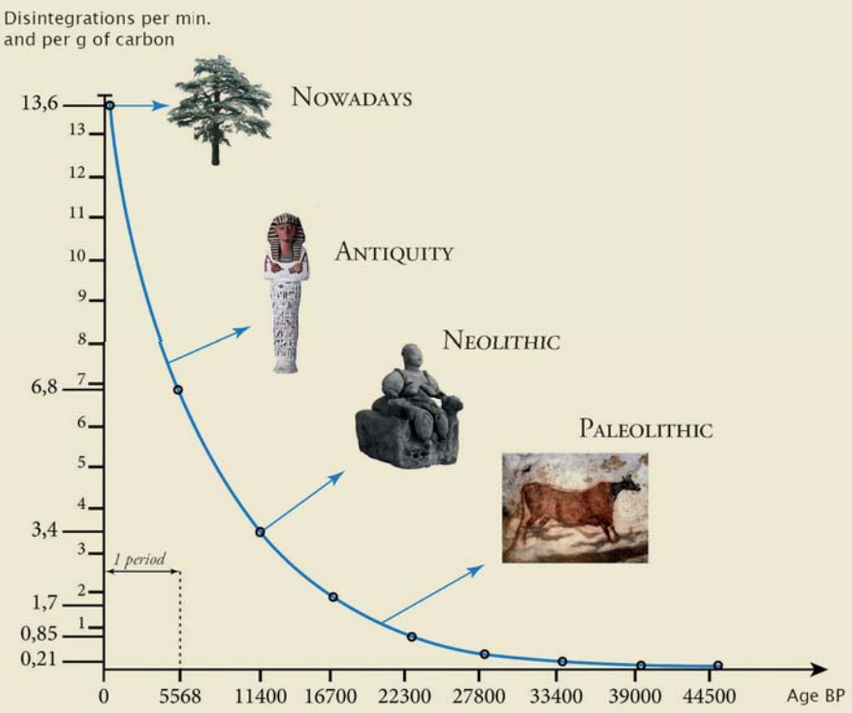

FIG. 1: Carbon-14 exponential disintegration curve with chronological references.
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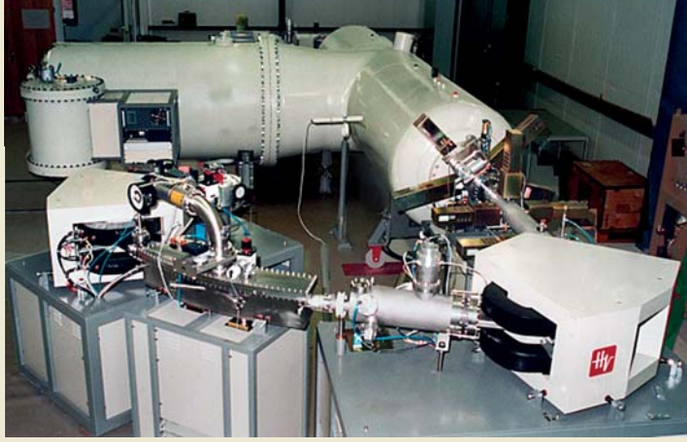

FIG. 2: Linear particle accelerator and associated mass spectrometer (AMS).

CARBON-14 DATING FOR TRIBAL ART

By Olivier Bobin and Armel Bouvier

How does it work?

Beginning in the late 1940s, American researchers began to use the natural radioactive properties of carbon-14 to date organic materials. Soon after, in the 1950s, Willard Frank Libby began to date Egyptian samples with great success. He was rewarded for his work with the 1960 Nobel Prize for chemistry. Carbon-14 dating, also called radiocarbon dating, makes it possible to determine how much time has elapsed since an organism's death (the felling of a tree or the death of an animal, for example). This technique, which has revolutionized archaeometry, allows for the dating of wood, ivory, bone, teeth, hair, textile, paper, and shell.

The method is based on the measurement of the amount of carbon-14 remaining in the tested material. Carbon-14 is a radioactive carbon isotope, which is to say that it disappears over time.

