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THE INTEGRATION OF RADIOCARBON DATING IN ARCHAEOLOGY*

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In the past 30 years many hundreds of archaeologic samples have been dated by radiocarbon laboratories. Yet, one cannot say that ^{14}C dating is fully integrated into archaeology. For many archaeologists, a ^{14}C date is an outside expertise, for which they are grateful, when it provides the answer to an otherwise insoluble chronologic problem and when it falls within the expected time range. But if a ^{14}C date contradicts other chronologic evidence, they often find the 'solution' inexplicable. Some archaeologists are so impressed by the new method, that they neglect the other evidence; others simply reject problematic ^{14}C dates as archaeologically unacceptable. Frequently, excavation reports are provided with an appendix listing the relevant ^{14}C dates with little or no discussion of their implication. It is rare, indeed, to see in archaeologic reports a careful weighing of the various types of chronologic evidence. Yet, this is precisely what the archaeologist is accustomed to do with the evidence from his traditional methods for building up a chronology: typology and stratigraphy. Why should he not be able to include radiocarbon dates in the same way in his considerations?

One reason, of course, is that the archaeologist does not produce the evidence himself. In most cases, he is not trained in physics and chemistry, and therefore has little feeling for the subtleties of the dating method. There is, however, another reason. In my opinion archaeologists often do not clearly realize why they want ^{14}C dates. In this paper, it is my purpose to specify the various functions ^{14}C dates can have in archaeologic reasoning. All examples are taken from old world prehistory.

First of all, ^{14}C provides us with an absolute time scale which extends not only far beyond the historic time scale, but also beyond the time scales provided by geochronology and dendrochronology. We can place archaeologic phenomena on the radiocarbon time scale and along it we can measure the duration of developments or periods. So we know that the expansion of cereal growing and cattle breeding from the Aegean coasts to those of the North Sea took 1500 years and that the period during which Bell Beakers were made in the Netherlands lasted just about 300 years.

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* This paper is from an invited talk.

The archaeologic interest of such statements is limited, once the absolute time scale is roughly known. Far more interesting is that radiocarbon dating provides us with a tool for establishing relative chronology. Our own methods, typology and stratigraphy, both have their inherent weaknesses. Good stratigraphies are rare in any case, and hiatuses may be very difficult to discern. Typologic sequences are, by their very nature, impressionistic and speculative. It is often difficult to isolate the chronologically significant features in the observed variability. In the past years, radiocarbon has solved many problems of relative chronology. The sequence of the main archaeologic stages is now well established in many areas. Gaps in the sequences are easily identified; hypotheses as to how they should be filled up can be tested by active sampling. In the Netherlands, typochronology has, for some periods, been pushed to the limit, to the degree of detail where the statistical error of the measurements starts to interfere. As an example, I may point to the sequence of Beaker cultures in the later part of the Neolithic period (Lanting and Mook, 1977). For such well-analyzed periods, further dates are in themselves pointless; they will always be 'according to expectation'.

Even more important for archaeology is the importance of ^{14}C dating in establishing correlations between archaeologic sequences that are too far apart in the geographic sense to permit the direct application of stratigraphy and typology. For long-distance correlations, we have in principle a method of our own which is sometimes called 'comparative stratigraphy': the cross-dating of regional sequences by means of exports, imports, or imitations, and by observed parallels in stylistic or technologic developments. A spectacular example of this is Milojčič's (1949) correlation of the historic Egyptian and Mesopotamian sequences with the protohistoric and prehistoric sequences of Anatolia, Crete, Greece, the Balkans, central Europe, and northwestern Europe. For large parts of this geographic range, his correlations have turned out to be correct; that he was completely wrong in the correlation between the Aegean and the Balkans is not a fault of the method, but of its application at a time when the material available for comparison was too limited and a Near Eastern origin of any cultural innovation was still commonly presupposed.

For northern Europe and parts of central Europe, pollen analysis provided a means for long-distance correlations. It worked well for the late glacial and early postglacial periods, such as the Allerød, Upper Dryas, and Preboreal periods, but for the later postglacial periods, the major changes in vegetation were not quite synchronous and too few in number to be of practical use for archaeologic synchronizations.

In the same area, Quaternary geology should provide another means for long-distance correlations, especially for the earlier periods of prehistory. But in practice, there are great difficulties in correlating the moraines of the Alpine glaciers with those of the Scandinavian glaciers, of the loess sections in western Europe with those in central Europe, of the river terraces in the different river systems, of the cave sequences in different limestone areas. Radiocarbon has been able to correct a few errors, but unfortunately, its range of application does not extend far enough backwards in time.

For the late and postglacial periods, however, radiocarbon has been of enormous help in studying such problems as the spread of farming, megalithic burial customs, copper metallurgy, in short, any cultural process occurring on a continental scale. Comparison of local sequences gives the direction of cultural movement and suggests possible areas of origin.

As a fourth contribution of ^{14}C dating to archaeology, I consider its power for <u>independent correlation of archaeologic sequences with environmental sequences</u>, such as derived from geology or vegetational history. For prehistoric man in the Netherlands, the fertile but subsiding and ephemeral delta environment was very attractive. Cultural deposits are often found deeply buried under later sediments. For reconstructing and understanding the settlement history of the delta, the independent dating of environmental sequences has proved to be of vital importance (Waterbolk, 1981).

