

RADIOCARBON DATING AND THE DEAD SEA SCROLLS: A COMMENT ON “REDATING”

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Introduction

Radiocarbon (^{14}C) dates for the Dead Sea Scrolls have been measured by three independent ^{14}C laboratories in the 1990's.¹ Recently, a critical treatise concerning the dating of the scrolls has been published in this journal: Atwill et al., “Redating the Radiocarbon Dating of the Dead Sea Scrolls.”² The critique of the authors is based on a comparison of palaeographic dates with calibrated ^{14}C dates. Their conclusion is that an “inaccurate dating curve” was utilized, and that the interpretation of the ^{14}C dates was “inaccurate from a purely statistical point of view.”

However, here it is shown that this conclusion is wrong and unjustified. It is based on an incorrect understanding of statistical processes underlying the principles of ^{14}C dating, the calibration of ^{14}C dates, and their interpretation. In addition, “Redating the Dating” exhibits major mathematical deficiencies to the point that the argument used by the authors backfires: it is *this* article that uses the wrong mathematics. The interpretation of the texts and other discussions concerning the scrolls are outside of the expertise of the author, and are therefore not discussed here. This comment solely concerns ^{14}C related matters.

¹ G. Bonani, S. Ivy, W. Wölfli, M. Broshi, I. Carmi, and J. Strugnell, “Radiocarbon dating of fourteen Dead Sea Scrolls,” *Radiocarbon* 34 (1992) 843–49; A.J.T. Jull, D.J. Donahue, M. Broshi, and E. Tov, “Radiocarbon dating of scrolls and linen fragments from the Judean desert,” *Radiocarbon* 37 (1995) 11–19. Only 3 samples were submitted to the Oxford ^{14}C laboratory, but no ^{14}C measurements were produced.

² J. Atwill, S. Braunheim, and R. Eisenman, “Redating the Radiocarbon Dating of the Dead Sea Scrolls,” *DSD* 11 (2004) 143–157.

In what follows, first the principles of the ^{14}C method are briefly summarized, as well as procedures, conventions and calibration of the ^{14}C dates into historical ages. Then the “redating” treatise of the ^{14}C dates of the Dead Sea Scrolls will be discussed.

The ^{14}C Dating Method

Radiocarbon dating is based on the decay of the radioactive isotope of the element carbon ^{14}C , which occurs in minute concentrations in nature—including organisms like plants, animals and people. It is produced in the atmosphere by cosmic radiation, oxidizes to $^{14}\text{CO}_2$ and enters the biosphere through plants via photosynthesis. An equilibrium exists between uptake and decay of ^{14}C . After an organism dies, the ^{14}C concentration in the remains decreases. This forms the basic principle of the radiocarbon dating method: by measuring the remaining ^{14}C concentration in a sample, the sample can be dated. A more detailed account of the method may be found in the standard textbooks.³

Although the principle of the method is rather straightforward, in practice there are many complications and pitfalls. These are largely understood by isotope scientists but can easily create misunderstanding between ^{14}C experts and, e.g., archaeologists. The main complications to the simple theoretical principle described above are: 1) The ^{14}C content in nature is not constant, but rather varying in time; 2) the decay half-life of ^{14}C is not known exactly; 3) mass dependent effects in natural processes (so-called isotopic fractionation) change the ^{14}C content in materials, and thus the age. For this reason, the international ^{14}C community has agreed to a convention to deal with these complicating matters. The convention is that the ^{14}C content of samples is measured relative to a standard radioactivity; a conventional (not necessarily exact) half-life value is used to calculate ^{14}C ages; fractionation effects are corrected for (this is possible using the stable isotope ^{13}C). The ^{14}C ages thus calculated from the measurement are expressed in the unit BP. The standard radioactivity corresponds to the natural level of 1950. The original meaning of BP is “Before Present”