A living organism contains a constant quantity of carbon-14 as a result of its exchange with the atmosphere (respiration or photosynthesis). When it dies, this exchange with the atmosphere ceases and the quantity of carbon-14 diminishes at a known rate. Its concentration is divided in half every 5,730 years. The measurement of the amount of carbon-14 present in a sample compared to its total original content is what makes it possible to date materials. Measurements can be made on samples up to 50,000 years old. Beyond that age, the quantities of carbon-14 present are too small to be measured using the techniques we have at our disposal today.

Measurements are made using a mass spectrometer in conjunction with a particle accelerator. Very little material is now needed to perform the test (today as little as 0.01 of a gram, although in the past 1 gram was needed), it takes very little time to perform (about an hour, where days or weeks were needed before), and results are much more accurate than they used to be using older methods.

Dealing with Pollutants

The sample is first subjected

FIG. 3 (right): Salt container. Sapi-Portuguese. 16th century.
Ivory. H: 23.1 cm.
Private collection. Reproduced by kind permission of Entwistle, London.
Photo: Ed Parrinello/SquareMoose.

FIG. 4 (below): View of the back of a wooden mask and of the sample removal area (2 to 3 millimeters in diameter).
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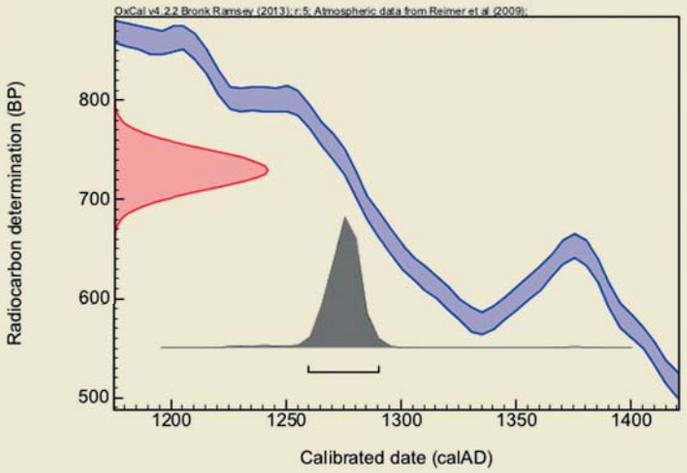
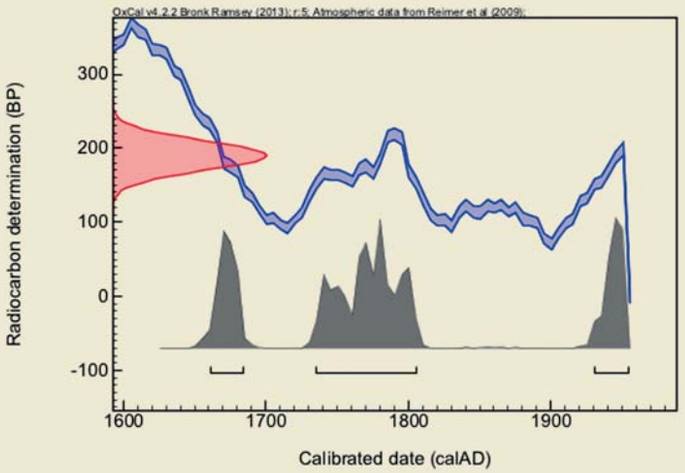




to a number of processes: soxhlet extraction, acid and base, and demineralized water treatments. The CO_2 extract obtained is purified and converted into graphite. These procedures allow for the elimination of potential pollutants (such as glue, resin, wax, polish, and other materials used in restoration and conservation). The cleaning of objects is essential to obtaining credible and accurate results, especially where artworks are concerned.

As an illustration of this, imagine an object that was recently covered with a petroleum-based microcrystalline wax, which we will endeavor to test without prior treatment. The date we might obtain could be very old, because petroleum contains very old fossilized carbon. The mixture of this very old material with recent wood might give us an average age that would be much older than the object's true date of manufacture.

