Appendix B: Radiocarbon Determinations from the Middle Bronze Age Jordan Valley

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Introduction

The application of radiocarbon analysis to the MB chronology of the Levant, let alone to a specific subregion like the Jordan Valley, is a relatively new development in archaeological research in this region. Although new radiocarbon determinations appear from time-to-time of samples from on-going and occasionally older excavations, it is only recently that a sufficient data set has begun to emerge, enabling these results to be incorporated meaningfully into general discussions of MB chronology and process (Bruins & van der Plicht 1995; 1996; 2003; Marcus 2003; Falconer & Berelov 2006: 62–64; Bourke 2006; Bourke *et al.* 2009; Fischer 2006a; Marcus *et al.* 2008; Marcus, Porath & Paley 2008). Among the more important developments that have spurred the increase in sampling for radiocarbon are the development of AMS radiocarbon, the improved precision of the radiocarbon method, which has made it more efficacious in historical periods, and the powerful statistical tools enabled by computer programs such as OxCal (Bronk Ramsey 2009). The following is a review of the current state of the MB radiocarbon dataset for the Jordan Valley and its contribution towards providing "absolute" or calendrical ranges for this period.

The Radiocarbon Dataset

Table 9 and Fig. 67 represent, respectively, the currently available radiocarbon assays of short-lived (single-year cultigens) samples from MB sites in the Jordan Valley and their calibrated probability distributions.[137] Assays on long-lived samples (i.e., wood and charcoal) have been excluded as they may represent old wood. While these may occasionally provide a useful terminus post quem and be consistent with the short-lived samples, their potential long lifespan and inestimable reuse render them unreliable for the chronological precision required in historical periods. At first glance, this dataset is unbalanced both with regards to the number of sites and the number of samples per phase and site. In particular, note the absence of samples from many of the key MB sites such as Dan, Hazor and Beth Shean.[138] In three instances, radiocarbon determinations are the result of the excavator's initiative (Gesher, Tell el-Hayyat and Pella), but most of the radiocarbon assays are the result of problem-oriented research initiatives, such as the MB I[139] radiocarbon project carried out under the auspices of SCIEM2000 (Marcus 2003) and Bruins's and van der Plicht's work on Jericho (1995; 1996; 2003), which were designed to best apply these methods to chronological questions.[140]

Sampled Sites

Gesher

A single radiocarbon determination was carried out from this early MB I cemetery. Unfortunately, there is some confusion in the literature regarding this sample. Initial reports described the sample as being "wood from the socket of a spearhead from Tomb 13" (Garfinkel & Bonfil 1990: 132; *author's transla-*

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[137] All determinations discussed here were calibrated using OxCal 4.1.5 (Bronk Ramsey 2009) employing the IntCal09 curve (Reimer *et al.* 2009).

[138] See Mazar (2007b) for the results of five radiocarbon determinations from charred olive wood and charcoal from MB Beth-Shean, all of which demonstrate the problem of using long lived samples.

[139] Note that this author maintains the traditional nomenclature of MB IIA–IIB/C, but has adopted the MB I–II/III scheme solely for the consistency of the volume.

[140] The MBIIA C14 project, which was carried out under the auspices of SCIEM2000 headed by M. Bietak, focused on the first half of the Middle Bronze Age and therefore no attempt was made to obtain samples for the latter half of the period; that is project still to be done. In the course of this project, numerous excavators were queried and extant collections were sought, but ultimately there was a dearth of suitable samples. See Marcus 2003, 101–103 for an outline of the protocols employed for sample selection.

