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Chapter Six

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With permission from Jean-Baptiste Humbert (EBAF), Mireille Bélis (EBAF), and Orit Shamir (IAA), a batch of new radiocarbon tests were run in 2015 and 2016 to determine the dates of items from Cave 11Q. Samples were chosen and cut by Naama Sukenik at the IAA Organic Materials Unit, in collaboration with Joan Taylor of King's College London.[1] The tests were run at the Center for Isotope Research, Groningen University, under the supervision of Johannes van der Plicht, with a prior examination for chemical characteristics done under the supervision of Kaare Lund Rasmussen, Department of Physics, Chemistry and Pharmacy at the University of Southern Denmark. Additionally, with permission from Martin Schøyen, a sample from the Temple Scroll (11Q19) wrapper was acquired from the Schøyen Collection, Norway, and this was by agreement published initially in a volume dedicated to objects within this archive.[2] Funding was obtained from King's College London, Department of Theology and Religious Studies, supplemented by the Leverhulme International Network for Dispersed Qumran Caves Artefacts and Archives (a partnership between Joan E. Taylor, Marcello Fidanzio and Dennis Mizzi).

1. 11Q Samples

In Cave 11Q a large number of pieces of linen were discovered, in quite good condition. These linen fragments are now conserved in the holdings of the IAA's Organic Materials Unit, Jerusalem. Some of these have blue lines associated with scroll wrappers, while some may be from jar covers, or from packing pieces. It was not absolutely clear that all these should be dated to the Roman period. For example, it was noted that one of these pieces (Gr11Q132, IAA 577293) is unusual in that it has a kind of mending which is very rare in the ~~Land of Israel~~ during the Roman period and has been found in only one imported textile wrapper from Masada.[3] This mending, using two sewing threads, often ignores the warp and weft direction.[4]

1. We are grateful also to Gregory Doudna for his comments on a draft of this paper.

2. J.E. Taylor and J. van der Plicht, "Radiocarbon Dating of the Temple Scroll Wrapper and Cave 11Q," in T. Elgvin, K. Davis, and M. Langlois (ed.), *Gleanings from the Caves: Dead Sea Scrolls and Artefacts from The Schøyen Collection* (LSTS 71; London: Bloomsbury T&T Clark, 2016) 351-6.

3. A. Sheffer and H. Granger-Taylor, "Textiles from Masada: A Preliminary Selection," in J. Aviram, G. Foerster, and E. Netzer (ed.), *Masada IV: The Yigael Yadin Excavations 1963-1965: Final Reports* (Jerusalem: Israel Exploration Society/ Hebrew University, 1994) 149-256, on pp. 223-5.

4. F. Letellier-Willemin, "The Long and Narrow Sleeved Tunic

Six 11Q linen samples were taken for analysis (see Table 1), including the piece (Gr11Q132) that was thought might indicate a later period of occupation. They are as follows:

1. Bundle of strings (Gr11Q183, IAA 577250) that are tied together. The fibres have been identified as flax (*Linum usitatissimum L.*). The string made with two S–spun (clockwise direction) threads in Z ply (s2Z). The colour of the strings is very white and this probably indicates bleaching.

2. Fragment of textile (Gr11Q119, IAA 577264). Measurements: 12.5 cm x 10 cm. The fibres have been identified as flax (*Linum usitatissimum L.*) and the threads (warp and weft) were made in S-spun (clockwise direction) in tabby weaving. The colour of the textile is beige-white and this probably indicates bleaching. A few unidentified grey and purple stains were observed.[5]

3. Fragment of beige textile (Gr11Q132, IAA 577293). Measurements: 21.5 cm x 9 cm. The fibres have been identified as flax (*Linum usitatissimum L.*) and the threads (warp and weft) were made in S-spun (clockwise direction) in weft faced weaving, with warp predominating. In two places it has mending.

4. Fragment of textile (Gr11Q107, IAA 577252). Measurements: 6 cm x 4 cm. It is cut fabric in a square shape. The fibres have been identified as flax (*Linum usitatissimum L.*) and the threads (warp and weft) were made in S-spun (clockwise direction) in tabby weave. The textile is decorated with a faded blue band, composed of three rows of weft threads (as for example textile no. 43 from Cave 1Q[6]). The color of the textile is beige-white and this probably indicates bleaching.

5. Fragment of textile (Gr11Q76, IAA 577220). Measurements: 4 cm x 1.5cm. The fibres have been identified as flax (*Linum usitatissimum L.*) and the threads (warp and weft) were made in S-spun (clockwise direction) in tabby weave. The colour of the textile is very white and this probably indicates bleaching.

6. Fragment of linen textile (Gr11Q101, IAA 577245). Measurements: 7 cm x 3.8 cm. The fibres have been identified as flax (*Linum usitatissimum L.*) and the threads (warp and weft) were made in S-spun (clockwise direction) in tabby weave. The textile has a crowded selvedge that is made of warp threads without any special reinforcement. The colour of the textile is very white and this probably indicates bleaching.

In addition, there was one further sample included in the batch:

7. A piece of linen (IAA 585785) from the Christmas Cave, in the Wadi en-Nar (Kidron). From the splicing technique of the textile[7] it appears that this textile comes from the Chalcolithic/Early Bronze period. It was thought to be important because it could provide a more accurate dating within this period, and could function as an interesting comparison to the 11Q linen.