The four aspects I mentioned - absolute chronology, relative chronology, long-distance correlation of regional sequences, and correlations with environmental sequences - are, in my opinion, the major outside contributions of radiocarbon dating to archaeology. But radiocarbon can do more for archaeology.

Quite often, I have the feeling that a submitter presents a sample for the sole purpose of having an independent check on his or her identification of pottery, grave, or house type, or on its stratigraphic position. The pottery may be typologically a little deviant, the grave may be in an area where, hitherto, the same grave type has not been found, the house may be incompletely preserved, an important find may have been brought to light without professional control, stratigraphic complications may render difficult the attribution of a cultural deposit to the standard geologic sequence of the area. In all these situations, a radiocarbon date will be of great help - not for dating the find itself, but for verifying archaeologic considerations of the find, as a check on the conclusions derived from typology and stratigraphy. In these cases, dates will often turn out to be 'according to expectation', but this does not mean that the measurement has been superfluous. If there is reason for some frowning on the part of the ^{14}C laboratory, it is because the archaeologist has not stated explicitly why he needed the date. But, as I said before, he may not have realized that what he wanted was anything else than the date itself.

I can elaborate a little further on this point. In strict archaeologic reasoning, find associations, in particular so-called closed finds, form the basis for connecting typologic sequences with each other and for the abstraction of units of material culture. The underlying supposition is that associated finds were deposited together. Wether this is true or not will, in each individual case, depend not only on the circumstances of deposition but also on the quality of the stratigraphic observations and may be open to some doubt. But even accepting contemporaneous deposition, this need not mean that all associated objects were made simultaneously. In the light of new finds, doubts may arise as to the reliability of earlier find associations. The same applies to stratigraphies that should provide proof for the chronologic value of typologies. Field data may be less convincing than published reports. In fact, archaeologists are constantly turning back to the old data, to see whether they are in need of reinterpretation in the light of new evidence. It is in this process of continuous critical analysis that ^{14}C dates can be of great help and the recovery of suitable organic materials from museum stores can be most profitable. Here again, the dates themselves are of less importance than their contribution to archaeologic discussion.

We can go a step further. In planning new excavations or in typologic treatment of new find groups, ^{14}C dates can be used to analyze complicated stratigraphies and to bring an initial chronologic order in the find group. The resulting stratigraphies and typologies will have already profited from radiocarbon and need no verification afterwards. A condition for applying this procedure is, of course, that ^{14}C samples are available in sufficient numbers, so that a selection can be made which is relevant to the problem being studied.

Finally, I want to point out the great advantage of having ^{14}C dates available soon after the first campaign of an excavation that is planned for a number of years. Such dates may help in the preliminary analysis of the findings and in the detailed planning of the campaigns for future. This will be particularly true for sites with complicated stratigraphies such as tells. In the end, we will perhaps have more dates than seem necessary for a chronologic analysis of the site as a whole, but the improvement of the quality of the excavation is worth the effort.

In the examples mentioned - verification of typologic or stratigraphic identifications, critical analysis of closed finds, assistance in establishing reliable typologies and stratigraphies, and monitoring excavation projects - ^{14}C dating serves goals in archaeology that go much further than chronology. It functions as a basic method in the search for chronologic order in the material remains of the past, alongside the traditional methods of typology and stratigraphy. It can fulfil this function because of its nearly universal applicability. Of course, archaeology is more than only chronology. But a sound chronology is a necessary starting point for the definition of cultural units and for all considerations of cultural change and cultural movement.

It is, however, clear that such an integration of ^{14}C dating in archaeology can only be successful if the archaeologist is constantly aware of the subtleties of the method, in the same way as he knows the strong and weak points of typology and stratigraphy. This awareness can only be achieved by training. Some problems involved in ^{14}C dating should not be so difficult to appreciate for the archaeologist: the varying reliability of the association between the dated organic material and the diagnostic finds is just another manifestation of the problem surrounding closed finds. That dates of charred wood are always older than the moment the tree in question was cut is a problem akin to the problem which the archaeologist has when he studies hoards of bronzes or coins. The possibility that samples may be contaminated or even mixed will be easily appreciated by an archaeologist who knows by experience that in complex stratigraphies isolated Neolithic sherds keep turning up in overlying Bronze Age layers and vice versa. In 1971 I published a paper with some guidelines for the use of ^{14}C dates in archaeology (Waterbolk, 1971). In an abbreviated and slightly amended form it will appear again (Waterbolk, in press).

Only radiocarbon scientiests are qualified to teach the physical and chemical side of radiocarbon dating. By this I mean the fundamental aspects of the method, the laboratory procedures, the statistical side of the measurements, the role played by the variations in the ^{14}C content of the atmosphere, the estimation of the quantitative effect of contamination, the problems involved in the use of samples from aquatic or volcanic environments, the calibration of the ^{14}C time scale, etc. I refer once more to the Proceedings of the Groningen symposium, which, in its introductory and invited papers, contains useful material for teaching purposes.

I want to end with a call to fellow archaeologists to include courses in radiocarbon dating in their curricula, and to radiocarbon scientists to help the archaeologists in implementing such courses. There are a few places in the world where such courses exist, but they are still far too few. If radiocarbon dating is allowed to grow from an outside expertise to a basic method of archaeology, training is a vital matter. And to make this training successful, archaeologists and radiocarbon scientists must join forces.

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