Laboratory #	Site, Context and sampled material		$d^{13}C$ ‰	^{14}C-age BP	2σ calibrated range BCE	Reference
OxA-1955	**Gesher**; wood from a spearhead in T.13			3640±70	2205–1776	HEDGES *et al.* 1990: 229; HOUSLEY 1994: 66; GARFINKEL & COHEN 2007: 3, fig. 1.3, table 6.2
AA-1236	**Tell el-Hayyat**	Phase 5 (lower), 5 lentils		3460±100	2029–1525	FALCONER & BERELOV 2006: table 4.2
AA-1239	**Tell el-Hayyat**	Phase 5 (upper), 4 seeds		3600±60	2136–1774	FALCONER & BERELOV 2006: table 4.2
AA-1238	**Tell el-Hayyat**	Phase 4 (lower), 3 lentils		2930±80	1380–925	FALCONER & BERELOV 2006: table 4.2
AA-1237	**Tell el-Hayyat**	Phase 4 (middle), 2 olive stones		3280±100	1876 –1321	FALCONER & BERELOV 2006: table 4.2
VERA-2037	**Tell el-Hayyat**	Phase 5, Unit E, L.102 *Triticum aestivum*, humic acids	–21.1 ± 1.3	3555±40	2021 (5.2%) 1993 1982 (90.2%) 1769	FALCONER & BERELOV 2006: table 4.2
OxA-10986	**Tell el-Hayyat**	Phase 5, Unit E, L.102, *Triticum aes*	–22.4	3470±36	1888–1691	BRONK RAMSEY *et al.* 2002: 82; FALCONER & BERELOV 2006: table 4.2
VERA-2038	**Tell el-Hayyat**	Phase 5, Unit H, L.067, *Triticum aestivum*	–21.9 ± 2.1	3530±60	2026 (93.3%) 1735 1714 (2.2%) 1694	FALCONER & BERELOV 2006: table 4.2
VERA-2038W	**Tell el-Hayyat**	Phase 5, Unit H, L.067, *Triticum aestivum*	–22.5 ± 0.6	3565±30	2021 (5.4%) 1993 1982 (78.3%) 1872 1845 (7.1%) 1813 1802 (4.7%) 1777	
OxA-10987	**Tell el-Hayyat**	Phase 5, Unit H, L.067, *Triticum aestivum*	–22.9	3497±37	1922 (94.0%) 1738 1709 (1.4%) 1698	BRONK RAMSEY *et al.* 2002: 82; FALCONER & BERELOV 2006: table 4.2
VERA-2039	**Tell el-Hayyat**	Phase 4, Unit E, L.092 *Olea* stone, humic acids	–23.4 ± 1.5	3495±35	1915 (94.4%) 1739 1707 (1.0%) 1699	FALCONER AND BERELOV 2006, table 4.2
OxA-10988	**Tell el-Hayyat**	Phase 4, Unit E, L.092, *Olea* stone	–21.3	3502±37	1926 (94.9%) 1739 1705 (0.5%) 1700	BRONK RAMSEY *et al.* 2002: 82; FALCONER & BERELOV 2006: table 4.2
VERA-2040	**Tell el-Hayyat**	Phase 4, Unit J, L.074, *Olea* stones	–24.0 ± 1.5	3500±35	1922–1740	FALCONER AND BERELOV 2006: table 4.2
OxA-10989	**Tell el-Hayyat**	Phase 4, Unit J, L.074, *Olea* stone	–21.3	3523±39	1951–1745	BRONK RAMSEY *et al.* 2002: 82; FALCONER & BERELOV 2006: table 4.2
OzG 611	**Pella**	Area XXXII, L6514, cereal grain		3630±40	2134–1891	BOURKE *et al.* 2009: table 1; BOURKE 2006: table 1
OzG-613	**Pella**	Area XXXII, L2503, cereal grain		3470±40	1891–1689	BOURKE *et al.* 2009: table 1; BOURKE 2006: table 1
OzJ-035	**Pella**	Area XXXIIW, 10.3, unknown		3560±60	2120 (2.0%) 2090 2040 (93.4%) 1740	BOURKE 2007b
GrN-18539	**Jericho**	HAF.XII–XIII.lii.liii; *Hordeum vulgare*	–23.09	3312±14	1628–1528	BRUINS & VAN DER PLICHT 1995; 1996; 2003
GrN-18542	**Jericho**	HAF.XII–XIII.lii.liii; *Triticum sp.*	–23.54	3288±20	1619–1510	BRUINS & VAN DER PLICHT 1995; 1996; 2003
GrN-18543	**Jericho**	HAF.XII–XIII.lii.liii; *Triticum sp.*	–23.31	3331±18	1684–1532	BRUINS & VAN DER PLICHT 1995; 1996; 2003
GrN-18544	**Jericho**	HAF.XII–XIII.lii.liii; Cereal, fragmented	–23.28	3312±15	1631–1527	BRUINS & VAN DER PLICHT 1995; 1996; 2003

Table 9 The MB Radiocarbon Data set for the Jordan Valley. All calibration done on OxCal 4.15 (BRONK RAMSEY 2009) based on the IntCal 09 curve (REIMER *et al.* 2009)