³ E.g., R.E. Taylor and M.J. Aitkin, eds, *Chronometric Dating in Archaeology* (New York: Plenum, 1997); C. Tuniz, J.R. Bird, D. Fink, and G.F. Herzog, *Accelerator Mass Spectrometry: Ultrasensitive Analysis for Global Science* (Boca Raton, FL: CRC, 1998).

so that “Present” corresponds to 1950—admittedly a confusing term. For more technical details we refer the reader to the specialized literature.⁴

Thus, the ¹⁴C timescale is a defined timescale; it is not a calendar timescale. The ¹⁴C clock is out of pace (and a varying pace at that) with the calendar. Nevertheless, the ¹⁴C dating method is a good and reliable dating method because the varying clock rate is known. The two timescales, ¹⁴C and calendar, can be connected by measuring ¹⁴C from wood samples which are absolutely dated by dendrochronology. Measurements for many hundreds of tree-ring samples together form the radiocarbon calibration curve—a plot showing the natural variations of ¹⁴C, and which forms the relation between the BP and calendar timescales. The presently recommended calibration curve is called *intcal98*,⁵ to be replaced by *intcal04* soon.⁶ A small part of the calibration curve *intcal98*, relevant for the discussion here, is shown in Figure 1. As can be seen, the curve is “wiggly” due to solar variations which influence the cosmic ray flux impinging on earth, and thus also influence the ¹⁴C production rate.⁷ Figure 1 shows the calibration datapoints with (1σ) errors, as obtained from paired ¹⁴C/dendrochronology measurements, as well as a curve drawn through these datapoints which are decadal (10 year resolution). As an illustrative example, we calibrate the ¹⁴C date 2054 ± 22 BP. This is the ¹⁴C date for the sample 1QpHab (Habakuk Peshier from cave 1), as measured by the Arizona laboratory (AA-13417).⁸

Figure 1 shows two probability distributions. First, along the vertical axis, the probability distribution corresponding to the measurement

⁴ W.G. Mook and H.T. Waterbolk, *Handbook for Archaeologists. No. 3. Radiocarbon Dating* (Strasbourg: European Science Foundation, 1985); W.G. Mook and J. van der Plicht, “Reporting ¹⁴C activities and concentrations”, *Radiocarbon* 41 (1999) 227–39.

⁵ M. Stuiver, P.J. Reimer, E. Bard, J.W. Beck, G.S. Burr, K.A. Hughen, B. Kromer, F.G. McCormac, J. van der Plicht, and M. Spurk, “INTCAL98 Radiocarbon Age Calibration,” *Radiocarbon* 40 (1998) 1041–1083.

⁶ P.J. Reimer, K.A. Hughen, M.G.L. Baillie, E. Bard, J.W. Beck, C.E. Buck, K. Cutler, P.E. Damon, M. Friedrich, T.P. Guilderson, B. Kromer, F.G. McCormac, C. Bronk Ramsey, R.W. Reimer, S. Remmele, J.R. Southon, M. Stuiver, J. van der Plicht, and C.E. Weyhenmeyer, “Intcal04 terrestrial Radiocarbon age calibration, 0–26 cal kyr BP,” *Radiocarbon* 46 (2004), 1029–58.

⁷ H.E. Suess, “The three causes of secular ¹⁴C fluctuations, their amplitudes and time constants” *Radiocarbon Variations and Absolute Chronology* (ed. I.U. Olsson; Nobel Symposium 12; New York: Wiley Interscience Division, 1970), 595–605.

⁸ Jull, Donahue, Broshi, and Tov, “Radiocarbon dating of scrolls and linen fragments.”

