ARTICLES

CORRELATION OF C-14 AGE WITH THE BIBLICAL TIME SCALE

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WHAT THIS ARTICLE IS ABOUT

The biblical constraints on a time scale are combined with the constraints provided by carbon-14 data in the formulation of a mathematical relationship for conversion between C-14 age and real time. This relationship is developed for convenient adaptation to varied interpretations of the biblical time constraint specifications, and is presented by an equation of exponential terms, a tabulation of useful data points, and a graph.

INTRODUCTION

Among individuals who have a concern regarding the validity of the historical and chronological data in the book of Genesis, there has been a desire for a reliable conversion between radiocarbon age and real-time age that extends over the full range of biblical specifications. Such a conversion would be an aid in the formulation and testing of models for earth history. The object of this treatment is to summarize the constraints to such a conversion that are provided by data in the biblical text and by C-14 age data, and incorporate these constraints into a compatible mathematical relationship.

The era with which this treatment is primarily concerned dates from the beginning of the refashioning of Earth's geology, geography, climate, and ecology that resulted from the universal catastrophe described in the seventh and eighth chapters of the book of Genesis — the Flood.

BIBLICAL CONSTRAINTS

According to the text of the Bible that was the universal standard among Christians for the first six centuries, the Flood occurred 5352 years BP (Brown 1990). (BP refers to years before AD 1950, the zero reference time for C-14 age.) Since the Authorized Version (King James) of AD 1611 Western European Christianity has favored a biblical text according to which the Flood may be dated at 4472 BP (Shea 1979). For a treatment that encompasses both of these traditions I can take as

the biblical specification for the date of the Flood the approximation 5000±500 BP (a simplification of the straightforward 4950±450).

Some interpreters contend that the dates for the Flood given in the preceding paragraph should be reduced by 215 years. This view is based on the presumption that the Apostle Paul's statement in Galatians 3:17 overrides the testimony of Moses. Considering two statements made relatively close to an event, and speaking directly to that event (Genesis 15:13 and Exodus 12:40, 41; also quoted in Acts 7:6), to be more definitive than a passing allusion made fifteen hundred years later, I conclude that the Hebrew nation lived in Egypt for 430 years prior to the Exodus, not merely 215 years as may be inferred from Galatians 3:17. This view places Galatians 3:17 in the category specified in 2 Peter 3:16.

I prefer to place the Flood at 5350 BP, rather than the 5000 BP which I will use in the following mathematical treatment. This preference is based on the evidence that the chronological data in the fifth and eleventh chapters of Genesis as given in the scripture used by the early Christian church (the LXX) are much closer to the values specified by Moses than are those in the Masoretic text (MT) of the ninth century AD. As a set of numbers related to human genealogy, those given in the LXX are much more reasonable and internally consistent than those in the MT. The MT data in Genesis 11 are more difficult to fit into a reasonable treatment of historical data, ethnographic considerations, or C-14 data. There is substantial evidence that a source for the MT gave numbers in the fifth and eleventh chapters of Genesis that had been systematically reduced from the values in the primary source (Zurcher 1959).

What motivation could there have been for such reduction? The millennial concepts that were held among both Jews and Christians at the beginning of the Christian era (Fox 1986, p 265-267; Taylor 1855) (i.e., belief that the coming of the Messiah would occur before or at the conclusion of six millennia following creation, with a seventh millennium of universal idealistic conditions) would give determined opponents to designation of Jesus of Nazareth as the Messiah strong motivation for removal of evidence that they were nearing the close of the sixth millennium since Creation. This objective is accomplished by the difference between the MT and the LXX of about 1500 years for the time since Creation Week. Anyone who wishes to investigate this consideration more fully should consult Zurcher's treatment (Zurcher 1959). On page 42 of his monograph he says: "For about fourteen

centuries, almost all the theologians thought there had been a subtraction made by the Jews of Palestine ..."