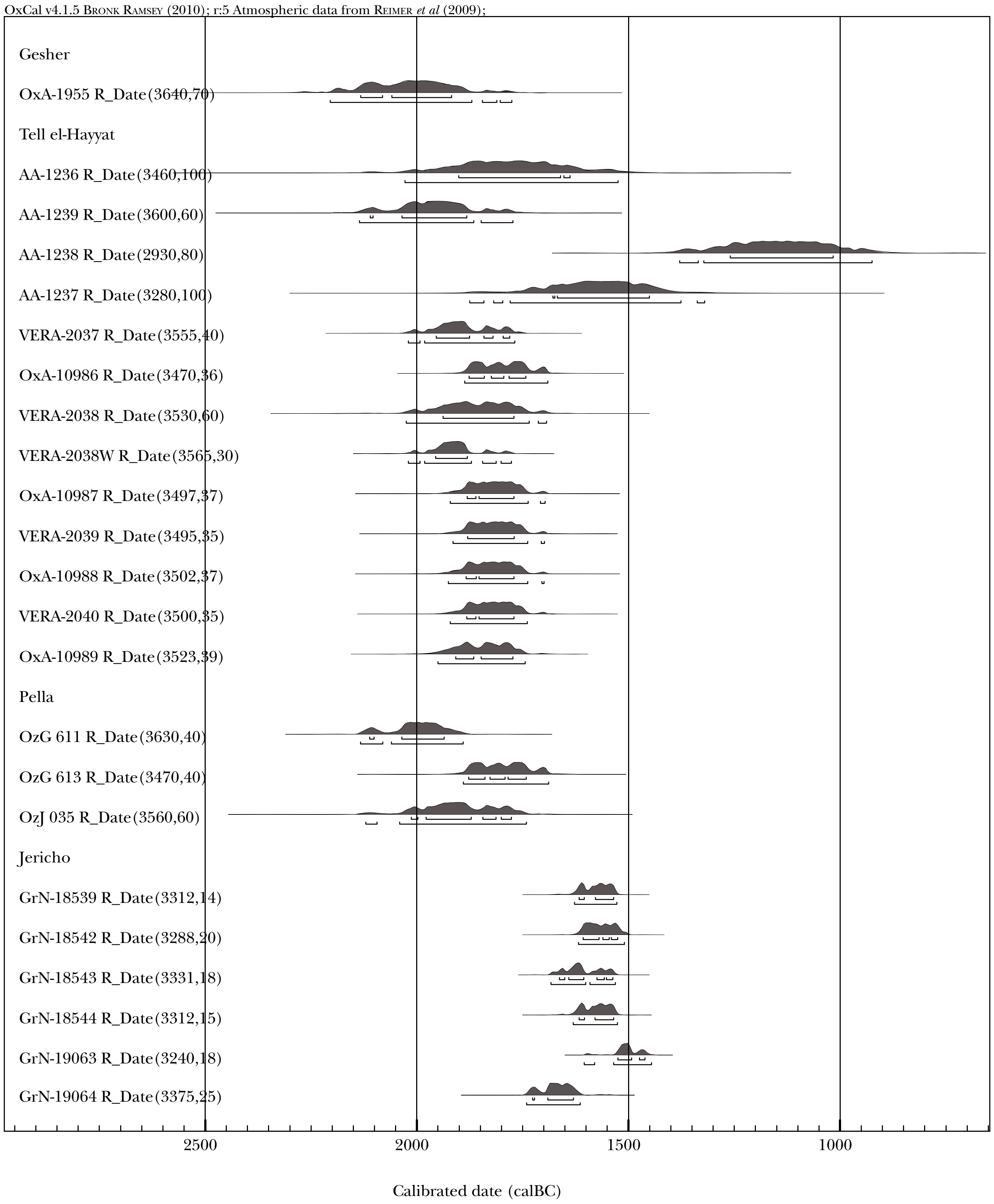

Fig. 67 Probability distribution of the MB Jordan Valley radiocarbon data set

tion from the original Hebrew) and "wood representing part of a handle from a bronze spearhead" (Hedges *et al.* 1990: 229; Housley 1994: 66). However, the recently published final report (Garfinkel & Cohen 2007) describes the lone sample as being "from wood in association with a bronze axe" (p. 3) and subsequently as "twine on socket OxA 1955 3640 ±70 bp", albeit clearly indicated as being from the Tomb 13 spearhead (page 102, table 6.2). Although an argument might be made that wood for a spearhead is unlikely to be made of old hardwood (Ward & Dever 1994: 57), clearly if the sample were twine it would more likely be temporally contemporaneous with the manufacture of the spear. Although the initial excavations by Garfinkel should be credited with having submitted one of the first MB I samples for radiocarbon dating, it does not appear that the renewed excavations at Gesher saw the recovery of samples for radiocarbon determinations to have been of importance. Otherwise, attempts might have been made to sample the twine or wood from two additional spearheads (Cohen & Liphschitz 2007).[141]

Tell el-Hayyat

This site has six principal phases from the Early Bronze Age IV through the end of the Middle Bronze Age (Falconer & Berelov 2006; see this volume, Chapter 3). Two sets of AMS radiocarbon determinations are available for this site from Phases 5 and 4, both of which are ascribed to the Middle Bronze Age I (Falconer & Berelov 2006: 46–52). The first, which was submitted by the excavators in the 1980s to the University of Arizona AMS laboratory, includes four assays from Phases 5 and 4. The second set was carried out as part of the author's MB I radiocarbon project (Marcus 2003) and includes four samples, two each from Phase 5 and 4 that were split and sent to two laboratories: the Oxford Radiocarbon Accelerator Unit (ORAU) and the Viennese Environmental Radiocarbon Accelerator (VERA). In one instance, a sample (VERA-2038) was subjected to a second measurement, which is presented here for the first time. The two sets cannot be compared in any detail, as other than the assignment to general phases, no other stratigraphic information is included regarding the earlier set. As the results are from a single laboratory, the anomalous results from AA-1238 cannot be resolved. Moreover, some of the larger errors, i.e., ±100, produce calibrated ranges of little meaning. In contrast, the second set offers an excellent inter-laboratory comparison and the opportunity to combine the results of identical samples (Table 9 and Figs. 67, 68).

Pella

Bourke (2006: 243–244, table 1; 2007; Bourke *et al.* 2009: 907–909, tables 1 and 2) has reported three radiocarbon determinations from the MB I levels at Pella (Table 9). However, details as to the nature of the material sampled and the precise chronological horizon are still awaited.[142]

Jericho

Bruins and van der Plicht (1995; 1996; 2003) carried out a study of the end of MB Jericho, using long and short-lived samples (Table 9).

General Discussion

The Middle Bronze Age I

The Tell el-Hayyat dataset is the largest and most informative suite of determinations obtained thus far, with seven measurements from Phase 5 and four from Phase 4 (Fig. 68). The consistency between the ORAU and VERA results are excellent and even the slightly higher additional measurement of VERA-2038W is consistent over a 2 sigma range. Combining the determinations from identical samples from each individual locus provides greater precision and slightly shorter and more meaningful calendrical ranges. While, based on the combined measurements of L.067, Phase 5 could have begun as early as 1942 BCE (Figs. 68, 69), unless this phase lasted 40 years or more, perhaps the upper bound for the harvest of the wheat in L.102 date provides a more probable terminus post quem of 1906 BCE (Figs. 68, 70). Prior to the additional measurement of VERA-2038W, the combined average of L.067 had an upper bound of 1916 BCE. Ideally, additional measurements should be carried out in other laboratories to increase preci-

[141] In the context of the aforementioned SCIEM2000 sub-project, two samples of ovicaprid bones from Gesher tombs 10 and 13 were submitted to VERA. Unfortunately, on two attempts each, no collagen survived the sample pretreatment.

