Radiocarbon Dating and Archeology in North America

Radiocarbon dating provided a chronology for American prehistory at a time when it was most needed.

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The development of radiocarbon dating by W. F. Libby revolutionized archeological ideas concerning the chronology of human events during the last 40,000 years. Because chronology is essential to the understanding of prehistory, archeologists have made great efforts to extract measures of time from their data, which are hardly adequate for this purpose. With few exceptions, this extraction was by inference and guessing; nevertheless, the various systems presented have been staunchly supported. Libby's provision of a means of counting time—one that promised a definable degree of accuracy and worldwide consistency—caused all sorts of consternation because many of the new findings threw doubt on the validity of some established archeological opinions. The initial reactions of archeologists were sometimes amusing but more often significant, for they led to the foundation and emergence of the radiocarbon chronology that has so profoundly affected our understanding of prehistory. In tracing the history of this development I shall concentrate on North America and discuss a few salient aspects; the experience of American archeologists with radiocarbon has resembled developments all over the world.

When the method was announced, the committee (*1*) appointed in 1948 to assist Libby in selecting and evaluating samples to be dated found itself in the midst of controversy. Eighteen years ago American archeologists had become accustomed to collaboration with earth scientists, biologists, and those in associated fields. Collaboration with researchers on radiocarbon was quite different, for physicists applied to archeologic and geologic samples techniques based on ideas that were completely foreign to archeology. There was no way in which archeologists could check the validity of a radiocarbon date on a sample of unknown age except by comparing it with archeological opinion. When, as at the beginning, there were frequent disagreements concerning variations of from several hundred to more than 1000 years, some archeologists believed that their credibility was threatened and they rebelled. At this primary stage, a question of authority arose: Who was right? Some believed that archeology had the prerogative and that it should declare that its inferences were valid, even though there was a good chance that some of them were wrong. One somewhat typical comment was based in part on this conviction: the author of a very reputable monograph wrote in 1951, "We stand before the threat of the atom in the form of radiocarbon dating. This may be the last chance for old-fashioned, uncontrolled guessing" (*2*).

One interesting development has broader significance than is immediately apparent. The initial period of adjustment brought about reappraisal of the archeological evidence. This return to the trenches for a more careful look at the provenience of samples—often for the purpose of proving the radiocarbon dates to be erroneous and useless—resulted in refinement of methods of recording in the field, in order to determine more precisely associations of samples with levels.

The physics and chemistry of the method are formidable barriers to humanists, and only rarely have archeologists attempted to become familiar with the theory and operation of the method. This has been one hindrance to its full application; another is the way in which the statistics have been misused. Archeologists employ statistics sometimes in a highly arbitrary—frequently individualistic—manner in order to analyze the distribution of the materials that they excavate. Many continued this practice with radiocarbon dates, sometimes disregarding the characteristics of the standard deviation by which a radiocarbon date is expressed. Some results of this occasionally stubborn arrogance, which still continues but with declining frequency, are erroneous—in fact, ridiculous.

Archeology has many of the attributes of history; it is concerned with development of all kinds of artifacts, with the arts often applied to these artifacts, and with structures such as houses and temples. Changes in character of communities identified by these artifacts and structures, ranging from simple hunting camps to complex and sophisticated urban centers, are measured against time, and an adequate chronology is a basic necessity. The nearest approach to a means of telling time that archeologists have, where there is no record, is interpretation of position and quantity of artifacts, floors, and other evidences of human life in stratigraphic sequence. At best this interpretation is a kind of guessing, based on notions concerning the way in which culture develops and populations change. The guessing progresses from site to locality to region, producing relative chronologies covering vast areas of the New World. The astonishing thing about this chronologic structure is the degree of accuracy that has been attained; the system has been improved and refined by the use of various tools of which radiocarbon is the most recent. Because of the worldwide scope of radiocarbon, and because all its results are directly comparable, it has had an unprecedented effect on archeologic opinion—largely because the method has supplied the closest approach to the ultimate need: that is, an absolute chronology expressed by a calendar based on sidereal time.