CARBON-14 CONSTRAINTS

Agreement of C-14 age with real-time historical age can readily be established as far back as the middle of the second millennium BC (3500 BP) (Libby 1955). Correlation beyond 4000 BP must be based on models that involve assumptions, due to lack of objects that can be precisely dated from historical records. The most successful model has been the Bristlecone Pine dendrochronology developed by C. W. Ferguson (1968). Dr. Ferguson arranged specimens of dead Bristlecone Pine wood from the White Mountains in California into an approximate sequence according to their C-14 age, and then "fine tuned" this sequence by growth-ring matching. His correlation between dendrochronology and C-14 age won reluctant acceptance from anthropologists, Quaternary geologists, and other scientists whose models had required much greater ages than were given by C-14 (Gladwin 1976, Lee 1981). The latest refinements to the dendrochronologic age versus C-14 age relationship are given by Stuiver et al. (1991). According to the dendrochronologic model there was an increasing C-14 concentration in the biosphere with increasing age beyond 3000 BP (C-14 age increasingly less than the corresponding real-time age).

Due to its characteristic complacent growth ring patterns, Bristlecone Pine wood from the White Mountains is not well suited for the development of a dendrochronology standard. This difficulty was emphasized by Dr. Ferguson in a letter to Herbert Sorensen, dated 3 March 1970, by the statement: "I am often unable to date specimens with one or two thousand rings against a 7500-year master chronology, even with a 'ball-park' placement provided by a radiocarbon date." (Sorensen 1975). There is need for a demonstration as to whether an equally good, if not better, master growth-ring sequence can be established with Bristlecone Pine specimens preliminarily arranged in a sequence of real-time age such as would be obtained from the correlation relationship developed in this paper.

The retrograde increase in biosphere C-14/C-12 ratio between 3500 BP and 7000 BP required by the Ferguson Bristlecone Pine dendrochronology reaches about 10% over the present value. A further increase up to about 50% going back to 20,000 BP has been proposed on the basis of recent dating of corals by both the uranium-thorium (U-Th) method and the C-14 method (Bard et al. 1990). In my judgment, a

correlation of real time with U-Th age has even greater uncertainty than with C-14 age.

There is increasing evidence that organic specimens which can be established confidently as fossils of material that was involved in the Flood (e.g., coal) have C-14 ages in the 40,000 year range (Brown 1988b). This constraint, together with placement of the Flood at about 5000 years BP, specifies that at the beginning of the Flood the biosphere had no more than about 1/100 of the C-14/C-12 ratio that has characterized it over the past 3500 years. (A 1/100 ratio corresponds to a C-14 age slightly greater than 38,000. An added 5000 years of real time would give such material a present C-14 age of 43,000.)

A MODEL FOR CORRELATING C-14 AGE WITH THE BIBLICAL TIME SCALE

With the preceding background on constraints provided by the chronological data in the Bible and by C-14 data, we can now proceed to the task of correlating these constraints. The correlation developed will be an interpretation, and should be based only on fundamental data, not on other interpretations such as the Bristlecone Pine dendrochronology model or the U-Th age model. It is to be compared with these other interpretations, but to be kept distinct from them.

For the major readjustment period following the Flood we can presume that radiocarbon levels in the atmosphere may be represented by Equation 1:

$$A = A_1 (1 - e^{-at}).$$

In Equation 1, A represents C-14 level, either as the ratio of C-14 to C-12, or as C-14 spontaneous transformations per unit of time per unit mass of carbon; A_1 represents the equilibrium level of A; e is the base of the natural logarithms — 2.718... —; a is a parameter which is related to the rate at which A re-approaches equilibrium after a disturbance from its equilibrium value A_1; and t is real time measured from zero at the end of the Flood. The value of A for plant tissue will be essentially the same as for the CO_2 in the air from which it obtained its carbon. In animal tissue A will represent the average for the food supply which furnished the carbon in that tissue.

The large amount of organic material, and probably some of the carbonate sediment, buried during the Flood and now existing only as fossil material indicates that prior to the Flood the world inventory of C-14 was associated with a much larger amount of C-12 than has been

the case since the Flood. This is in agreement with the evidence that A for this material was about or less than 1/100 of the present value (equal to or less than $0.01A_1$). For simplification, Equation 1 treats A as having zero value at the end of the Flood. To obtain a significant comparison in the time immediately following the Flood a constant in the vicinity of 0.005, and within a range of uncertainty that might extend to 0.01, should be added to the exponent at.

