# Radiocarbon Dating and Egyptian Chronology: Can C-14 Dating Contribute to the Chronology?

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## 1. Introduction

Radiocarbon dating, invented by Libby during 1940s, has had a major impact on archaeology. Archaeologists now have access to independent dates of prehistoric and historical periods. Egyptian chronology, which had been established by historical records, was to benefit by this dating method, realizing cross-check between radiocarbon dates and the calendar dates established by historical evidence.

However, as the number of samples increased, discrepancies between the radiocarbon and calendar dates have been found: The calendar dates are higher than the radiocarbon dates for earlier Egyptian historic finds (Derricourt 1971:271). This discrepancy caused many Egyptologist to reject the applicability of the radiocarbon dating method to Egypt. In this paper, we will review calibration of the radiocarbon dates with the results of Dynasty I and Amarna periods, and the contribution and limitation of C-14 dating to Egyptian chronology in order to determine whether such rejection can be justified.

## 2. Calibration Curve

A basic assumption of the radiocarbon method is that a global level of C-14 in the atmosphere has not changed with time. Since this was proven to be incorrect and secular variations of the C-14 content in the atmosphere were discovered, a calibration curve to convert radiocarbon dates to calendar dates has been necessitated (Shaw 1985:295).

The first calibration curve proposed by Suess was based on the bristlecone pine. However, as Shaw (1985:295) indicates, this calibration curve was beset by controversy. At the 1974 Edinburgh symposium, though the calendar dates and the calibrated dates agreed for the Old Kingdom. McKerrell (1975:70) stated that for samples more recent than 2000 B.C. in calendar years there was systematic error after correction that would make the dates too old by up to three centuries. Endorsing McKerrell, Watkins (1975:3) mentioned that acceptance of C-14 dates calibrated by bristlecone pine tree-rings forces us to reconcile both the Egyptian calendar and the Mesopotamian, which is derived independently of the Egyptian and corresponds to the Egyptian chronology.

Clark (1978:16), on the contrary, insisted that the calibration curve of the bristlecone pine and calendar dates were compatible throughout the period 3100 to 300 B.C., not just the period 3100-1800 B.C. He also indicated that the C-14 content of bristlecone pine trees was unlikely to differ significantly from that of contemporaneous Egyptian samples only in the period 2200-1250 B.C. and not at other times. Therefore, he concluded that any errors in the bristlecone pine dendrochronology for the period 2200-1250 B.C. would have to be compensating errors, in order for the dendrochronology to be correct both before and after this period (1978:16; cf. Clark & Renfrew 1973:266-270).

The situation was totally transformed by the publication of a 6000 year high-precision calibration curve based on the tree rings of Irish oaks (Pearson et al 1983). Pearson et al demonstrated that the Belfast curve, based on liquid-scintillation counting of benzene synthesized from Irish oak sample carbon, could be matched almost perfectly with the Seattle curve, which was based on gas-proportional counting of $CO_2$ from sample cellulose deriving from northwest Douglas fir and California sequoia.

This achievement is significant in three aspects: firstly, this curve is applicable to the whole northern hemisphere; secondly, since the rings of oak and fir tress are wider than those of the bristlecone pine, more precise measurements are possible; thirdly, estimated error of this calibration curve is less than twenty years realizing improved precision of calibration for the Egyptian radiocarbon dates (Shaw 1985:297).

## 3. Dynasty I and Akhenaton

Reliable radiocarbon age estimates exist for the Dynasty I to Dynasty V, Akhenaten and Ramesses II periods (Hassan & Robinson 1987:122). From these, Dynasty I and Akhenaten are selected for review below.

Dynasty I, although there is a problem of identification, was first reigned by Narmer, succeeded by Hor-aha. Using Manetho's figure of 955 years for the first eight dynasties as a guideline, with assistance of astronomical records, the beginning of Dynasty I varies from 3400 B.C. to 2900 B.C. (Shaw 1985:300), from high to low chronology. Radiocarbon dating might resolve this kind of chronological dispute.

Derricourt (1971) calibrated the Dynasty I dates on the Suess curve, and showed the beginning corresponding to 3300 B.C. Mellaart also supported a high chronological date of 3400 B.C. for the beginning and suggested discarding the middle and low chronology (1979:18).

Hassan (1980), on the other hand, favored the middle chronology and suggested 3125 B.C. for the beginning of Dynasty I. Hassan & Robinson, using the high precision calibration now available, later revised the date to 3050 B.C. (1987:125), which follows low chronology.

Shaw (1985:301), considering various radiocarbon dates for Dynasty I, insists that the radiocarbon dates simply reiterate the controversy, failing to provide any wholly reliable solution. However, the low date of 3050 B.C. now corresponds with the calendar date agreed among Egyptologists. Most of the scholars at the 1987 International Colloquium on Absolute Chronology endorsed the low chronology, while a few supported the high and middle chronologies (Astrom 1989:76). Therefore, the calibrated radiocarbon date and the calendar date of Dynasty I in low chronology are compatible and acceptable.

Tel el-Amarna, the capital of Akhenaten, was a one-generation site occupied from 1352 B.C. to 1337 B.C. according to the calendar date (Kitchen 1987:52). Both high and low chronologies suggest the same dates for the period. In addition, the calibrated radiocarbon date is 1333∓50 Cal.B.C., compatible with the calendar date (Hassan & Robinson 1987:123). This attests that it is possible to obtain calibrated radiocarbon dates which are compatible with the accepted astronomical chronology for Egypt (Shaw 1985:297).