Samples (10, 11) were previously taken of objects Gr11Q9/1 (464628) and Gr11Q9/2 (464629)[8] and a further sample of linen string from Gr11Q9/1 (8) was tested to ensure there was no error. As noted, a sample was also previously taken of the Temple Scroll wrapper in the Schøyen collection (MS 5095/1) and published elsewhere,[9] and this is included in Table 1 for completeness.

of the Mummy W14 of El Deir," ," in A. de Moor, C. Fluck, and P. Linscheid (ed.), *Textiles, Tools and Techniques of the 1st Millennium AD from Egypt and Neighbouring Countries: Proceedings of the 8th Conference of the Research Group 'Textiles from the Nile Valley': Antwerp, 4th-6th October 2013* (Tielt: Lannoo Publishers, 2015), 26-37, on p. 32.

5. For similar stains see M. Bélis, "The Unpublished Textiles from the Qumran Caves," in M. Fidanzio (ed.), *The Caves of Qumran: Proceedings of the International Conference, Lugano 2014* (STDJ 118; Leiden: Brill 2016) 123-36, on p. 133.

6. G.M. Crowfoot, "The Linen Textiles," in D. Barthélemy and J.T. Milik, *Qumran Cave 1* (DJD 1; Oxford: Clarendon, 1955) 18-38, on p. 35.

7. See O. Shamir, "Textiles from the Chalcolithic Period, Early and Middle Bronze Age in the Southern Levant - The Continuation of Splicing," *ATR* 57 (2015) 12-25, on p. 17, Fig. 6.

8. See J. Taylor, "Organic Items from Cave 11Q: B. Gr11Q9/1 and 2," in this volume.

9. Taylor and van der Plicht, "Radiocarbon Dating."

In terms of ~~the~~ any possible contamination of the linen samples, IAA conservator Raia Viniski explained that the linen from Cave 11Q did not require extensive cleaning, which is significant in a cave that was accessible to bats and covered in bat guano, since it cannot then have been covered with dung and substance. Some textiles were dirty with soil and dust (perhaps from the Bedouin excavations), but not dung. This is different to the condition of linen found in Cave 1Q which reportedly was quite smelly and dirty, having been sometimes found under a thick layer of dung.[10] It is therefore unlikely that the 11Q textiles were exposed to the open cave environment for very long. Either they were protected below rockfall or they were pieces removed from jars and strewn in the cave as a result of the Bedouin's activities prior to the arrival of the archaeologists. The textiles required merely light cleaning (only with alcohol, as verified by Dr. Viniksi) and this good condition makes them particularly useful for radiocarbon dating.

2. Pre-testing of the Samples

The samples were all tested prior to radiocarbon treatment by Py-GC-MS in the search for conservational fluids or other modern contaminants. No contaminants were found. A second check of the possible presence of contaminants is tracing by the stable isotope of Carbon, ^{13}C (see next paragraph). These δ^{13}C values are all within the expected range.

3. The Radiocarbon Dating of the Samples

Dating by Radiocarbon (^{14}C) of organic samples provides a measure of time, to be more precise: the moment of death of the organism. Successful dating depends on the samples being cleaned thoroughly because they may contain foreign carbon with a different ^{14}C content, such as carbonate, humic substances and/or plant remains, and preservatives as applied in e.g. museums. These components must be removed in order to obtain the correct radiocarbon age of the organic material itself. Standard procedures for the chemical pretreatment of samples have been developed and are applied by all ^{14}C laboratories.[11]

The standard treatment of samples consists of the following steps: (i) Acid (HCl) in order to remove soil carbonate and possibly infiltrated humic acids; (ii) Alkali (NaOH) to remove e.g. soil humates; (iii) Acid (HCl) to remove any atmospheric CO_2 absorbed during step (ii). This pretreatment is referred to as the "AAA" (Acid-Alkali-Acid) treatment.

The pretreated and purified sample fraction is combusted into CO_2 gas using an Elemental Analyser, coupled to an Isotope Ratio Mass Spectrometer (IsoCube/IsoPrime). This EA/IRMS also provides the stable Carbon isotope value δ^{13}C. This is given as so-called delta-values, or δ^{13}C, defined as the deviation of the $^{13}C/^{12}C$ ratio from that of a standard material, expressed in permil.[12]

For ^{14}C analysis, part of the CO_2 is routed to a cryogenic trap to collect the samples for further processing. The CO_2 is transformed into graphite powder by the reaction $CO_2 + 2H_2 \rightarrow 2H_2O + C$ at a temperature of 600°C and using Fe powder as catalyst.[13]

Next, the graphite is pressed into target holders for the ion source of the AMS (Accelerator Mass Spectrometer). The Groningen AMS is based on a 2.5 MV particle accelerator built by High Voltage Engineering Europa.[14] The AMS measures the $^{14}C/^{12}C$ and $^{13}C/^{12}C$ isotope ratios of the graphite. From these numbers, the conventional ^{14}C age is determined.

By definition, the conventional ^{14}C age is based on the Libby halflife value, an international oxalic acid standard as a reference material and correction for isotopic fractionation using $^{13}C/^{12}C$. For a detailed

10. J.E. Taylor et al., "Qumran Textiles in the Palestine Exploration Fund, London: Radiocarbon Dating Results," *PEQ* 137 (2005) 159-67.

11. W.G. Mook and H.J. Streurman, "Physical and Chemical Aspects of Radiocarbon Dating," in W.G. Mook and H.T. Waterbolk (ed.), *Proceedings of the First International Symposium ^{14}C and Archaeology, Groningen, 1981* (PACT 8; Strasbourg: Council of Europe, 1983) 31-55; M. van Styrdonck et al., "What's in a ^{14}C Date?," in J. Evin (ed.), *Actes du 3ème Congrès International ^{14}C et Archéologie, Lyon, 6-10 avril 1998* (Paris: Société Préhistorique Française, 1999) 433-48.

12. W.G. Mook, *Introduction to Isotope Hydrology: Stable and Radioactive Isotopes of Hydrogen, Carbon, and Oxygen* (London: Taylor and Francis, 2006).