Calibrating Results

The amount of carbon-14 that an object retains is proportional to its age. What is called the "radiocarbon date" is expressed in years "before present," or BP, (730 ± 20 years, for example). The "carbon-14 present" was fixed by Libby in 1950 and radiocarbon age is calculated on the assumption that the concentration of carbon-14 has remained constant over time. However, today we know that this is not at all the case and that carbon-14 concentrations vary as a function of solar activity, climate change, and industrial activity. Preliminary results need to be corrected, or "calibrated." Calibration curves have been established which allow for BP ages to be transformed into calibrated dates associated with a percentage of probability. For instance, 730 ± 20 years BP corresponds to the time interval AD 1260–1290, with a probability of 95.4%.

Concrete Examples

BEFORE THE SEVENTEENTH CENTURY

The dating of a Sapi ivory salt-cellar belonging to Entwistle Gallery in London was successful in establishing the period of its manufacture. The calibrated dates of the sample taken from under its cover include two intervals: AD 1438–1518 (82.5%) and AD 1593–1619 (12.9%). Based on a combination of stylistic approach, consideration of the materials involved, and the carbon-14 date, it can be said that this object most probably dates to the sixteenth century.

The Dogon-Tellem cultures produced objects for an extended period of time, and that is why carbon-14 dating is very appropriate for defining these sculptures' chronology. The analysis done on Galerie Alain Bovis' male figure with upraised arms made it possible to confirm that the statue dates from the fifteenth century.

Its radiocarbon age is 440 ± 20 years BP. Calibration of this result furnished only one very precise interval: AD 1427–1469 (95.4%).

AFTER THE SEVENTEENTH CENTURY

Carbon-14 dates are not always as precise for this period because the calibration curve does not have a uniform incline. There is a "plateau" zone between the eighteenth and twentieth centuries that does not allow for differentiation in this period.

The example of a Kwele mask tested for Galerie Claes in Brussels is typical. The object's radiocarbon age is 190 ± 20 years BP, which would place it between AD 1740 and 1780. Calibration yields three different intervals: 1661–1664 (20.4%), 1735–1806 (54%), and 1930–1954 (21%).

The test confirms that the mask most probably dates to the beginning of the nineteenth century.

FIG. 5 (far left): Calibration curve (blue) and interval of calibrated dates (grey peak). Radiocarbon age: 730 ± 20 BP. Calibrated dates: AD 1260–1290 AD (95.4% probability).

FIG. 6 (near left): Calibration curve (blue) and interval of calibrated dates (grey peak). Radiocarbon age: 190 ± 20 BP. Calibrated dates: AD 1661–1684 (20.4% probability); AD 1735–1806 (54.0% probability); AD 1930–1954 (21.0% probability).

This example illustrates the limitations of carbon-14 testing for dating art in general and for tribal art in particular. The scientific analyses cannot be considered conclusive but instead represent a complement to the research done by art historians and dealers. It can be thought of as technical assistance or scientific support. It is not the calculation of probabilities alone that points to the most likely interval but rather an exchange with art professionals that allows for the identification of one interval as being more credible than another.

BEFORE OR AFTER 1954

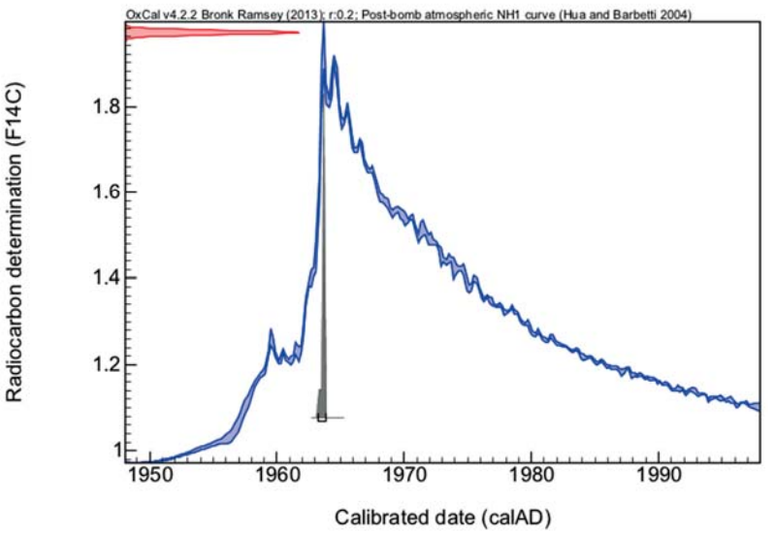
Carbon-14 allows for definitive determination of whether the tested material existed before or after 1954. This artificial "cutoff" line is man-made. The atomic bombs over Nagasaki and Hiroshima, and especially the extensive nuclear testing that ensued in the 1950s, resulted in a near doubling of the amount of carbon-14 in the atmosphere. In recent objects, that is to say objects made after 1954, one finds abnormally elevated concentrations of carbon-14, at levels higher than ever before in history.