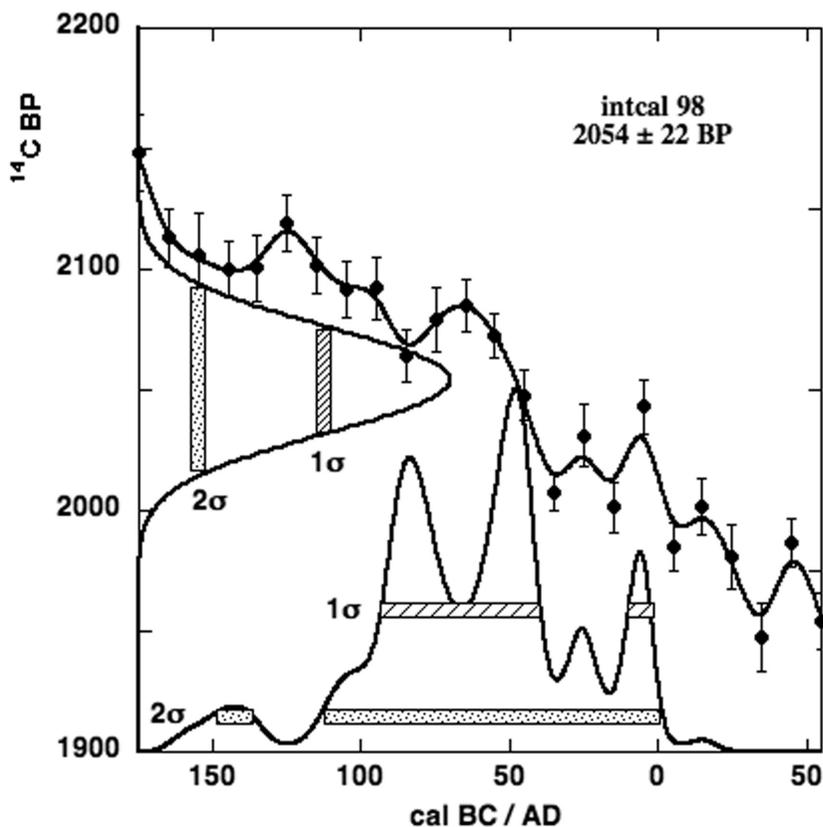


Figure 1. Calibration of the ^{14}C age 2054 ± 22 BP. The graph shows the calibration curve connecting the calibration datapoints, the Gaussian probability distribution corresponding to the ^{14}C measurement (vertical), and the calibrated calendar age probability distribution (horizontal). The 1σ and 2σ confidence intervals are indicated.

2054 ± 22 BP is plotted. This is a so-called Gaussian, which represents the probability distribution of data around the mean value. The deviations from the average value (in this case, 2054 BP) are given in terms of the standard deviation σ . The meaning of this term is that the probability of observing values between $2054 + \sigma$ and $2054 - \sigma$ is 68.3%, and between $2054 + 2\sigma$ and $2054 - 2\sigma$ is 95.4%.

Along the horizontal axis, the calibrated probability distribution is plotted. This distribution no longer has a Gaussian shape (it would be Gaussian only in the case that the calibration curve would be a straight line). As can be seen, the distribution has a complex shape

due to the “wiggles” in the calibration curve. In theory, one ^{14}C date can correspond to several calendar ages. Computer programs are needed to calculate the errors in terms of confidence levels. The calibration plot shown here is generated using the Groningen calibration program,⁹ updated with the latest datasets. The program calculates the 1σ and 2σ confidence intervals for the calibrated probability distribution, corresponding to 68.3 and 95.4% probability, respectively. These confidence levels are indicated as horizontal bars in the figure. This means that for these date ranges, the area under the probability distribution curve is 68.3 or 95.4% of the total area, which corresponds to 100% probability. For the ^{14}C date of 2054 ± 22 BP, the 1σ calibrated age range thus determined is 95–40 and 10–1 cal BC; the 2σ calibrated age range is 150–135 and 115–1 cal BC. We use here the convention¹⁰ “cal BC” or “cal AD” for calibrated ^{14}C ages and have rounded the numbers to the nearest 5. Note that the 1σ range for the calibrated dates is larger than for the (not calibrated) ^{14}C date; the ^{14}C date has a 1σ error of only 22 BP which is a rather good precision for ^{14}C dating. The calibration curve in this time range happens to make the dating method relatively imprecise.