13. A.T. Aerts-Bijma, J. van der Plicht, and H.A.J. Meijer, "Automatic AMS Sample Combustion and CO_2 Collection," *Radiocarbon* 43/2A (2001) 293-8.

14. J. van der Plicht et al., "Status Report: The Groningen AMS facility," *NIM B* 172 (2000) 58-65.

explanation we refer to the literature.[15] These conventional ages are reported in the ^{14}C unit of time BP. The latter is not synchronous with calendar time because of past fluctuations in the natural ^{14}C concentration.[16]

For absolute dates, the conventional ^{14}C ages need to be calibrated into calendar ages. Calibration curves are obtained by paired dating of samples by ^{14}C and by dendrochronology, the latter being absolute. The presently recommended calibration curve is IntCal13.[17]

The calibration curve is non-linear, as can be seen in the example plot shown below (Figure 1). This results in non-gaussian probability distributions for the calendar age, sometimes yielding multiple solutions. The calibrated ages are reported in calBC or calAD, or simply BC or AD. All numbers (BP and BC/AD [for BCE/CE])[18] are rounded to the nearest 5. The measurement uncertainties are given as 1-sigma (68.2% confidence level).

The results of the dating are shown in Table 1. It shows the sample description, the IAA (Jerusalem) number, the KLR (Odense) number, the GrA (Groningen) number, the material analysed, the chemical treatment, the ^{14}C age (in BP) and its measurement uncertainty (1-sigma), the stable isotope ratio δ^{13}C (in ‰), the organic carbon content (C%) and the calibrated age in BC/AD (1-sigma range).

No samples could receive the full chemical pretreatment (AAA): 4% HCl, 1% NaOH and again 4% HCl, all at room temperature. They received only the first acid bath (A only) because they were very small or delicate or both. They would not survive the full treatment.

In general, good indicators for sample material integrity is the organic carbon content (the C% value) and the stable isotope content (the δ^{13}C value). Samples 10 and 11 (Gr11Q9/1 and Gr11Q9/2 = GrA-64961 and 64963 = IAA 464628/9) show a low C% value, which means the material (string) is partly degraded. In addition, these samples were very small, yielding larger measurement uncertainties. The measured δ^{13}C values are all within the expected range, and this lends credence that the pre-treatment procedure has been effective.

The calibrated age is given as 1-sigma range. To explain the calibration curve, Figure 1 is chosen as an illustration, representing Sample 1 (linen string sample, Gr11Q183 = IAA 577250 = GrA-65493 = QM GIIQ). The radiocarbon date (2160 ± 30 BP) is plotted in red along the vertical axis, the calibrated date in black along the horizontal axis. The relevant part of the calibration curve – the relationship between ^{14}C time and calendar time, IntCal13 – is shown in blue. The calibrated age range for this date is 350-300 and 230-165 BC. Both the ^{14}C age in BP, and the calibrated age range in calAD are reported at 1-sigma confidence level, with numbers rounded to the nearest significant 5, as in Table 1. At 2-sigma, the calibrated age range would be 358-279 and 259-108 BC.

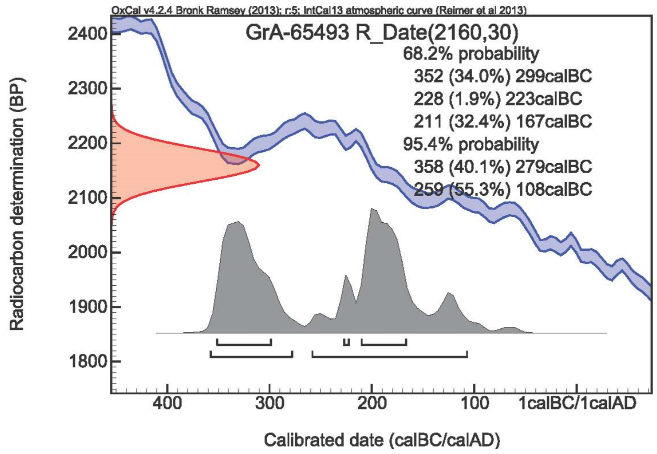

Fig. 1. Calibration curve for Sample 1: 11Q linen string, Gr11Q183, IAA 577250, GrA-65493.

Figures 2-7 illustrate the calibration curves for the remainder of the linen samples tested, excepting Samples 8, 9 and 10 (Gr11Q9/1 and Gr11Q9/2; GrA-64961, 64963 and 65505; IAA nr. 464628 and 464629) which appear elsewhere in this volume in a

15. W.G. Mook and and J. van der Plicht, "Reporting ^{14}C Activities and Concentrations," *Radiocarbon* 41/3 (1999) 227-39.

16. For a treatise on "absolute dating" related to Qumran, we refer to J. van der Plicht and K.L. Rasmussen, "Radiocarbon Dating and Qumran," in J. Gunneweg, A. Adriaens, and J. Dik (ed.), *Holistic Qumran: Trans-Disciplinary Research of Qumran and the Dead Sea Scrolls: Proceedings of the NIAS-Lorentz Center Qumran Workshop 21-25 April 2008* (STDJ 87; Leiden: Brill, 2010) 99-121; and J. van der Plicht, "Radiocarbon dating and the Dead Sea Scrolls: A Comment on 'Redating'," *DSD* 14 (2007) 77-89.

17. P.J. Reimer et al., "IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0-50,000 Years cal BP," *Radiocarbon* 55/4 (2013) 1869-87.

18. Note that in this chapter the conventional laboratory use of BC/AD is adopted except where historical discussion takes place.