Since the halt of nuclear testing in the atmosphere, which took place in the early 1960s, the diminution of the amount of carbon-14 has been very regular. This has made it possible to date recent materials very precisely, with an error margin of only one to two years, and this has made the method useful for dating wine, among other things.

FIG. 7: Standing figure. Tellem, Mali.
Wood, ritual surface. H: 47.5 cm. Courtesy of Galerie Alain Bovis.

FIG. 8: Mask. Kwele, Gabon.
Wood, pigment. H: 30.5 cm. Private collection. Reproduced by kind permission of Didier Claes, Brussels.

FIG. 9: Post-bomb calibration curve (blue) and interval of calibrated dates (grey peak). Radiocarbon date: post 1954. Calibrated dates: 1963–1964 (95.4% probability).



Q&A

Carbon-14 is useless for tribal art!

False. First of all, carbon-14 testing allows for unequivocal differentiation of objects made before or after 1954. Moreover, it is highly accurate for objects from ancient cultures such as those of the Dogon, Tellem, and Djenneke. It also provides multiple date intervals that express the most probable period of an object's manufacture.

The conditions in which an object is preserved (sediments, water, cave environment) will alter its date.

Absolutely not, because it is a date of death that is being identified. By definition, death marks an end to an organism's carbon-14 exchange with the environment. After this, carbon-14 disappears at a rate that has nothing to do with the environment.

Scanning or intentional irradiation will alter a carbon-14 date.

Not at all. The organism is dead, and it cannot be "recharged" with carbon-14. Nor can carbon-14 be extracted or removed to age an object artificially.

Given a piece of wood, ivory, paper, or textile of identical age, for which will carbon-14 testing yield the most accurate result?

There will be no difference in the accuracy. These materials have integrated the same concentrations of carbon-14 and their disintegration will proceed at the same rate regardless of the environment. The dating of ivory requires large samples, however, because we are dating the collagen in it, which represents only about ten to twenty percent of its mass. A minimum sample size is 200 milligrams.

Can patinas on wood (such as blood, millet, oil, egg, etc.) be dated using the carbon-14 method?

In principle, yes, because these are organic substances, but in practice, the results are not generally very convincing because such materials might have been applied repeatedly and at different times. The dating obtained will thus represent an average of periods that is not very useful. Nevertheless, the study and analysis of the composition of patinas can supply interesting technical information.

Will a sample taken from the center of a mask or sculpture differ in age from one taken at the edge?

Yes, and this represents one of the method's limitations. In most cases, there is a difference of between the date of a tree's felling and the date of the death of its heartwood (duramen). We call this the "old wood" effect, and for this reason, we always take our samples from the outer areas of objects so that we can identify the event closest to its date of manufacture.

OLD BUT NEW

It is vital to remember that carbon-14 dates the death of an organism and not an object's date of manufacture. One can easily imagine a recently sculpted object being made of wood that is two or three hundred years old. The date of the material must conform to the style of the object. As examples, we cite a copy made of 35,000-year-old mammoth ivory that was preserved in continually frozen permafrost or a copy of an Egyptian Late Period (first millennium BC) statue made of wood harvested in the 15th century AD. Astonishing!

THE PLACE OF SCIENCE

Carbon-14 dating has constituted a major advance for archaeology and art history. Over time, it has become an important tool for the art market. In the words of noted tribal art dealer Bernard Dulon, "Carbon-14 testing is perfectly suited to the detection of fakes, particularly in the tribal art field." It supplies objective information that contributes to the study of an object, just as thermoluminescence does for terracotta and micro-analysis does for metal. On the other hand, these scientific "tests" are not a substitute for the historical and stylistic evaluation of art works. They are rightly seen as aids to decision making, as indicators of risk, and as tools used in connection with buying.

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