Dating Early Man

The characteristics of New World archeology began to be discernible shortly before the turn of the century; with some very prominent exceptions, archeologists were then turning their

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backs on antiquarianism. Although they had little sense of "problem, solution, and new problem" (*3*), there were questions in which they were deeply interested. Prominent among these was the question of the antiquity of man in America. By 1948 the discussion of the date of the first Americans had reached almost a stalemate. The argument had begun somewhere in the dim past with attempts, patterned on developments in Europe, to prove that man was present in the New World during the Pleistocene glaciation. Later, because of poor reasoning and the introduction of fraudulent specimens, it became almost a habit to deny the possibility of man's antiquity (*4*). The feeling was so strong during the 1920's that the late Kirk Bryan used to say to his classes in geomorphology, "If you ever find evidence of human life in a context which is ancient, bury it carefully, but do not forget about it" (*5*). The authoritative reporting of the discovery in 1926 of arrowpoints in association with extinct bison near Folsom, New Mexico, was a rallying point for those inclined to correct the tendency toward intolerant denial of antiquity; a period of mutually profitable collaboration between archeologists, geologists, palynologists, and biologists was soon to follow. The age of early man in North America was calculated in several ways, varying from 10,000 to 25,000 years. Great progress was made, but even so there were a number of uncertainties to reckon with in the chronologies.

During the 1940's the disagreement among geologists created problems for archeologists. The correlation of culture complexes with deposits related to glacial phenomena, oscillation of climate, and so on became increasingly close. The real problem was with time. Correlation of geological dates on events in Europe, for which there was a more complete time scale, with geological events in America could be only on the basis of estimates, and archeologists had to depend upon schemes proposed by Bryan, Antevs, and other geologists. The differences between the schemes and the occasional changes in the estimates of dates could easily be accommodated by geologists, but it was difficult to adjust cultural sequences to such variations of opinion.

Considerable clarification of the confusion came with the introduction of radiocarbon dating. The first list of dates by Arnold and Libby in 1950 (*6, 7*) had been preceded by distribution and discussion of preliminary and tentative lists. All these dates were prophetic of many things, including the date of the earliest known occupation of the New World. The date of the Two Creeks Forest Bed was confirmed by several measurements at about 9400 B.C.; this date and those from other geological deposits provided ages for levels surrounding varieties of Folsom complexes that were dated between 7000 and 8000 B.C. These figures contrasted with Bryan's estimate of 10,000 to 25,000 years ± 30 percent made in 1940 (*8*). Antevs claimed that Bryan's estimates were in serious error and attacked the radiocarbon dates on Two Creeks, saying they were 8000 years too late (*9*).

Previously there had been no way of proving that glacial events in the New and Old Worlds were synchronous. Both Bryan and Antevs could with reason use similar data to compile contrasting correlations of glacial events with estimates of time. In 1951 Flint compared the Alleröd horizon in Germany, England, and Ireland, dated about 8850 B.C., with the Two Creeks horizon, dated about 9450 B.C.; he concluded that the essential agreement of the dates implies that deglaciation of northern Europe was contemporary with that of North America (*10*). Since these "early days" many more radiocarbon determinations by many laboratories have helped define—as yet unclearly—a glacial drift underlying Wisconsin but post-Sangamon. The Two Creeks peat presents a special problem: the present radiocarbon date for the top of the peat averages about 9250 B.C., which date is about 400 years earlier than the present average for Alleröd oscillation in Northern Europe, although the two represent what is presumed to be the same period of cooling (*11*).

The first date on unquestionable Folsom material was published in 1951 (*7*); it was from sample No. C-558, burned bison bone from a Folsom horizon near Lubbock, Texas, and dated at 7977 ± 350 B.C. Since 1951 there have been few samples from Folsom or from fluted-point horizons, but determinations have been both earlier and later than the first date; we do not yet know the full range of the age of this kind of material. The chronological problem is currently an archeologic one, being in fact the difficulty of discovery and definition. Fluted points, sometimes accompanied by an inventory of associated tools, are distributed from Nova Scotia to the Southwest; from near the Arctic Circle to the Rio Grande. However, it is clear that there are regional and possibly temporal differences in the complex. Furthermore, despite a scattering of dates, indicating general contemporaneity, the time and place of origin remain hypothetical.

Since the first age of fluted points appeared, the search for the earliest inhabitants has unearthed many widely scattered sites, in both North and South America, dating between 7000 and 14,000 B.C. Briefly, a base consisting of a simple hunting culture appears to have been diffused throughout the New World. This may have been preceded by a cruder type of culture said by some to include no projectile points (*12*), but the artifact inventory may not be yet complete and the chronology is not at all clear. The projectile points used by the early hunters include types such as Lerma, Agate Basin, Cascade, and others of comparable shapes in a general class usually called Lanceolate.