Since the Amarna dates satisfy the following three conditions, they represent a useful contribution to Egyptian chronology. Firstly, the samples come from a sealed archaeological context, and ground water or modern disturbance did not cause contamination. This is important because flood waters may cause grasses to acquire some older carbon from water soluble carbonates. Secondly, various types of organic material including short-lived reeds and linen to long-lived wood and bone should be used. Thirdly, the counting error and inter-laboratory bias should be kept to a minimum (Shaw 1985:298).

## 4. Contribution and Limitation of C-14 Dating

The subtle matters of chronology (e.g., determining when Ramesses II ascended the throne) may not be resolved by radiocarbon dating. Nevertheless, radiocarbon dating with a precision of several decades rather than one to three centuries has potential to solve problems in the historical chronology of Egypt (Hassan & Robinson 1987:130).

A good example is the East Karnak settlement. Although the archaeological date is from c.750 B.C. to c.350 B.C., careful examination of radio carbon dates of this settlement indicates that the samples date to 794∓41 Cal.B.C.: 826-794 Cal.B.C. at a 68 % confidence level and 845-621 Cal.B.C. at 95 %. Radiocarbon dating in this case provides a better age estimate than the archaeological date (Hassan & Robinson 1987:129).

As Hassan & Robinson (1987:130) rightly state, radiocarbon age measurements are not truly dates, but statements of probability. A radiocarbon date cannot be interpreted as a gospel just because it affirms the expected date of the sample. In this sense, we agree with the statement of Shaw (1985:304) : Egyptian chronological problems cannot be solved automatically by the Irish oak calibration.

However, we disagree with the Shaw's argument that the calibrated radiocarbon dates cannot form the basis for an alternative chronology and can only be commentary on the existing framework (1985:304). Shaw, as indicated by Hassan & Robinson (1987:120), was probably daunted by cases where there is a wiggle in the curve and a single radiocarbon measurement is potentially equivalent to two or more calendrical dates.

## 5. Improvements for Precision

Until the mid 70s, the validity of the calibration curve and the existence of wiggles were the main concern of archaeologists, but now, since the establishment of the reliability of the high-precision curve, the methods of collection and analysis are the true sources of error (Shaw 1985:298). Several improvements are to be made in order to achieve precision of radiocarbon dating.

Firstly, samples should be judiciously selected. It is regrettable that a large proportion of Egyptian radiocarbon dates over the last thirty years failed to fulfill at least one of the conditions the Amarna samples satisfied. Samples should reflect archaeological integrity; high precision dates will be useless if the samples are not backed by tight stratigraphy (Shaw 1985:298).

Secondly, the old-wood problem should be taken into account. Wood, commonly used for dating, may come from trees like cedar that are known to have a life-expectancy of 400 years (Hassan & Robinson 1987:119-120). Because of variability in rates of wood decay processes in the environment and in systemic context, Schiffer (1986:13) warns that archaeological chronologies based on a series of radiocarbon dates on wood are potentially biased towards excessive antiquity. In addition, the organism of a large tree may cease to exchange carbon with the biosphere before death since the inner trunk can decay while the outer trunk is alive (Bowman 1990:51). Furthermore, delayed use and reuse of wood can frequently occur: seasoning process may have occurred before the timber was actually used; large timbers might be reused in building as the historic buildings demonstrate (Bowman 1990:53).

Thirdly, samples and their presumed historical context must be closely associated. It is necessary to secure a set of several measurements for each target event; multiple sets for the same event are desirable. For instance, samples from different parts of a building should be taken to eliminate the chance of obtaining samples from a later addition (Hassan & Robinson 1987:120).

Fourthly, a series of samples must go through statistical examination to detect outliers, which are aberrant measurements. After the removal of outliers, the measurements are to be statistically averaged. Then, the averages can be converted to calendric years by the high-precision calibration curve (Hassan & Robinson 1987:129).

Finally, a quality assurance scheme has to be established in order to ensure reliability and direct compatibility of C-14 age measurements. The reason is that radiocarbon age measurements from International Collaborative Study in 1988 revealed that a significant number of laboratories were systematically biased by up to 200 years relative to the mean age value. A total of 52 laboratories participated in the study, and 37 of these completed three stages: the process of counting, sample synthesis and raw material pretreatment. A laboratory, then, is considered to be performing adequately if it meets the following criteria: it has no significant systematic bias and is assessing its internal and external variability adequately. However, only 15 of the laboratories which completed three stages fulfilled these criteria. Therefore, establishment and publication of a quality assurance scheme are immediate necessities (Scott et al 1990:319-321).

## 6. Conclusion

In conclusion, we have reviewed the calibration of the radiocarbon dates with the results of Dynasty I and Amarna periods, and the contribution and limitation of C-14 dating to Egyptian chronology. The result is that radiocarbon dating is applicable to the Egyptian chronology contrary to the opinion of some Egyptologists. Controversy over the Suess curve, which some scholars insisted was not valid for samples more recent than 2000 B.C., was resolved by the publication of the high-precision calibration curve of Irish oaks. Using the calibration curve, the beginning of Dynasty I can be dated to about 3000 B.C., which corresponds with the historical low chronology agreed among Egyptologists. The period of Tel el-Amarna (1352-1337 B.C.) was attested not only by high and low chronologies but also by the calibrated radiocarbon dates.

Although a radiocarbon date cannot be considered as a gospel, it has potential to date more precisely than the archaeological investigation does as shown by the example of the East Karnak settlement. In order to achieve such precision of radiocarbon dating, several improvements are necessary: judicious selection of samples, assessment of the old-wood problem, close association of samples with their historical context, statistical examination of samples, and establishment of a quality assurance scheme.

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