Table 1

	Material	Inventory nr.	IAA nr.	Visual identifier at time of sampling (J.E. Taylor)	Sample identifier	KLR nr.	GrA nr.	Treatment	14C age (BP)	Sigma	δ13C (‰)	C%	Calibrated age at 1 sigma
1	11Q linen string	Gr11Q183	577250		QM GIIQ	10423	65493	A	2160	30	-25.81	42.2	350-300, 230-165 BC
2	11Q linen	Gr11Q119	577264		QII	10424	65494	A	2085	30	-25.14	41.6	160-55 BC
3	11Q linen	Gr11Q132	577293		QII	10425	65495	A	1925	30	-25.11	41.9	55-125 AD
4	11Q linen	Gr11Q107	577252		QMGII	10426	65496	A	1990	30	-25.72	40.8	35 BC - 50 AD
5	11Q linen	Gr11Q76	577220		QMGII	10427	65497	A	2110	30	-24.84	42.9	180-90 BC
6	11Q linen	Gr11Q101	577245		QMGII	10428	65498	A	2025	30	-25.37	42.2	55 BC - 20 AD
7	Christmas Cave Linen		585785		QCC 585 785	10430	65501	A	4745	35	-24.32	43.1	3635-3515, 3395-3385 BC
8	11Q-9/1 linen string	Gr11Q9/1	464628		11Q-9/1	10432	65505	A	240	30	-24.30	44.0	1645-1670, 1780-1800 AD
9	Schøyen Linen wrapper		--		Schøyen 5095/1	--	62331	AAA	1900	30	-25.12	42.4	70-130 AD
10	11Q linen string		464628		11Q-9/1	--	64961	A	190	50	-24.40	29.6	>1655 AD
11	11Q linen String		464629		11Q-9/2	--	64963	A	210	60	-24.96	37.3	>1640 AD

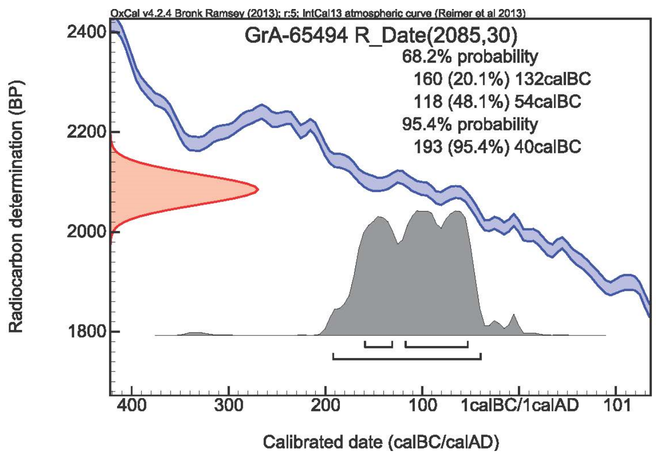

Fig. 2. Calibration curve for Sample 2: 11Q linen, Gr11Q119, IAA 577264, GrA. 65494

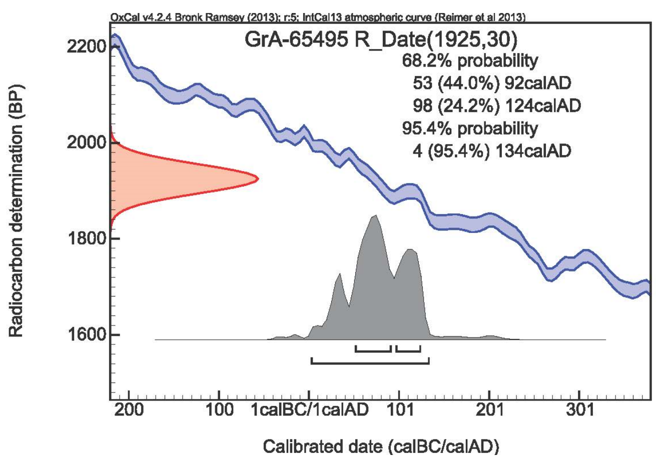

Fig. 3. Calibration curve for Sample 3: 11Q linen, Gr11Q132, IAA 577293, GrA 65495

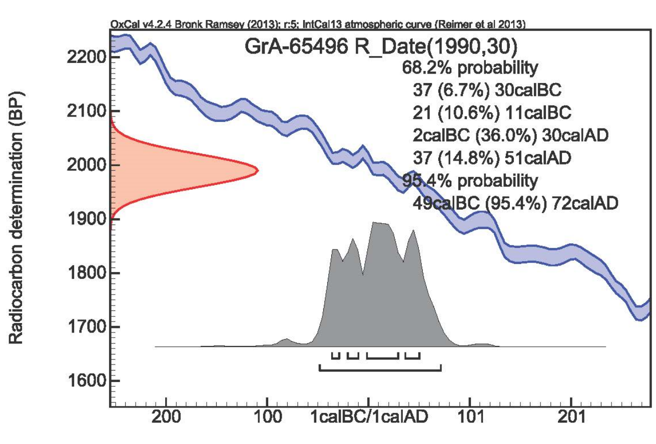

Fig. 4. Calibration curve for Sample 4: 11Q linen, Gr11Q107, IAA 577252, GrA65496

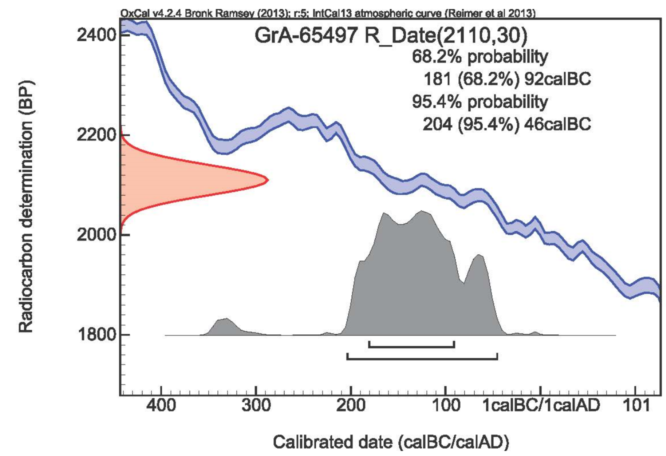

Fig. 5. Calibration curve for Sample 5: 11Q linen, Gr11Q76, IAA 577220, GrA 65497