Whether these, along with fluted points—and let us not forget the significant inventories of other kinds of tools—reflect differences in time or cultural processes associated with adjustments to differing environmental resources is by no means clear. However, there is some evidence that the Lanceolate points may be among the earliest and that their use continued down through the ages, they being replaced at various times in many places by stemmed or notched forms. Fluted points have a more restricted distribution; perhaps they existed concurrently, but we cannot really document this opinion very well for it is virtually certain that the levels including the earliest and latest fluted points have not been dated.

Intermontane Plateau and Great Basin

During the 1920's, if not earlier, ethnologists were discussing an "ancient culture stratum" in the Intermontane Plateau and Great Basin. Twenty-five years ago Steward (*13*) recognized an ancient, simple hunting culture that had existed in what he called the Intermontane area during Pluvial times. As the climate became more arid the people commenced collecting seeds and indulging in specialized types of hunting. Steward also recognized that there were regional differences in this culture, and he tried to account for these by

tracing the diffusion of traits from the Basket Makers of the Southwest and from cultures outside the Intermontane region. He could not be expected to see the temporal difficulties that his analysis produced, because there was no scale that was generally applicable. Since 1940, steadily increasing knowledge has pointed toward antiquity of the primary occupation and to an extraordinarily long period during which a hunting-gathering economy was the only mode of life.

As archeologic research continued, various types of Lanceolate points, in levels representing a number of different environments, came to light, but for a number of reasons it was difficult to assemble the sequence (*14*). Jennings has written, "Until 1950, when radiocarbon dating was developed, there was no way to prove that 8,000 to 12,000 years of age could be ascribed to certain of the remains that were being discovered" (*15*). This is not the complete explanation, but it does indicate that chronologic ordering of the data is an important factor in their interpretation.

The first dates from levels in Washington and Oregon, published in 1951, were confusing because, until the field situation was reviewed and additional details of the provenience of the samples were determined, the order of the volcanic eruptions (which in part were control points in the stratigraphy) appeared to be reversed. There were problems too with the associations of samples, and so it was difficult to decide exactly what the dates really meant; and time has proved that the number of dates available at first was quite inadequate.

Increase in the number of dates helped to outline the situation, which became increasingly better known through archeologic and geologic research. Currently the several ancient complexes are falling into line, apparently to be identified as part of an ancient Paleo-Indian stratum distributed from the Yukon, and perhaps even from Eastern Asia, into Mexico and South America (*16*). The cultures in the Intermontane West have been included by Daugherty in his "Early Period," dating from about 9000 to 6000 B.C. (*17*). He continues a description of an Intermontane Western Tradition by postulating a transitional period lasting from about 6000 to 2500 B.C.; this includes the Thermal Maximum, marking the onset of a period of aridity and the beginning of economic specialization, so that one may identify the Southwest, Great Basin, and Plateau culture areas. The cultural variations are seen as more or less distinctive cultural traditions in which can be identified certain basic elements of the Intermontane Western Tradition surviving into the Historic period.

The presentation of this concept concerning the development of culture in the Intermontane West and other ideas advanced by Jennings, Swanson, and Butler (*18*) is the culmination of 10 to 15 years of exciting archeological progress in this vast region. Radiocarbon dating has been of considerable aid, by setting things in order. However, I emphasize that the dates provide only chronologic order; it is intelligent use of this order that has been responsible for the progress.

Dates on Later Cultures

Pre-radiocarbon chronologies for the later cultures and dating of the earlier sequences were established differently. Between 1904 and 1917 Charles Peabody, Uhle, Nelson, Kroeber, Kidder, Guernsey, and Spier (*19*), to mention the major figures, introduced to American archeology stratigraphy and the building of a stratigraphic sequence of cultural data, usually pot sherds, by seriation. The experiments with stratigraphy and seriation in order to establish chronology were first extensive in the Southwest, but the inherent ideas spread to other regions. For many and different reasons, adoption of these methods in the several areas was rather erratic; the results varied in consistency and accuracy. The greatest progress was made during the 1930's, which, marked by many large excavation projects under the relief agencies, saw great advances in American archeology as a whole. The labor supply not only produced mountains of potsherds and other artifacts; there were people to wash, count, and record them.