“Redating” the Scrolls: Calibration and the “Amount of Error”

Atwill, et al.,¹¹ use calibrated ^{14}C dates and compare these with palaeographic dates, and calculate the “amount of error.” Furthermore, it is stated that an “inaccurate dating curve” was used in the publications concerning ^{14}C dating of the Dead Sea Scrolls.¹² What is meant here is “inaccurate calibration curve.” Here it is argued, that this “amount of error” cannot be used as a measure of the difference between ^{14}C dates and palaeographic dates, and that the conclusion concerning the “inaccurate dating curve” is not relevant.

In Figure 1 we have illustrated the calibration of the ^{14}C date for sample 1QpHab, 2054 ± 22 BP. The calibrated age range is 95–40

⁹ J. van der Plicht, “The Groningen Radiocarbon Calibration Program,” *Radiocarbon* 35 (1993), 231–237.

¹⁰ W.G. Mook, “Business meeting: recommendations/resolutions adapted by the twelfth International Radiocarbon Conference,” *Radiocarbon* 28 (1986) 799.

¹¹ “Redating the Radiocarbon Dating of the Dead Sea Scrolls,” *DSD* 11.

¹² That is, in Bonani, et al., “Radiocarbon dating of fourteen Dead Sea Scrolls,” and in Jull, et al., “Radiocarbon dating of scrolls and linen fragments.”

and 10–1 cal BC. This is the 1σ range, formally the 68.3% confidence level. The 2σ confidence level is 150–135 and 115–1 cal BC (the numbers are rounded to the nearest 5).

In Atwill et al. this is the second sample from their table.¹³ Here the calibrated age range is listed as 88–2 BC. This is almost the same range as the 1σ range we deduced (Figure 1); the numbers are not exactly the same because of minor differences in calibration curve handling, which will be discussed below. So we agree that the calibrated age range covers (almost) the first century BC. This is a 100% perfect overlap with the palaeographic date range which is 30–1 BC. Statistically there is *no* difference between both age determinations of this particular Dead Sea Scroll. Atwill et al. state a difference of 30 years by comparing the average values of the ranges 88–2 and 30–1 BC. This value of 30 years is called the “amount of error.” However, from the ^{14}C point of view, the whole range has a probability—the true date can be e.g. 75 cal BC, 5 cal BC, or another value within the range with a probability as indicated by the distribution shown in Figure 1. The average value, or median of the calibrated range should not be used. This is more clearly demonstrated in illustrative calibration examples:¹⁴ one ^{14}C date can result in two separated calibrated ages, such that the median has no probability.

The fact that there is no difference between ^{14}C and palaeography is not only true for the sample used above as an illustrative example, 1QpHab. Atwill et al. list in the same table 10 samples for which the calibrated ^{14}C dates are compared with palaeographic dates. For these 10, the 7 samples 1QpHab, 1QS, 4Q521, 4Q267, 4Q22, 4Q2 and 1QIs all have an overlapping range at the 2σ confidence level, some (1QpHab, 1QS, 4Q22, 4Q2) even show perfect overlap—the palaeographic age range falls completely within the calibrated ^{14}C age range as stated in the table. The other 3 samples—4Q266, 4Q258 and 4Q208—do not overlap at the 2σ level, but only barely so.

In addition, the same table in Atwill et al. (146–147) quotes the calibrated age ranges in 2σ from the Arizona publication obtained using the 1986 calibration curve¹⁵—with exception of the sample 1QpHab, where the 1993 (or 1998, which is not clear) calibration curve has

¹³ “Redating the Radiocarbon Dating of the Dead Sea Scrolls,” 146.

¹⁴ J. van der Plicht and W.G. Mook, “Automatic Radiocarbon Calibration: illustrative examples,” *Palaeohistoria* 29 (1987), 173–182.

¹⁵ Jull, et al., “Radiocarbon dating of scrolls and linen fragments.”

been used. This is comparing apples with oranges because the “amount of error” is calculated from these numbers. In order to be consistent, the quoted calibrated age range should have been 120–5 BC, making the “amount of error” larger by 15 years.