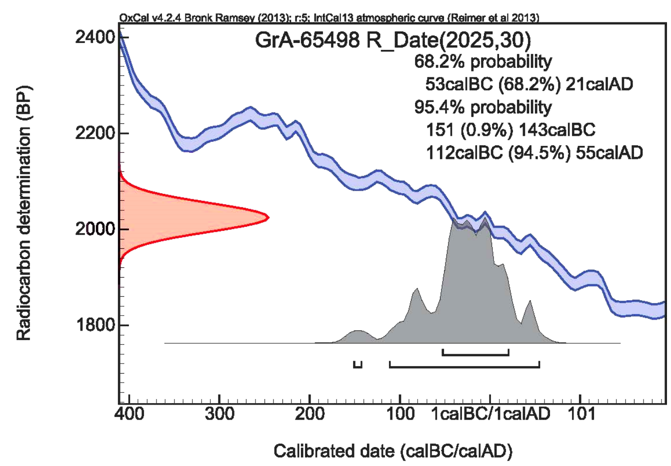

Fig. 6. Calibration curve for Sample 6: 11Q linen, Gr11Q101, IAA 577245, GrA 65498

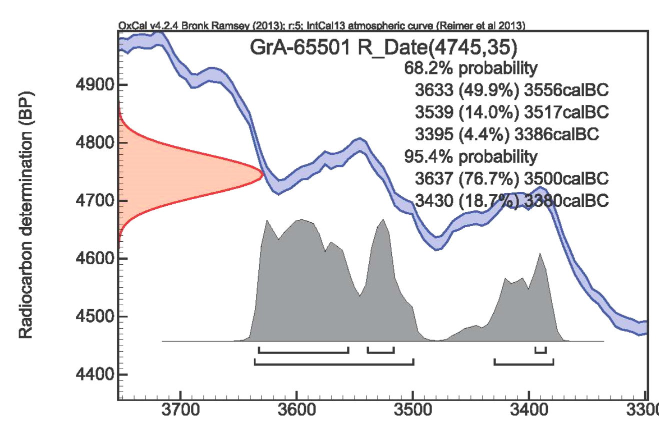

Fig. 7. Calibration curve for Sample 7: Christmas Cave linen, IAA nr. 585785, GrA 65501

separate discussion of these objects. These samples yielding subrecent datesoriginate from a time characterised by large and prolonged fluctuations in the natural ^{14}C content, going over in modern times with ^{14}C influenced by anthropogenic effects (fossil fuels and nuclear bomb tests). The calibration yields 3 eras, ca. 1660, ca. 1770 and younger than

4. The Temple Scroll Wrapper

The Temple Scroll (11Q19) wrapper now in the Schøyen collection can be considered along with the dates obtained from material in the IAA holdings. This linen is unusual in being uncleaned, not even with light alcohol. While the main part of the wrapper

(MS 5095/2) is preserved in one display unit, Martin Schøyen also retains numerous other small pieces from the wrapper (MS 5095/1) in another case, and permitted one of these to be taken for analysis, on the proviso that it was first published in the volume that focused on his collection.[19] The result from the radiocarbon testing of this wrapper provided a result of 1900 ± 30 BP, calibrated to 70-130 AD at 1 sigma, and 28-214 calAD at 2 sigma (95.4% probability), and within this range 88.5% confidence attached to a date between 50 and 180 calAD.

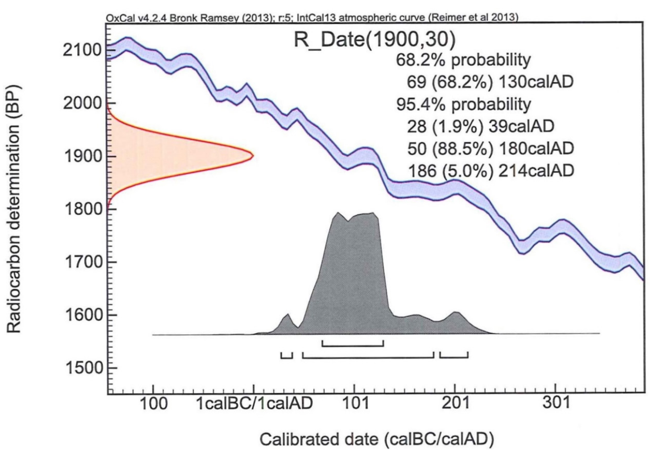

Fig. 8. Calibration curve for the Temple Scroll Wrapper (MS 5095/1).

This result needs to be compared to the radiocarbon date of the Temple Scroll (11Q19) itself. Gelatinised and ungelatinised samples from the manuscript were radiocarbon dated in the ETH Zurich laboratory in 1990 and provided a result of 2024 ± 49 (gelatinised) and 2066 ± 78 (ungelatinised) years BP, giving it an averaged result of 2030 ± 40 years BP, or date range of 97 BC-1 AD at 1 sigma, as calibrated using the dataset of this time.[20] The 2-sigma (95.4% probability) calibration of Gregory Doudna[21] done in 1998 indicated an averaged range of 166 BC-67 AD. Using the IntCal13 atmospheric curve,[22] the date of 2030 ± 40 years BP can now be plotted as providing a range from 164 BC to 57 AD at 2 sigma. The results present the possibility that the scroll was created some time earlier than the wrapper.