Development of statistical treatment and the use of bar graphs, as by James Ford, resulted in recognition of periods of cultural development, especially in the eastern United States; inevitably, several chronologies for these were inferred. In the plains, in 1935, Strong could make broad and generalized comparisons with the eastern sequence, but, except for a few dates based on geologic observations, he could not suggest a useful absolute chronology for the sequences he identified and described (*20*).

Establishment of stratigraphic sequences in various parts of the country, and the accompanying estimates of time, set the stage for an occasionally hair-raising period during which a number of relative chronologies were expanded and combined to cover vast regions of eastern North America. These eastern chronological estimates pushed back the dates on the early village communities, which were beginning to be called Archaic, to about the beginning of the Christian era or a millennium or two earlier; they produced what was known as the "gap." That is, the complexes eventually called Paleo-Indian were isolated from the more recent Indian cultures by a period of 4000 to 6000 years. During the 1940's and the early 1950's this was a somewhat worrisome situation. Continuing field investigations brought to light sequences of cultural complexes that obviously filled the gap, but the fact that the order and chronology of these could only be guessed was frustrating.

The radiocarbon chronology closed the gap, but the closure was not easy or immediately acceptable. Despite objections from some archeologists, radiocarbon dates pushed back in time the beginning of agriculture in eastern North America, the first development of village life, pottery making, and, shall we say, the age of the "Archaic Cultures." At the same time, radiocarbon dates provided lesser ages for some of the complexes that were intermediate between Paleo-Indian and more recent people. The sequence is, of course, imperfect because much remains to be discovered. However, stratified sites such as Graham Cave and Modoc Rock Shelter, and the sites in the Carolina Piedmont, together with fluted-point sites such as Williamson, Quad, and the dated ones, Bull Brook and Debert (the latter in Nova Scotia), strongly suggest that the chronology and history of the east is analogous to that of the west (*21*). Radiocarbon dates show that more than one cultural tradition existed in eastern North America in 7000 to 8000 B.C. We have little knowledge of these early traditions except that fluted points and a characteristic inventory of tools are approximately synchronous with complexes that include Lanceolate-shaped, side- and corner-notched varieties of points, and other distinct inventories of tools.

Dating the Adena and Hopewell Cultures

One of the most interesting of the controversies that arose concerned the age of the Adena and Hopewell cultures of Ohio and neighboring states. The spectacular art lavished upon the grave goods placed in mounds had figured prominently in early discussions of the mound builders. By the 1930's, accepted opinion was that Adena preceded Hopewell, and Hopewell was beginning to be seen as a major religious or ceremonial development, possibly contemporary with the introduction of maize agriculture. In the northern Mississippi Valley, Hopewell continued the elaboration of ceremonial practices initiated in Adena. However, the style and character of the paraphernalia differed in such regions as the Ohio Valley, Illinois, Wisconsin, Kansas, and the adjacent plains areas. To account for this variation there was urgent need to know the sources and ages of the customs.

During the 1930's and 1940's, estimates of the time differed but were of the same order: 400 years, from about 900 to about 1300 A.D., was a common figure for Hopewell, especially in the north; as good an estimate as any for Adena was 500 to 900 A.D. In the south those who considered Marksville material to be Hopewell dated it about from 900 to 1150 A.D.

The agricultural base for Hopewell had been proven as early as 1882, but the vagaries of analysis obscured this finding and challenges arose (*22*). We now have rather clear confirmation of an established and varied agriculture (*23*). In the 1940's the estimates of age began to be questioned: For example, boldly but logically Krieger traced trade materials from the Mississippi Valley, across Texas, to the Puebloan sequence in the Southwest and suggested that Hopewell must be older than was believed (*24*). A few years later the pendulum swung the other way and estimates of the date of Hopewell returned to the vicinity of 1200 A.D. (*25*).

While very incomplete, these notes illustrate the point that the time and energy spent in trying to establish the age of Hopewell ended in nothing but a succession of frustrating estimates and furious debates. New excavations and publications, together with the expansion of analyses, added fuel to the debate, but prospects of solving the chronologic problem by purely archeological means did not improve.

Radiocarbon dating broke the back of the dilemma dramatically. The situation was analogous to the introduction of tree-ring dates in the Southwest. There were howls of protest; people wrote angry (now amusing) letters to the committee advising Libby. It was some time before archeologists relearned the lesson of the previous decade. A tree-ring date, a radiocarbon date, or any date of this character does not date a site, building, grave, or level; the date is that of the sample, and it is the task of the archeologist to discover the true relation between the sample and its source—not always an easy task.