[142] Note the slight difference in the reported values of the measurements published in 2006 and 2009; the latter ones have been used here.

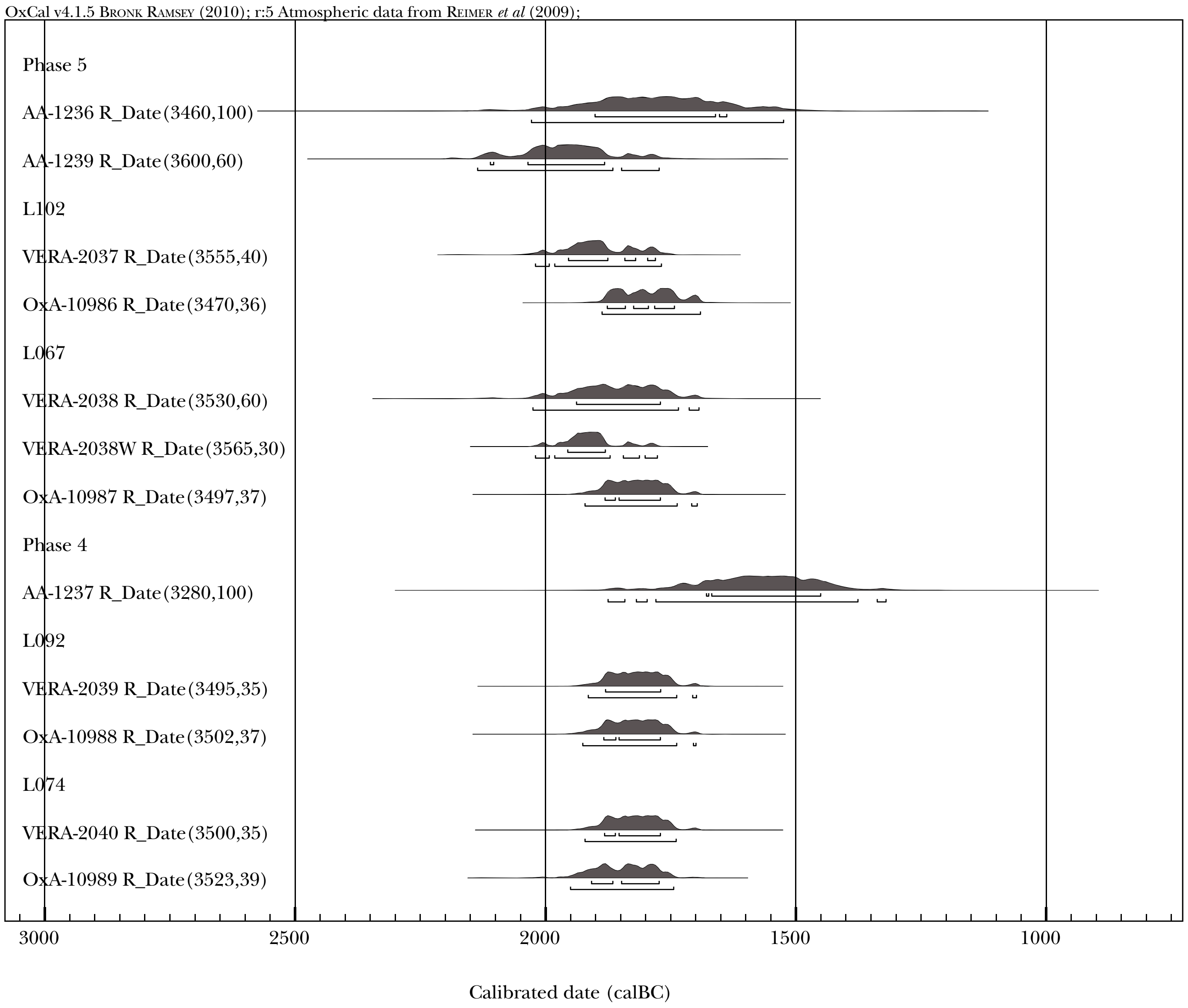

Fig. 68 Probability distribution of the radiocarbon determinations from MB I Phases 5 and 4 at Tell el-Hayyat

sion. In any event, the trimodal probability distribution of L.067 (Fig. 69) weighs more towards the 1921–1877 BCE range in 1 sigma. Phase 4 dates more probably in the 19th century BCE and is no higher than 1983 BCE (Figs. 68, 71–72). Note that the earlier AA series for both phases is largely consistent with the more recent and more precise suite of determinations, but that is not surprising given the broader calibrated ranges. If we were to assume that the entire suite of new determinations from Phase 5 represented the same harvest, their combination would result in an upper bound of 1922 BCE (Fig. 73). Similarly, the combination of all of the new data from Phase 4 would provide an upper bound of 1889 BCE (Fig. 74). Incorporating the stratigraphic sequence into a Bayesian model, using the boundary function for discrete phases, which slightly truncates the ends of the distributions, offers a 2 sigma range of 1921–1780 BCE for Phase 5 and 1884–1759 BCE for Phase 4 (Fig. 75). Thus, in any way of manipulating the data, it is much more likely that Phase 5 began in the latter half of the 20th century followed by Phase 4 in the 19th century. Therefore, an "early start" for Tell el-Hayyat around 2000 BCE is not supported by this suite of dates (*contra* Falconer & Berelov 2006: 62–63). That having been said, the beginning of MBA settlement of the Jordan Valley and the southern Levantine coastal plain appears to have been largely contemporaneous (Marcus 1998; 2003; Marcus *et al.* 2008; Bourke 2006: 243–244; this volume, Chapter 4), albeit at different scales and pace, demographically and spatially.