To summarize, from the ^{14}C point of view, no significant offset between the palaeographic dates and the calibrated ^{14}C dates are observed for at least 7 of the 10 dates listed. The whole situation is perhaps best illustrated for the scroll 1QIs: the quoted age ranges are 356–103 BC for ^{14}C , and 150–125 BC for palaeography. These age ranges are in perfect agreement, but nevertheless the “amount of error” calculated by Atwill et al. is 97 years—which is practically a century of difference in dating. Not only that, but the calibration here yields two 2σ ranges: 356–291 and 250–103 BC², which are conveniently taken together by Atwill et al. There is (almost) no probability between 291 and 250 cal BC. The “median concept” for calibrated ranges should not be used, and the “amount of error” used this way is a meaningless concept.

Various Calibration Curves

In our example shown in Figure 1, calibration of the ^{14}C date for the sample 1QpHab, the calibration curve intcal98 is used. The issue of calibration curves has a history by itself. During the last two decades, various calibration curves have been published by the journal *Radiocarbon*. The first data were recommended for calibration at the 12th International Radiocarbon Conference in Trondheim, and published in the first special calibration issue of the journal.¹⁶ This is the so-called “1986 dataset,” with a bi-decadal resolution (wood sections with an age range of 20 years have been used) going back to 2500 cal BC. By the year 1993, a wealth of much needed new calibration had become available, and it was decided to issue a new special calibration issue.¹⁷ The calibration data were extended to 6000 cal BC, and

¹⁶ M. Stuiver and G.W. Pearson, “High-precision calibration of the Radiocarbon timescale, AD 1950–500 BC,” *Radiocarbon* 28 (1986) 805–838; G.W. Pearson, and M. Stuiver, “High-precision calibration of the Radiocarbon timescale, 500–2500 BC,” *Radiocarbon* 28 (1986) 839–862.

¹⁷ G.W. Pearson, and M. Stuiver, “High-precision bi-decadal calibration of the Radiocarbon timescale, 500–2500 BC,” *Radiocarbon* 35 (1993) 25–33; M. Stuiver, and G.W. Pearson, “High-precision bi-decadal calibration of the Radiocarbon timescale, AD 1950–500 BC and 2500–6000 BC,” *Radiocarbon* 35 (1993) 1–23.

corrections to the previous data were applied. This forms the “1993 dataset”. History repeated two more times; special calibration issues were published in 1998¹⁸ and 2004.¹⁹ Dendrochronology has kept extending so that it now covers the complete Holocene; beyond the tree ring limit, paired ¹⁴C/U-series dating on corals and layered sediments extends the ¹⁴C calibration curve now back to 26,000 years ago. Through the datapoints, calibration curves are constructed with a decadal resolution: intcal98 and intcal04. These are the “1998 dataset” and “2004 dataset.” Both intcal98 and intcal04 were recommended for use at the 16th and 18th International Radiocarbon Conferences in Groningen and Wellington, respectively.

The main reason for new calibration curve releases is the growth of data, extending the age ranges which can be calibrated dramatically. In addition, corrections are necessary when mistakes are discovered in data previously released. Such errors and subsequent corrections were made both in dendrochronology and ¹⁴C, and are relatively minor considering the 1 σ errors in the usual ¹⁴C dates.

The most publicised correction, also referred to by Atwill et al., concerns the 1993 dataset. This dataset includes an instrumental correction of 18 ¹⁴C years to the 1986 dataset. Later on, this correction was questioned using special high precision studies.²⁰ But it was also stressed that the corrections are very small (about 0.2%), and therefore in general not detrimental in terms of archaeological utility of ¹⁴C dates.²¹ This is the reason many researchers kept using the “1986 dataset” instead of the “1993 dataset.” In addition, there was a formal reason: the “1986 dataset” had been recommended by the international ¹⁴C community for general use, whereas the “1993 dataset” had not been.

For the period 250 cal BC–250 cal AD, the four calibration datasets (1986, 1993, 1998, 2004) are compared in Figure 2. As can be seen, the differences between the four datasets are not very significant for purposes of calibrating archaeological ¹⁴C dates.