The parameter a in Equation 1 is determined by the rate at which CO_2 is taken out of the atmosphere by the reestablishment of vegetation over the Earth's surface after the Flood, and by the cooling of the oceans associated with glaciation and the development of frigid climate zones. (The solubility of CO_2 in water increases with a lowering of temperature.) An effective change in the parameter a would be produced also by a *change* in the rate of formation of C-14 by interaction of cosmic rays with nitrogen in the upper atmosphere. The proportion of the cosmic rays from outer space to interact with Earth's atmosphere and produce C-14 is determined by the strength of the geomagnetic field. Fluctuations in the geomagnetic field are to be expected during stabilization following the crustal disruption associated with the Flood. A decrease in the geomagnetic field (increasing the production of C-14), or a lowering of the ocean surface temperature (reducing the amount of atmospheric CO_2), would contribute to an increase in the value of a.

Equation 1 is based on the assumption that the combined effect of all the factors influencing the rate at which the level of C-14 in the atmosphere changed from its pre-Flood value to its post-Flood equilibrium value can be satisfactorily represented by a first-order exponential function with a single exponential constant. To the extent to which this assumption is inadequate and there has been fluctuation of A about a smooth simple exponential trend toward an equilibrium value, there will be uncertainty in a real-time age equivalent based on Equation 1.

The relationship in Equation 1 will be easier to work with if time is measured from the present, rather than from the beginning of the post-Flood era. This is accomplished by setting t = (F-T), with F equal to a biblically based BP date for the Flood, and T representing real time BP, as in Equation 2:

$$A = A_1 [1 - e^{-a(F-T)}].$$

To evaluate the parameter a in Equation 2 we can presume A was equal to or better than $0.9 A_1$ at T equal to 4000, since C-14 ages based on interaction with the atmosphere have a better than 95% agreement

with real-time historical age over the range of T from zero to 3500. To obtain a trial value for a we can set

$$0.95\ A_1 = A_1\ [1 - e^{-a(F - T)}]$$

at T = 4000, which gives

$$e^{-a(F-4000)} = 0.05,$$

or

$$e^{+a(F-4000)} = 20;$$

from which

$$a = 2.996/(F-4000).$$

With this value for a, the activity at T years BP as given by Equation 2 becomes (3):

$$A = A_1\ [1 - e^{-2.996(F-T)\ /\ (F-4000)}].$$

Since we are not making observations at time T, but at the present (T = 0), we need an expression for the activity now (zero BP), A_n, of a specimen that had activity A at T years BP. After T years ago the C-14 activity will have decreased exponentially at the rate given by the mean life of a C-14 atom. For simplification we can use 8300 years for the mean radiocarbon life, since this value differs by less than ½ of 1% from the correct value 8267 (half-life 5730 years divided by the natural logarithm of 2). Accordingly $A_n = A\ e^{-T/8300}$, with A given by Equation 3. Equation 4 is:

$$A_n = A_1\ [1 - e^{-2.996(F-T)\ /\ (F-4000)}]\ e^{-T/8300}.$$

The activity now, A_n, is interpreted to indicate a C-14 age R by the relationship (5):

$$A_n = A_l\ e^{-R/8300}.$$

Combination of Equations 4 and 5 gives Equation 6, a relationship between T and R for a specified F:

$$e^{-R/8300} = e^{-T/8300}\ [1 - e^{-2.996(F-T)\ /\ (F-\ 4000)}].$$

Equation 6 is not useful for values of T within about ten years of a value for F, or values of R greater than about 35,000 years, because A has been inaccurately assumed to be zero for T = F.

QUANTITATIVE CORRELATION BETWEEN BIBLICAL MODEL REAL-TIME AND C-14 AGE

For a treatment that is a median between various views of biblical chronology we can use 5000 years for F (I have already given my reasons for preferring 5350 years to be the "correct" value) to obtain Equation 7:

$$e^{-R/8300} = e^{-T/8300} [1 - e^{-2.996(5000-T)/1000}].$$

For the calculation of relations between R and T Equation 7 may be reduced to either Equation 8 or Equation 9.

$$(8)\ e^{-R/8300} = e^{-T/8300} - (3.121\times10^{-7})\ e^{+2.876T/1000}$$

$$(9)\ R = T + 8300 \ln [1 - e^{-2.996(5000-T)/1000}]^{-1}$$

(ln designates "the natural logarithm of".)