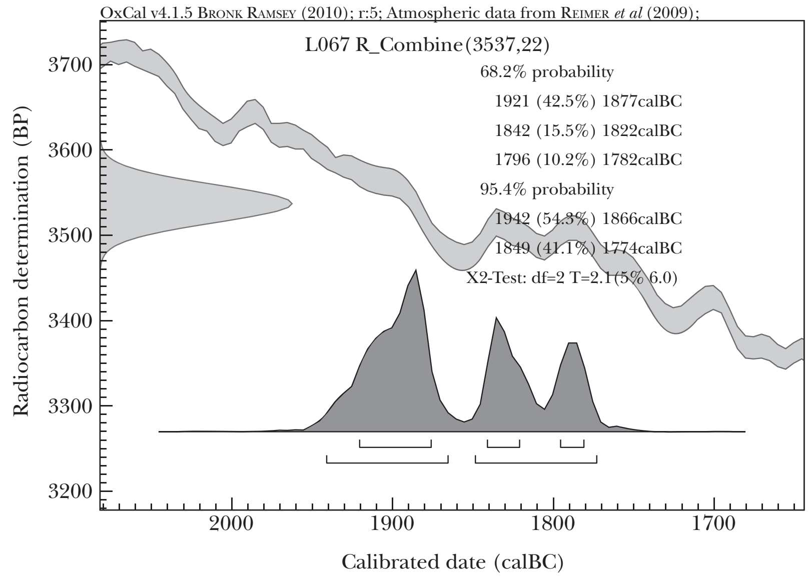

Fig. 69 Probability distribution of three combined radiocarbon determinations of Tell el-Hayyat, Phase 5, L.067

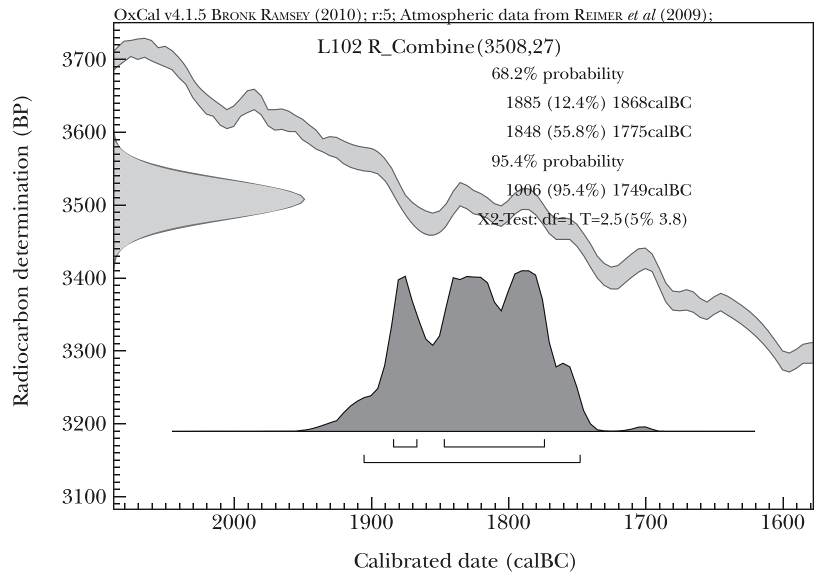

Fig. 70 Probability distribution of two combined radiocarbon determinations of Tell el-Hayyat, Phase 5, L.102

The three Pella dates (Table 9; Fig. 67) are a welcome addition to the radiocarbon dataset and suggest date ranges consistent with those produced for Tell el-Hayyat Phases 5 and 4 (cf. Bourke 2006: 243–244). However, further sampling and submission to multiple laboratories would increase precision and offer more meaningful calibrated ranges to the chronological discourse. The low precision of the lone Gesher date produces a calibrated range too great to be of use for the dating Tomb 13, apart from demonstrating that it is not inconsistent with other early MBA sites (Table 9; Fig. 67).

The subject of the relationship between the EB IV and the MB I cultures has recently been rekindled in the course of the analysis and publication of Gesher (Cohen 2007a, 136–137; 2009a) and Tell el Hayyat (Falconer & Berelov 2006; see this volume, Chapters 4–5). While this issue requires more consideration of the stratigraphic and ceramic parameters by which this relationship is assessed than can be dealt with here, the potential contribution of radiocarbon does not seem to have been fully explored. Bourke (2006: 243–244, table 1) suggests that the transition occurred sometime between 2100–1900 BCE. Unfortunately, there is a paucity of radiocarbon determinations on short-lived EB IV material. The exceptions are a single sample on olive stones from Bâb edh-Dhrâʿ: P-2573; 3770±60 BP = 2457–2026 BCE, 2 sigma (Weinstein 2003, table 22.2) and a suite of determinations from Tell Abu en-Niaj (Bronk Ramsey *et al*. 2002: 82). As this author noted in his comments to those determinations, *at least* a 200 year gap exists between the last phase of EB IV settlement at that site and the beginning of MB I settlement at Tell el-Hayyat. This gap has been confirmed by determinations on identical samples at VERA and will be published elsewhere. Thus, regardless of seeming ceramic similarities and suggested stratigraphic overlap, there is a sore need for radiocarbon sampling to bridge what may be a temporal divide between these two cultures.