¹⁸ Stuiver, et al., “INTCAL98 Radiocarbon Age Calibration.”

¹⁹ Reimer, et al., “Extension and revision of the radiocarbon calibration dataset: part 1. IntCal04 12.4–0 ka calBP.”

²⁰ J. van der Plicht and F.G. McCormac, “A note on Calibration Curves,” *Radiocarbon* 37 (1995) 963–64; J. van der Plicht, E. Jansma, and H. Kars, “The Amsterdam Castle. A Case Study of Wiggle Matching and the Proper Calibration Curve,” *Radiocarbon* 37 (1995), 965–68.

²¹ Van der Plicht and McCormac, “A note on Calibration Curves.”

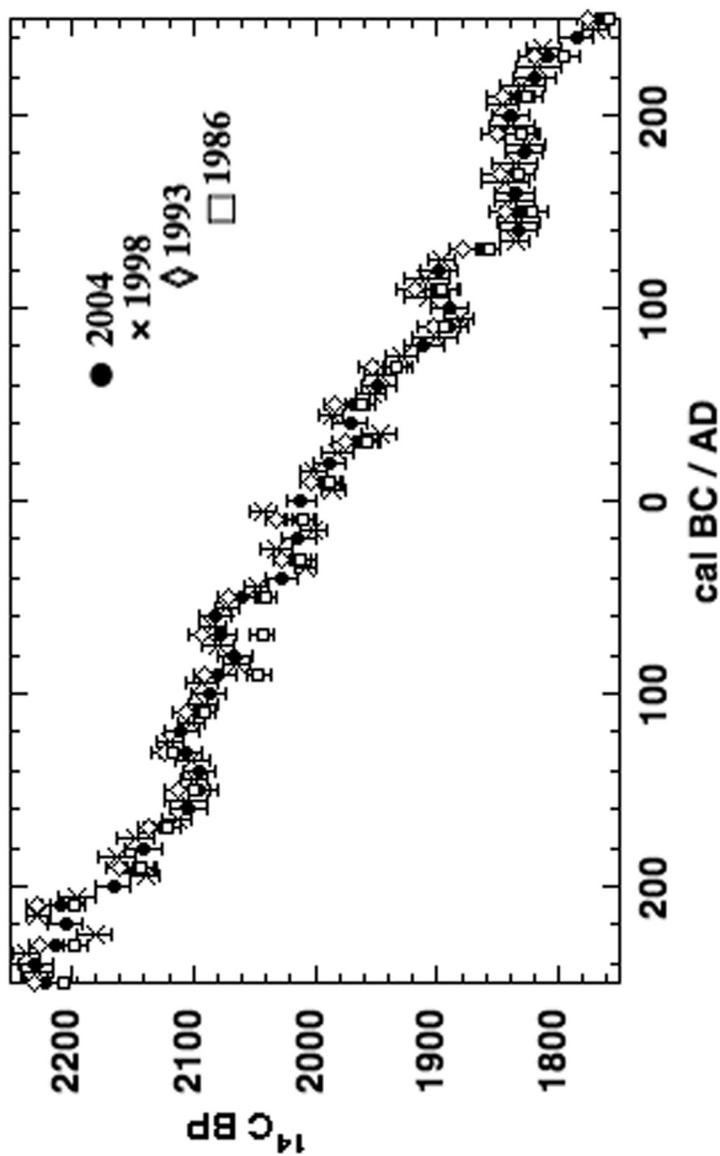


Figure 2. Calibration datasets from ^{14}C measurements of dendrochronologically dated wood, published by the journal *Radiocarbon* in 1986, 1993, 1998 and 2004. Only data for the time period 250 BC–250 AD are plotted.