The initial dates on Adena and Hopewell, taken at their face values, especially when the statistical errors were disregarded as they were by many, indicated first that Adena and Hopewell were older than had been believed; secondly, they showed that Adena was younger than Hopewell. There were problems with the samples too; some had been collected in 1891 when the original Hopewell site was excavated. In the south, Tchefuncte, presumably related to Adena, appeared younger than Hopewell by some 900 years, and Hopewell was older than Marksville by some 675 years.

This reversal of the opinions gleaned from archeologic excavations was simply unbelievable (*26*). During the last 10 years a number of dates from Adena and Hopewell material have been added to the list. Even so, the total number of dates available is inadequate to date these cultures which, in various forms, were distributed over most of eastern North America and represent more than 1000 or 1500 years of cultural development and degeneration. Assignment of the figures to one culture or another varies, depending on details of classification by the several authors, who do not always agree concerning assignment of traits to one culture or the other. Very broadly, however, Adena ranges from about 800 to 100 B.C., and Hopewell, especially in the north, existed from about 100 to about 500 A.D.

Arctic Dates

Radiocarbon dating has been unsuccessful in the Arctic and Subarctic. The archeologic sequence of Eskimo complexes from Denbigh, through Punuk, to modern Eskimo is rather firmly established; one cannot make more than minor adjustments in the sequence. The ranges of the ages of certain levels in northern Canada and Alaska are limited to a considerable degree by dated correlative materials in other parts of the continent. For the first published dates on Eskimo levels Libby used solid carbon; they were erratic in distribution and unsatisfactory, even though occasional dates appeared to be useful. More recent use of gas and proportional counting has produced dates that may be more accurate, but even an extensive analysis by the University of Pennsylvania failed to produce a chronology that was unequivocal; the reasons remain obscure.

Radiocarbon dating is applicable to a wide variety of problems, even in archeology. The Maya calendar has not yet been successfully correlated with the Gregorian. It was natural to use radiocarbon in an attempt to confirm some one of the at least nine different attempts at correlation. The various estimates differ by some 260 years. Over many years the problem of correlation developed a seemingly endless orgy of arithmetic and astronomy.

Libby and the Lamont Laboratory reawakened interest by deriving dates from a beam from structure 10 at the site of Tikal, which in a spectacular way appeared to confirm Spinden's correlation. The University of Pennsylvania, which was excavating at Tikal, commenced a project to date beams found there in the temples; the research entailed, among other things, examination of the tree rings of a beam so that one could judge from which part of the original trunk the beam was taken. Thus one could estimate the relation between the age of the rings in the beam and the age of the outer rings of the tree. The latter age roughly indicates the date of the cutting of the tree. If certain basic assumptions are correct, the results of this and of independent analyses favor the Goodman-Thompson-Martinez correlation (*27*). However, some believe that the distribution and comparisons of certain types of Maya pottery favor the Spinden correlation; the controversy continues. Nevertheless, radiocarbon dating has introduced a new element that may eventually help to resolve the problem.

There are inconsistencies in dates from archeologic levels in Mexico and Central America. Recent analyses are demonstrating that samples were taken from the fill between floors in mound or house sites; such fill, having been originally collected at random from

around the sites, may not be contemporary with construction or occupation. Dates from such samples are erratic and sometimes meaningless. When samples are chosen from specific features that can be tied to definite stages in the occupation, the radiocarbon chronology and the archeologic sequence become more compatible. There is hope that the criticisms of Central American dates may be tempered simply by the refinement of archeologic sampling, the importance of which was not originally realized.

Summary

The history of the development of a radiocarbon chronology shows how the establishment of the times of events and the order of them has greatly improved the understanding of prehistory in North America. This is true also of other parts of the world. Too little has been said of existing discordance between archeologically determined sequences, and interregional associations, and the radiocarbon chronology. It does appear that these will be resolved as additional dates are added and as the results become more finely calibrated so that secular variations may be accounted for.

The collaborative aspect of the venture was apparent at the outset. Nevertheless no one expects an archeologist to delve into nuclear physics and geochemistry, and vice versa. There is great need, nevertheless, for the man in the laboratory to comprehend the difficulties of sample collecting and of judgement of the significance of the source of organic matter to be dated. At the same time, the archeologist must become more familiar with the importance of the various steps in the processing of the sample and with, what is most vital, interpretation of the significance of the numbers that appear on the counters.

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