The Middle Bronze Age III

Despite the extensive excavations all along the Jordan Valley corridor of sites that existed during the second half of the Middle Bronze Age, there is a surprising absence of radiocarbon determinations. The one light near the southern end of this corridor is a focused study that sought to precisely date the end of MB Jericho (Bruins & Van der Plicht 1995; 1996; 2003). Although this work incorporated both long- and short-lived samples, only the latter will be discussed here. The samples derive from the terminal destruction of MB Jericho and include various grains (wheat and barley). Although the calibrated ranges overlap in 2 sigma ranges, two of the samples, GrN-19063 and GrN-19064 seem, respectively, to be slightly later and earlier than the remaining four (Table 9; Fig. 67). The higher sample might represent a residual seed; the calibrated ranges of the former one favor a significantly lower date range, albeit again overlapping with the bulk of the samples in a 2 sigma range (Figs. 67, 76). Combining all but GrN-19063 results in a date of 1631–1531 BCE for the end of Jericho (Fig. 77); the upper bound is lowered by 7 calendar years if GrN-19064 is removed. If replicated by additional samples, GrN-19063 might hint at a longer lifespan for MB Jericho (Table 9; Figs. 67, 76).[143]

Conclusions

This first summary and analysis of the MB radiocarbon chronology demonstrates that a significant contribution can be made by focused, repetitive sampling and submission to multiple laboratories. As a result of work up until now, sufficient data exists to produce an independent "absolute" calendrical framework for the MB I and some direction regarding the termination of MB II–III. Ideally, excavators should seek to obtain samples for combined averages that can reach the levels of precision reflected in the calibration curve (±10–20 radiocarbon years). Once such approaches become de rigueur, radiocarbon will offer a new temporal meter stick for a myriad of processual questions in the Jordan Valley.

Acknowledgements

I want to express my appreciation to Aren Maeir for the invitation to make a small contribution to his volume, even if it did force me to type MB I and MB II–III more than once. The MB IIa Radiocarbon Project, which produced some of the data discussed here was made possible by a generous grant from the Jubily Fund of the City of Vienna, Austrian Academy of Sciences. I thank Professor Manfred Bietak for his invitation to participate in the SCIEM2000 project, his assistance in obtaining the necessary funding, and his constant support and encouragement. I also thank Dagmar Melman and Angela Schwab for their extraordinary administrative assistance and encouragement throughout. Christopher Bronk Ramsey and Tom Highham at ORAU and Walter Kutschera and Eva Wild at VERA provided input throughout my research. I would be remiss if I did not acknowledge the excavators, whose labors produced the samples I submitted, in this case Steven Falconer (Tell el-Hayyat). Even though no successful results emerged from the Gesher samples, I thank Y. Garfinkel (Gesher) for kindly giving me access to the animal bone collection, which I searched with the aid of L.K. Horowitz.

[143] Note that the inclusion of GrN-19063 in any combination with nearly all the other five measurements results in a failure of the χ^2 test; the only exception is a combination of GrN19063 and GrN-18542 passes.

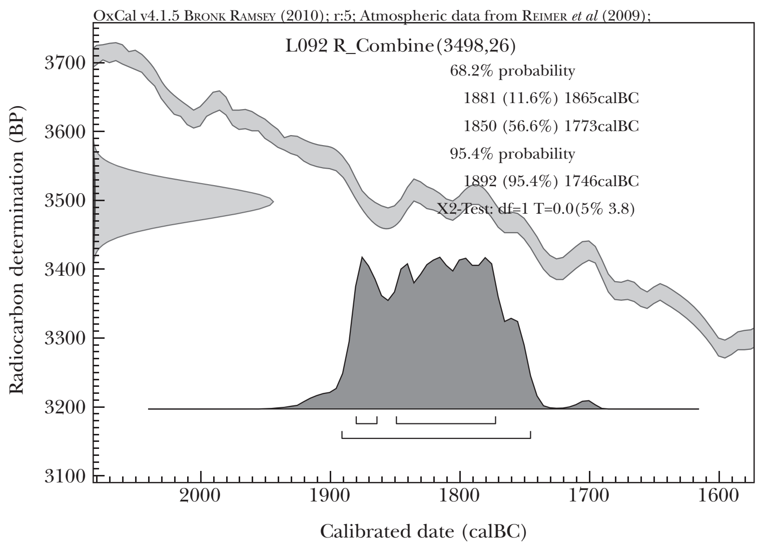

Fig. 71 Probability distribution of two combined radiocarbon determinations of Tell el-Hayyat, Phase 4, L.092