Atwill et al. criticize the use of the 1986 data for calibration, calling this dataset an “inaccurate dating curve” because there are newer datasets available (1993 and 1998). Above is explained why 1986 had preference to 1993; the 1998 data could not have been used simply because the publications from Arizona and Zürich date from 1995 and 1992. Hence, the statement by Atwill et al. on “inexact pre-1993 and 1998 calibration curves” is not correct. Admittedly, there has been a time with room for confusion concerning the issue of 1986 vs. 1993. Nevertheless, the effect is exaggerated by Atwill et al. (“great rejuvenation”). The authors themselves made a composition table (p. 150); in some cases there is a rejuvenation effect, for other samples there is not, depending on where exactly we are on the calibration curve. In general, the differences are not dramatic (as is illustrated in Figure 2), and are factors smaller than the obvious errors introduced by using their “amount of error” concept.

Note that calibrated age ranges (1σ and/or 2σ) may have minor differences, depending on the manner of calculation. Various computer programs have been developed for calculating calibrated age ranges. They all operate using the same statistical procedures, but differences are introduced by, for example, rounding off numbers and resolution differences. Also, different ways exist to construct curves through the datapoints; for example, they can be drawn going exactly through the calibration datapoints, or may have different ways of “smoothing.” One can fit the data using spline functions or polynomials. There is no unique solution or recommendation for these effects. Overall, this is not significant because the differences are negligible, usually within a decade. The present calibration dataset itself is decadal anyway. Most calibration programs have been tested, compared and approved.²²

Calculation of Age Differences

Apart from the “amount of error” concept shown to be incorrect, there is another serious error made by Atwill et al. For the sake of argument, let us take the “amount of error” as shown in the table as a correct number. There are positive numbers, corresponding to palaeo-

²² T.C. Aitchison, M. Leese, D.J. Mychczynska, W.G. Mook, R.L. Otlet, B.S. Ottaway, M.F. Pazdur, J. van der Plicht, P.J. Reimer, S.W. Robinson, M. Stuiver, and B. Weninger, “A comparison of methods used for calibration of Radiocarbon dates,” *Radiocarbon* 31 (1989) 846–62.

graphic dates that are older than the calibrated ^{14}C dates; and there are negative numbers, corresponding to palaeographic dates that are younger than the calibrated ^{14}C dates.

Next, the “amount of error” numbers are averaged, resulting in an average number of 66 years. This however must be the result of a wrong calculation: the averaged number of the “amounts of error” from the table is 16 years. This is a rather small number, much smaller than the authors have obtained. I suspect the authors ignored the minus signs of their “amount of error”; calculating the average from the absolute values indeed yields a number of 66 years.

Incidentally, there is an error in the table for sample 4Q267; the calibrated age range should read 194–45 instead of 94–45 BC, quoting the Arizona numbers.²³ And the “apples and oranges” argument should be repeated here for sample 1QpHab: the calibrated age range used here is different from the other samples. In conclusion, the “amount of error” concept, even if it were a useful concept, is applied wrongly because of basic calculation mistakes.

Other Remarks

The ^{14}C dating method is a proven dating method, with applications in many fields of science. But the measuring techniques are complex, and the resolution is finite; in particular when the calibration curve has an unfortunate shape for a certain time range, so that even precise ^{14}C measurements yield an imprecise calendar date range, or even multiple ranges. Therefore, the use of ^{14}C in historical periods has always been limited. Only in exceptional cases (pre)historical questions can be solved within a century.²⁴

Nevertheless the ^{14}C dating is a yardstick measuring time. When comparing (calibrated) ^{14}C dates with dates acquired from another independent method, they should be in agreement. Atwill et al. claim that the ^{14}C dates of the Dead Sea Scrolls do not demonstrate the reliability of palaeography. It is shown here, however, that this conclusion is based on a wrong interpretation of the available dataset of ^{14}C dates. When two dating methods produce different results, then at least one of them must be wrong. It is of course possible for a ^{14}C date to

²³ Jull, et al., “Radiocarbon dating of scrolls and linen fragments.”