5. Significance of Radiocarbon Dating Results for Cave 11Q

Radiocarbon dating of the organic materials of the Qumran caves should provide evidence for a clarification of the dating for the manufacture of the items. As noted, a radiocarbon date derives from the time of the death of the plant or animal used in the artefact. In regard to results, the actual date for the death of the organic material should lie before the *latest* date of a radiocarbon dating range. Thus, the date of a piece of linen textile created from flax harvested, prepared and spun in the year 10 CE should be indicated in a radiocarbon dating range in which the latest probable dates include a calibrated date designated as 10 AD at least. The 2 sigma (95.4%) radiocarbon dating results may well begin as late as 1 AD and range much later than this date, and within this range there may be clusters of higher and lower ranges of probabilities for dates, but the range should not start after or end before 10 AD. However, commonly only the 1 sigma range is given for the range, usually rounded to the nearest 5 as here. For more precise purposes the 2 sigma range should be consulted.

In terms of the comparative test sample, the Christmas Cave textile is a very old piece indeed, and in fact derives from the late Chalcolithic period (3637-3500 and 3430-3380 BC at 2 sigma, with a 76.7% probability within the older range). This result is consistent with objects found in the Christmas Cave that date to this era, including textiles.[23]

Hitherto, radiocarbon dating has largely focused on gaining further data to enable precise dating of the time of the writing of the scrolls, which can be used in parallel assessments from palaeography, but the high economic and religious value of scrolls and the difficulties of their manufacture would suggest their 'shelf-life' was comparably longer than textiles. Scroll wrappers may even have been designed for particular scrolls, meaning that their date of manufacture (preparation of linen) could be quite close to the time

19. Taylor and van der Plicht, "Radiocarbon Dating."

20. G. Bonani et al., "Radiocarbon Dating of Fourteen Dead Sea Scrolls," *Radiocarbon* 34/3 (1992) 843-9, on p. 845.

21. G.L. Doudna, "Dating the Scrolls on the Basis of Radiocarbon Analysis," in P.W. Flint and J.C. VanderKam (ed.), *The Dead Sea Scrolls after Fifty Years: A Comprehensive Assessment: Vol. 1* (Leiden: Brill, 1998) 430-71.

22. Reimer et al., "IntCal13." The programme can be accessed at https://c14.arch.oc.ac.uk/oxcal.html.

23. See R. Porat, H. Eshel, and A. Frumkin, "The 'Caves of the Spear': Refuge Caves from the Bar-Kokhba Revolt North of 'En-Gedi," *IEJ* 59 (2009) 21-46; O. Shamir and N. Sukenik, "The Christmas Cave Textiles Compared to Qumran Textiles," *ATN* 51 (2010) 26-30.

of the final use or deposit of a scroll. In the study of Shamir and Sukenik[24] it was noted that at least some of the linen textiles in the Qumran caves were previously used as garments. The linen textiles from scroll wrappers, packing and jar covers and string ties are particularly useful for radiocarbon dating as textiles usually have a relatively short 'shelf-life',[25] since they are easily worn out by use, thus previously used clothing and textiles then used for packing might have been just 10-20 years old at the time of their use in jars. Packing would normally be done with rags. One would nevertheless expect textile manufacture to be not that long before the time of their arrival in the caves, unless there was a particularly special or little used item of textile kept in storage. The question then is how old that special linen might be.

In terms of textiles and organic remains from Qumran Cave 11Q, a number of radiocarbon tests have already been run.[26] In the tests published in 2006, there were three results obtained from wood samples (from items with IAA numbers 864395 = Gr11Q22a and 864396 = Gr11Q22c).[27] The designation D024 in the published results relates to these.[28] A note associated with these wooden objects written at the time of the sampling defines them as 'D024 G.11 Q22 bois'. It can be readily seen on the pointed wooden artefact Gr11Q22a =864395[29] that two samples were taken from it. These two samples from the same object were then tested separately, and labelled QUM-515 and QUM-516 respectively. Not surprisingly these yielded almost identical results that places the object around the 10th century AD. QUM-515 (D024b) yielded a 68.2% (1 sigma) probability of 890-985 AD and 95.4% (2 sigma) probability of 820-1020 AD; QUM-516 (D024c) yielded a 68.2% (1 sigma) probability dated between 885-980 AD and 95.4% (2 sigma) probability between 770-1020 AD.

The other piece of sampled wood from 11Q (Gr11Q22c = 864396)[30] can also be identified by the cut still visible on the piece. It was identified as a piece of branch, also labelled as D024 (additionally labelled 'a' in the published sequence). The results of the dating of this were 1770-1640 BC (68.2% probability) or 1880-1610 BC (95.4% probability).[31] The piece of the tree, however, may not be assigned to human activity, as it may well be the residue of a living tree that grew proximate to (on top of?) the cave itself, at some point in the past. Cave collapse could have taken roots with it. The changing climatic conditions of the Dead Sea area mean different vegetation would have grown at different times, and the Middle Bronze II-III (c.1750-1550 BC) and the early phase of the Late Bronze periods were a time of comparative humidity with a wetter climate, when the Dead Sea level was also high.[32] Clearly, this item warrants further study by a botanical specialist. The likelihood of artefacts being dated variously may be understood already from what archaeologists have observed. The initial archaeological team already defined at least two earlier periods of cave use on the basis of pottery: part of a Chalcolithic small jar and fragments of jars and two lamps from the Iron Age.[33]

24. O. Shamir and N. Sukenik, "Qumran Textiles and the Garments of Qumran's Inhabitants," *DSD* 18 (2011) 206-25.

25. Y. Yadin, *The Finds from the Bar Kokhba Period in the Cave of Letters* (Jerusalem: Israel Exploration Society, 1963), 171.