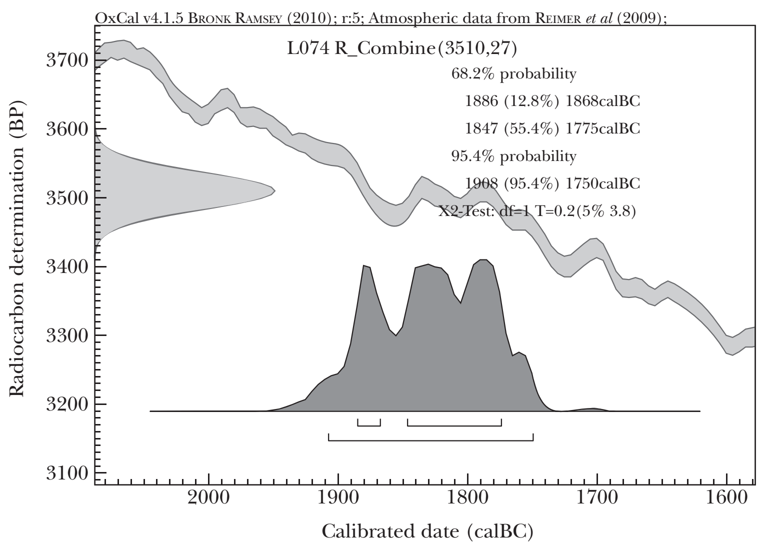

Fig. 72 Probability distribution of two combined radiocarbon determinations of Tell el-Hayyat, Phase 4, L.074

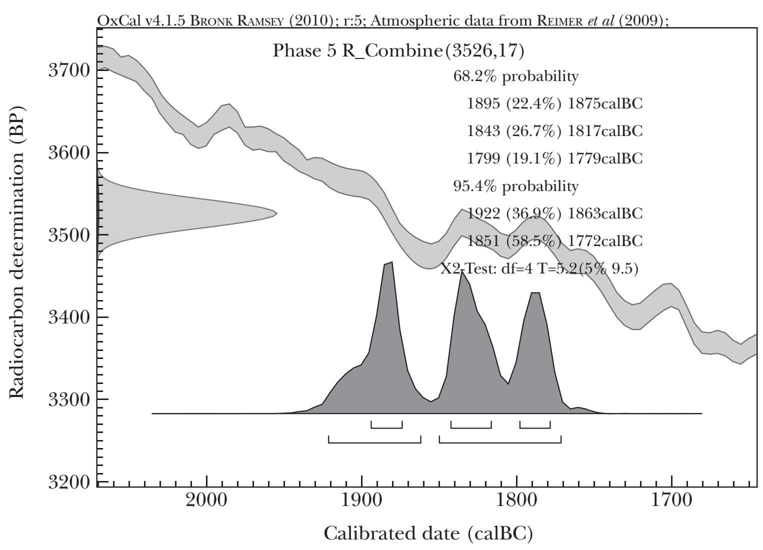

Fig. 73 Probability distribution of five combined radiocarbon determinations of Tell el-Hayyat, Phase 5

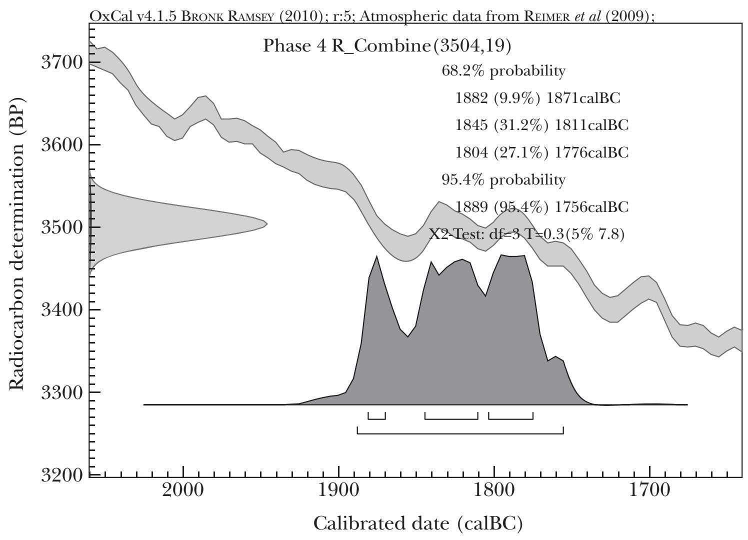

Fig. 74 Probability distribution of four combined radiocarbon determinations of Tell el-Hayyat, Phase 4