The relationship between R and T for representative values of R is outlined in Table 1. A graphical representation of these data for F = 5000 is given in Figure 1.

FIGURE 1. Conversion plot for Real-Time Age T Versus C-14 Age R. Presumed date for the Flood set at 5000 BP real time.

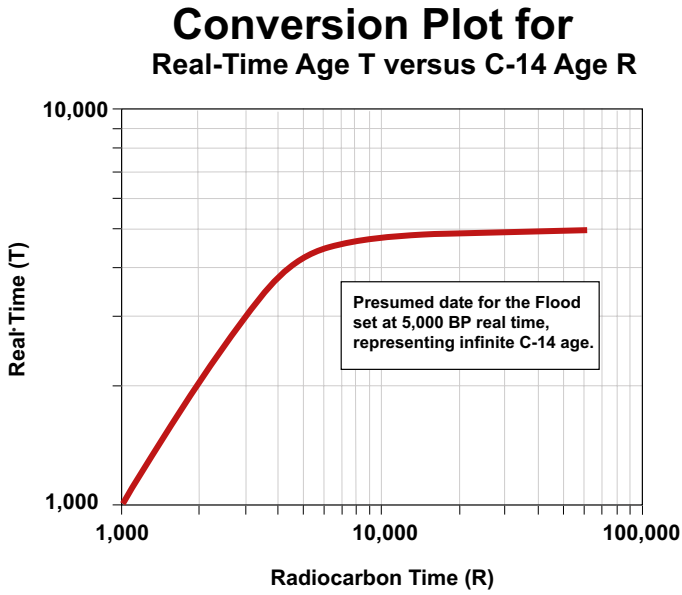

TABLE 1. Representative Values for the Relationship Between Biblical Model Real-Time Age T and Radiocarbon Age R. The R subscript indicates assumed date of the Flood. Estimates of relationship are not warranted for values of T within about ten years of the date for the Flood, or radiocarbon ages greater than about 35,000.

T	$R_{5,500}$	$R_{5,350}$
0	0	0
1,000	1,000	2,000
2,000	2,001	2,005
3,000	3,021	3,045
3,500	3,593	3,638
4,000	4,426	4,426
4,250	5,177	5,006
4,500	6,600	5,865
4,550	7,046	6,091
4,600	7,580	6,342
4,650	8,231	6,622
4,700	9,038	6,938
4,750	10,064	7,295
4,800	11,414	7,702
4,850	13,284	8,170
4,900	16,116	8,713
4,950	21,321	9,352
4,975	26,794	9,715
4,990	34,230	9,949
5,000	(infinite)	10,113
5,100	———	12,186
5,200	———	15,673
5,300	———	24,004
5,340	———	37,038
5,350	———	(infinite)

This conversion between C-14 age and real time resolves the enigma of the 7000±2000 C-14 age difference between hair and muscle for a musk ox carcass that was presumably frozen in Alaskan muck about 17,000 C-14 years ago (Stuckenrath and Mielke 1970). The correlation represented in Equation 7 places death of the animal in the vicinity of 4900 years ago (from C-14 age of hair), and suggests a life span within ten years of 50, rather than in the range between 5000 and 9000. Other examples of similar nature have been presented by the author previously (Brown 1987, 1988a, 1990).

CONCLUSIONS

There appears to be a basis for a quantitative correlation of C-14 ages over the range between zero and the vicinity of 35,000 years BP with real-time ages that are in conformity with biblical guidelines. Because the buildup of C-14 in the biosphere from less than 1/100 to the full zero BP reference standard level over the time between the Flood and about 3500 BP probably did not proceed with monotonous uniformity, some anomalies are to be expected in real-time ages derived from C-14 ages by means of a mathematical model for such correlation. Since the buildup of C-14 from levels associated with C-14 ages in the mid-40,000 years range to levels associated with a C-14 age of about 35,000 years evidently occurred over only a few years of real time, correlation with real-time for C-14 ages greater than 35,000 is highly uncertain. For C-14 ages in the range between 4000 and 30,000 years the associated real-time age probably may be significantly placed within a range of less than ±100 years.

It is the hope of the author that this treatment will contribute to confidence in the biblical chronological data, and increase the effectiveness with which that data may be utilized in scientific research.

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