26. K.L. Rasmussen et al., "Cleaning and Radiocarbon Dating of Material from Khirbet Qumran," in J. Gunneweg, C. Greenblatt, and A. Adriaens (ed.), *Bio- and Material Cultures at Qumran: Papers from a COST Action G8 Working Group Meeting Held in Jerusalem, Israel on 22-23 May 2005* (Stuttgart: Fraunhofer IRB, 2006) 139-64.

27. Two series of tests were run on the wood samples. In the cleaning of the wood samples, it was noted in regard to the first series of texts that the δ^{13}C-values constituted a warning of the possible presence of contamination. Only the results of the second series, after renewed cleaning are reliable (Rasmussen *et al.*, "Cleaning and Radiocarbon Dating," 147-8).

28. Rasmussen et al., "Cleaning and Radiocarbon Dating," 148-52.

29. See also J. E. Taylor and N. Sukenik, "Organic ~~Materials~~ from Cave 11Q: A. Leather, Basketry, Ropes, Wood and Seeds," in this volume, Table 1.

30. Taylor and Sukenik, "Organic Materials from Cave 11Q."

31. Rasmussen et al., "Cleaning and Radiocarbon Dating," 148-52.

32. D. Langgut et al., "Vegetation and Climate Changes During the Bronze and Iron Ages (~3600-600 BCE) in the Southern Levant Based on Palynological Records," *Radiocarbon* 57/2 (2015) 217-35, on pp. 217, 227-8, 231.

33. R. de Vaux, "Fouilles de Khirbet Qumrân: rapport préliminaire sur les 3e, 4e, et 5e campagnes," *RB* 63 (1956) 533-77, on p. 574; J.-B. Humbert and A. Chambon (ed.), *Fouilles de Khirbet Qumrân et de 'Aïn Feshkha: Vol. I: Album de photographies. Répertoire du fonds photographique. Synthèse des notes de chantier du Père Roland de Vaux OP* (NTOA.SA 1; Fribourg/Göttingen: Éditions Universitaires/Vandenhoeck & Ruprecht, 1994), 265-6, on p.344; see J.-B. Humbert, "Description de la poterie recueillie dans la grotte 11Q," in this volume.

In addition to the three wood samples, three textile samples from 11Q were tested in the same batch of 2004. While the exact IAA numbers were not recorded, these comprised a piece of cotton, given the designation QUM-533 (= Gr11Q35), and two pieces of linen labelled QUM-540 (= Gr11Q31b) and 541 (Gr11Q41).

The cotton piece was dated as follows (calibrated ages): Gr11Q35 (QUM-533 D037) 890 - 975 AD 1 sigma; 860 - 1020 AD 2 sigma.

This correlates well with the date of the wooden pointed artefact, placing both items around the 10th century, which suggests human activity in the cave in the Abbassid/Fatimid periods. The cave was therefore open before the deposit of the cotton piece and wooden artefact. This later dating can now be viewed alongside the result for Gr11Q9/1 and Gr11Q9/2. As noted above, analysis of Gr11Q9/1 and Gr11Q9/2 presented some surprises and provided further important indications that the cave was sufficiently open not only to bats but also to human visitors in the Ottoman period, most likely in the 17th or 18th centuries.[34] That the cave entrance could have been opened and closed over time is not surprising in an area of significant earthquake activity: an entrance once closed with stones could easily have been opened, and then closed again with rock fall. All evidence of original closures and openings can be erased by such activity. A massive earthquake of 746 destroyed Kh. el Mafjar near Jericho. Among others, there was a devastating earthquake affected the region in 1759.[35] One does not need to attribute the positioning or removal or rocks at an entrance to human activity. Passing wayfarers or herders may opportunistically have used (part of?) the cave when exposed. This would explain the diverse datings of the objects now examined. Cave 11Q was not a cave hermetically sealed from antiquity until the present day, with just a small opening accessible only to bats.

34. See Taylor, "Organic Items from Cave 11Q," in this volume.

35. D.H. Kallner-Amiran, "A Revised Earthquake-Catalogue of Palestine," *IEJ* 1 (1950-51) 223-46, on pp. 226-8; K.W. Russell, "The Earthquake Chronology of Palestine and Northwest Arabia from the 2nd through the Mid-8th Century A.D.," *BASOR* 260 (1985) 37-59, on pp. 47-9; I. Karcz, "Implications of Some Early Jewish Sources for Estimates of Earthquake Hazard in the Holy Land," *Annals of Geophysics* 47 (2004) 759-92, on pp. 778-81. There are numerous stories of cave entrances being opened by earthquakes, as in the case of the Drogarati caves in Kephalonia.

Of the materials likely to be associated with the scroll deposits, two linen textiles radiocarbon dated in 2004 yielded dates as follows:

A. Gr11Q31b (QUM-540 Cave 11Q D033b) 160 BC - 1 AD 1 sigma; 190 BC - 30 AD 2 sigma
B. Gr11Q41 (QUM-541 Cave 11Q D043) 50 BC - 25 AD 1 sigma; 100 BC - 70 AD 2 sigma

We add to this the Temple Scroll wrapper in the Schøyen Collection:

C. (MS 5095/1) 70-130 AD 1 sigma; 28-214 AD 2 sigma

These results can now be viewed along with the new set of radiocarbon dates which provide 2 sigma (95.4%) calibrated ranges as follows (see Figures 1-6):

1. Bundle of linen strings (Gr11Q183) 358-279 BC (40.1%) to 259-108 BC (55.3%).
2. Fragment of linen (Gr11Q119) 193-40 BC.
3. Fragment of linen textile with mended areas (Gr11Q132) 4-134 AD.
4. Fragment of linen textile with blue line (Gr11Q107) 49 BC-72 AD.
5. Fragment of linen textile (Gr11Q76) 204-46 BC.
6. Fragment of linen textile (Gr11Q101) 151-143 BC (0.9%); 112 BC-55 AD (94.5%).