²⁴ H.J. Bruins, J. van der Plicht, and A. Mazar, “ ^{14}C dates from Tel Rehov: Iron Age Chronology, Pharaohs and Hebrew Kings,” *Science* 300 (2003) 315–18.

be wrong, or better: not yield the expected result. There can be many reasons for this. Two of the most common reasons are: contamination with foreign carbon containing material, or a wrongly assumed relation between the “ ^{14}C event” and the “archaeological event.” This is perhaps the case with the sample “Kefar Bebayou” which Atwill et al. consider “off the board,” and requires further investigation.

Towards the end of their paper, it is argued that the errors for the ^{14}C dates should be increased (figure on p. 154). This is at best confusing, and not as straightforward as it seems based on common laboratory practice. For AMS dates, the measurement error depends on factors like the spread in the ^{14}C activity measurements of the standards, backgrounds, control samples as well as its ^{13}C values, and requires complex computational algorithms. The measurement error is given as the standard deviation (σ), which is a quantity indicating the probability range of the measured ^{14}C date, as explained above. Reproducibility is controlled by several factors, such as known-age control samples which are routinely measured for many AMS runs and thus should give the same result, time and again. In addition, there are blind tests or inter-comparisons between the laboratories which are a check for both reproducibility and systematic errors in the laboratory.²⁵ And finally, there is the possibility for multiple measurements. Duplicate or triplicate analysis for selected samples is a very good reproducibility test, yielding information on matters like inhomogeneity of the sample material, which are otherwise difficult to control. When the results overlap within 1σ , the multiple measurements can be averaged *reducing* the final error of the ^{14}C date. However, this requires a lot of effort and is only done in exceptional cases.²⁶

There seems to be a suggestion that the ^{14}C dating method can not be fully trusted. First, from the title of the article: “Redating the Radiocarbon Dating. . .” Furthermore, the article discusses ^{14}C dates

²⁵ E.M. Scott, C. Bryant, I. Carmi, G. Cook, S. Gulliksen, D. Harkness, J. Heinemeier, E. McGee, P. Naysmith, G. Possnert, J. van der Plicht, M. van Strijdonck, “Precision and accuracy in applied ^{14}C dating: some findings from the 4th International Radiocarbon Comparison,” *Journal of Archaeological Science* 31 (2004) 1209–1213; E. Boaretto, C. Bryant, I. Carmi, G. Cook, S. Gulliksen, D. Harkness, J. Heinemeier, J. McClure, E. McGee, P. Naysmith, G. Possnert, M. Scott, J. van der Plicht, M. van Strijdonck, “A report on the 4th International Radiocarbon Comparison FIRI (1998–2001),” *Antiquity* 295 (2003) 146–54.

²⁶ Bruins, et al., “ ^{14}C dates from Tel Rehov: Iron Age Chronology, Pharaohs and Hebrew Kings.”

measured by the laboratories at Oxford, Zürich and Tucson: “not incuriously, these were the same laboratories that had previously been selected for the C14 testing of the Holy Shroud of Turin.” This is not a very scientific statement: it is not related at all to the subject of the paper, i.e. the Dead Sea Scrolls. In addition, the Dead Sea Scrolls were only ^{14}C dated by Zürich and Tucson, and not by Oxford. At present, there are many AMS laboratories worldwide, providing the community with many thousands of ^{14}C dates annually.²⁷ Twenty years ago, however, only a handful of AMS facilities existed which specialized in ^{14}C and archaeology—including the laboratories mentioned here. And of course these were used for spectacular dating projects after the AMS technology had been introduced and matured as a significant dating tool—projects like the Shroud of Turin, the Dead Sea Scrolls, and many others in and out of archaeology. Dating such samples using the ^{14}C yardstick-in-time simply was not possible before. All the ^{14}C laboratories repeatedly check themselves against each other in intercomparison exercises.²⁸ We do not have an agenda, except providing the best possible ^{14}C measurements to the community.

²⁷ See www.radiocarbon.org for a complete list of ^{14}C laboratories.

²⁸ Scott, et al., “Precision and accuracy in applied ^{14}C dating;” Boaretto, et al., “A report on the 4th International Radiocarbon Comparison FIRI (1998–2001).”