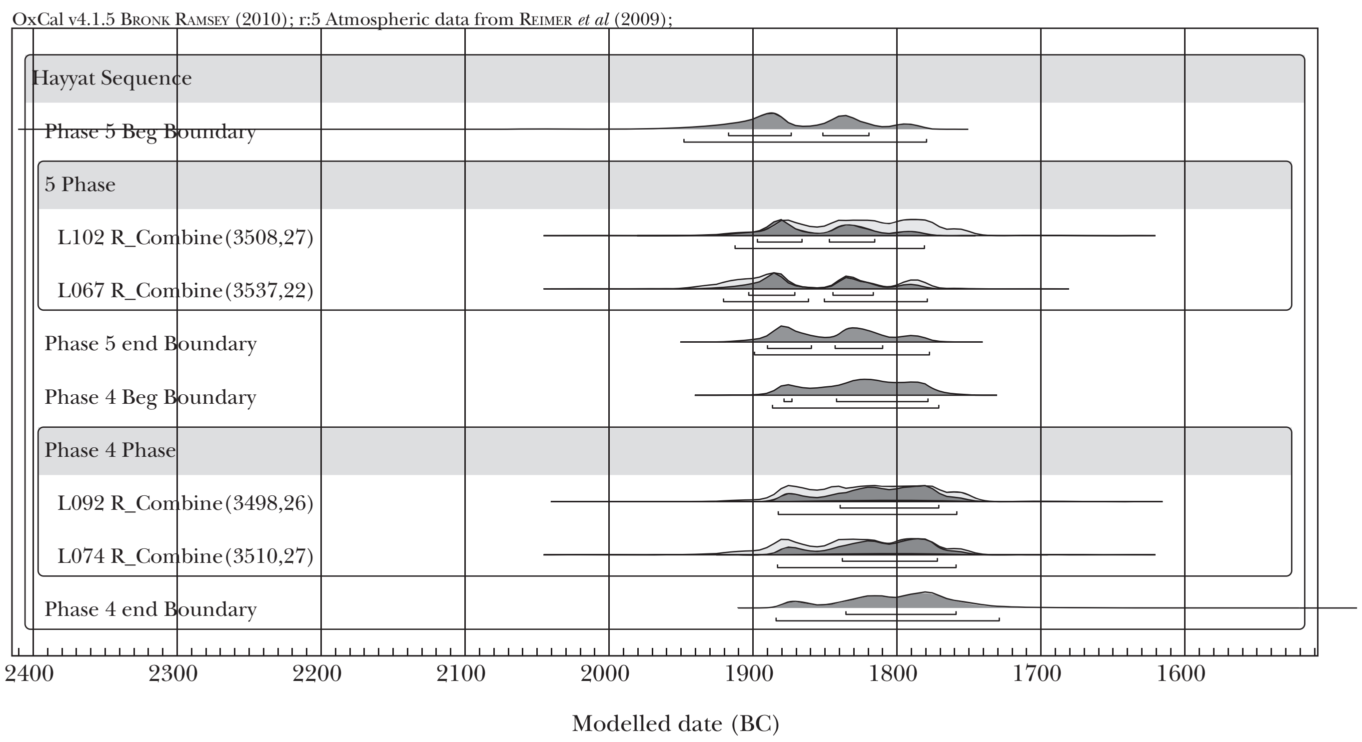

Fig. 75 A Bayesian sequence of Phases 5 and 4 at Tell el-Hayyat

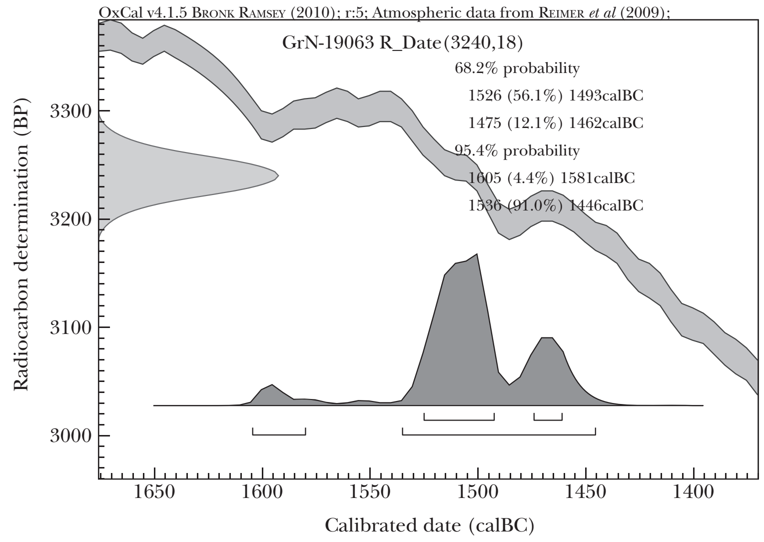

Fig. 76 Probability distribution of GrN-19063, a slightly lower date from the destruction of MB Jericho

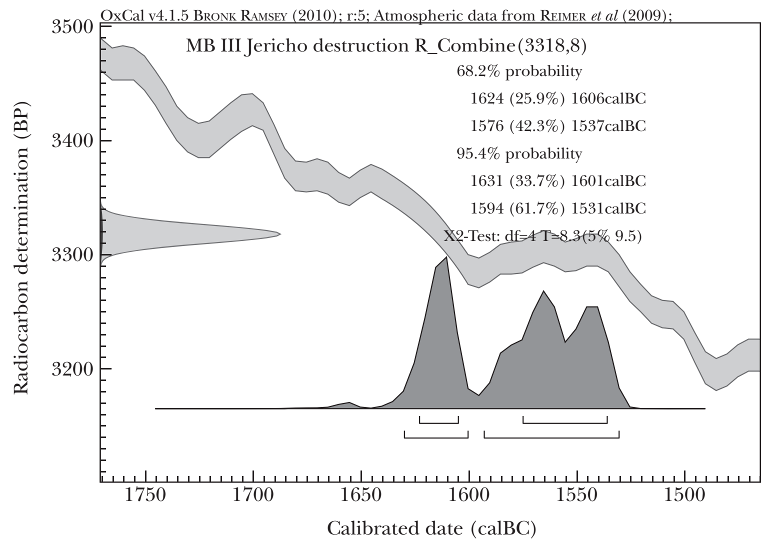

Fig. 77 Probability distribution of five combined radiocarbon determinations from the destruction of MB Jericho