The most striking element in the results from 11Q linen radiocarbon dating is the range of dates. Sample 1 from the bunch of linen strings (Gr11Q183) has a calibrated dating range at 2 sigma from 358 BC to 108 BC, with a probability dip in the middle of the curve (Figure 1). This string is not part of the packing but should form ties around a scroll wrapper or (possibly) string to tie on a jar lid in some way. Given this range there is no real possibility that the string was manufactured in the 1st century AD; even the very low probability trail peters out totally by the mid 1st century BC. Similarly early are Sample 2 linen (Gr11Q119), which has a 2 sigma range of 193-40 BC, and Sample 5, the piece of bleached linen (Gr11Q76), which yielded a range of 204-46 BC. Other dates in the 2 sigma ranges fall within the 1st century BC to 1st century AD, e.g. Sample 4 (the piece with the blue line Gr11Q107): 49 BC-72 AD and Sample 6 (Gr11Q101): 112 BC-55 AD at 94.5% probability. Sample 3, a piece that was thought to have later features in the sewing (with a mended area, not sampled) yielded a range spanning the 1st to mid-2nd century AD (Gr11Q132: 4-134 AD), as with the Temple Scroll wrapper. Importantly, even the outlying tiny probability trails of Sample 1 and Sample 3 do not intersect.

The dates indicate that the linen of Cave 11Q was manufactured at different times minimally stretching from 108 BC to 4 AD (using the outer parameters of 2 sigma ranges) but maximally stretching from 358 BC to 134 AD (likewise using these parameters). They do not cluster particularly strongly around certain dates, though they would generally correlate with the time of the Qumran settlement (early 1st century BC to end of 1st century AD). The conclusion must be that linen found in Cave 11Q was manufactured at different times over an extended period.

Given the significant variations of the dating of the linen, various questions may be asked: Were some scrolls (in their linen wrappers) deposited earlier than other scrolls in the same cave? Might there have been later uses of the cave, after some scrolls were deposited? Since caves have little stratigraphy the question of dating cave objects can be particularly difficult, and this is where radiocarbon dating can provide broad date parameters that can indicate whether an organic object comes from the Roman period, or the Iron Age, or even from the Mamluk period, when morphologies of artefacts (including textiles) can be ambiguous.

One may also ask how long a wrapper was in use prior to it being employed for depositing a scroll. Was the Temple Scroll given a fresh wrapper sometime prior to its deposit in a jar in Cave 11Q? Given that the palaeography of the Temple Scroll suggests that both this scroll and other manuscripts from Cave 11Q are relatively late, should we conclude, with Stökl Ben Ezra, that Cave 11Q is a 'young' cave?[36] We could note that it is the later part of manuscript radiocarbon range at 2 sigma that coheres with both the palaeography and indeed the earliest dating of the wrapper. The deposit of this material took place some time after this scroll and the wrapper was manufactured, and we do not know how long these were in use prior to their arrival in the cave. The Temple Scroll wrapper radiocarbon dating result would even raise the question of whether the linen was manufactured later than 68 AD, at a time corresponding to the occupation of Qumran in Period III, in de Vaux's system, or even the Bar Kokhba period; further tests could determine accuracy with greater precision.

However, arguing strongly against the view that 11Q is a 'young cave', exclusively, is indeed the evidence that suggests some of this linen is older than the 1st century AD. There may be various scenarios proposed to account for the early date range: for example, either (a) old scrolls now missing entirely were wrapped up in linen and stored for a long time before their placements in the cave, or (b) this older linen comes from extremely old rags used for packing, or (c) at least some of the scrolls were wrapped, packed and placed in jars in the cave already in the 1st century BC.[37] For this cave to have been used only in the 1st century AD one would have to argue that extremely old linen was used for storage and/or for rags, when rags would normally be torn from worn clothing or other textiles easily to hand. The question of how old a packing rag might be is impossible to answer, though normally linen cloth when worn is subject to quite rapid deterioration (from sweat, wearing and washing). Thus a more common approach would be to consider a radiocarbon date to be an indication of the time not only of manufacture but of use.

The dating range for samples from Cave 11Q, excluding those items that are from the 10th century or sub-modern, indicate that the manufacture and use of the linen of 11Q associated with scroll deposits did not likely take place all at the same time (e.g. either 1st century BC or 1st century AD).

36. D. Stökl Ben Ezra, "Further Reflections on Caves 1 and 11: A Response to Florentino García Martínez," in C. Hempel (ed.), *The Dead Sea Scrolls: Texts and Context* (STDJ 90; Leiden: Brill, 2010) 211-23; Id., "Old Caves and Young Caves: A Statistical Reevaluation of a Qumran Consensus," *DSD* 14 (2007) 313-33; cf. F. García Martínez, "Cave 11 in Context," in Hempel, *Dead Sea Scrolls*, 99-209, on p. 205.

37. See the arguments presented by G.L. Doudna, "The Legacy of an Error in Archaeological Interpretation: The Dating of the Qumran Cave Scroll Deposits," in K. Galor, J.-B. Humbert, and J. Zangenberg (ed.), *Qumran, the Site of the Dead Sea Scrolls: Archaeological Interpretations and Debates: Proceedings of the Conference Held at Brown University, November 17-19, 2002* (STDJ 57; Leiden: Brill, 2006) 147-57; Id., "Dating the Scroll Deposits of the Qumran Caves: A Question of Evidence," in Fidanzio, *The Caves of Qumran*, 238-46.