SUPPLEMENTARY MATERIAL

A centennial ambiguity: the challenge of resolving the date of the Jean-Baptiste Lainé (Mantle), Ontario, site—around AD 1500 or AD 1600?—and the case for wood-charcoal as a *terminus post quem*

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1. Radiocarbon dates from Jean-Baptiste Lainé (formerly Mantle) = J-BL

The ^{14}C data employed in this paper are all previously published (Manning et al. 2018a). We list the samples and dates here and give the detailed *intra*-site phasings used in Manning et al. (2018a). In the present paper, however, we use only a more conservative two-stage intra-site phasing (see main text for explanation): EARLY and LATER. The EARLY samples = EARLY and all others (MID-LATE, LATE, VERY LATE) are considered as LATER. The MULTIPLE samples cannot be placed within the intra-site sequence and are employed only in the analyses where the whole site is treated as one `Phase`. For details of the laboratory methods, see Manning et al. (2018a). The eight wood-charcoal samples and dates that are the focus of this paper are shown in **bold**. The maize sample VERA-6221, marked **, has a $\delta^{13}C$ value (-15.7 ± 0.6) that deviates, or is close to deviating, from the expected values for maize. In Manning et al. (2018a) this sample was therefore excluded. However, since this $\delta^{13}C$ value was measured from the AMS, and thus is only approximate, and the ^{14}C age appears within the range of the other LATER samples from the site, we include it in the present study. VERA-6222 and VERA-6225HS, marked with the # symbol, were listed as “Multiple, Earlier? = Earlier” in Manning et al. (2018a). Here we have been conservative and treated both as MULTIPLE, since there is a lack of certainty around the assignment to the EARLIER phasing.

Lab ID	Site	Sample ID	Mantle Intra-Site Sequence Phasing	Material	δ^{13}C‰	SD	^{14}C Age BP	SD
Beta-217159	Mantle	365-130 Feature 253	Multiple	*Zea mays*	-7.6		370	40
GrM-13833	Mantle	159 435-180 Feature 427	Early	*Fragaria virginiana*	-25.59	0.12	373	15
GrM-13834	Mantle	159 435-180 Feature 427	Early	Wood-charcoal, *Fraxinus* sp.	-25.25	0.12	331	15
GrM-13835	Mantle	159 435-180 Feature 427	Early	Wood-charcoal, *Ulmus* sp.	-23.21	0.12	329	15
GrM-13837	Mantle	159 435-180 Feature 427	Early	Wood-charcoal, *Fagus* sp.	-24.61	0.12	320	15
GrM-13838	Mantle	91 535-190 Feature 718	Early	Wood-charcoal, *Fraxinus* sp.	-25.73	0.12	348	15
GrM-13839	Mantle	91 535-190 Feature 718	Early	Wood-charcoal, *Acer* sp.	-24.3	0.12	388	15
GrM-13840	Mantle	91 535-190 Feature 718	Early	Wood-charcoal, *Fagus* sp.	-25.45	0.12	338	15
GrM-13842	Mantle	144 415-155 Feature 648	Early	Wood-charcoal, *Acer* sp.	-24.01	0.15	469	15
GrM-13844	Mantle	144 415-155 Feature 648	Early	Wood-charcoal, *Fagus* sp.	-24.15	0.15	854	15
OxA-33078	Mantle	91 535-190 Feature 718	Early	*Zea mays*	-9.74	0.3	376	26
OxA-33079	Mantle	91 535-190 Feature 718	Early	*Zea mays*	-8.48	0.3	401	25
OxA-33080	Mantle	57 470-155 Feature 1005	Multiple	*Zea mays*	-8.90	0.3	356	25
OxA-33081	Mantle	40 450-120 Feature 1237	Late	*Zea mays*	-9.95	0.3	374	25
OxA-33082	Mantle	40 450-120 Feature 1237	Late	*Zea mays*	-8.68	0.3	414	25
OxA-33083	Mantle	21 495-165 Feature 934	Multiple	*Zea mays*	-10.00	0.3	423	25
UGAMS-22831	Mantle	House 20 Feature (support post)	Multiple	*Zea mays*	-8.7	0.1	330	25
UGAMS-22832	Mantle	Feature 709	Multiple	*Zea mays*	-9.2	0.1	360	25
VERA-6212	Mantle	144 4150155 Feature 648	Early	*Fragaria virginiana*	-26.6	0.7	353	37
VERA-6212_2	Mantle	144 415-155 Feature 648	Early	*Fragaria virginiana*	-28.9	1.2	368	38
VERA-6213	Mantle	91 535-190 Feature 718	Early	*Zea mays*	-8.9	0.7	349	32
VERA-6213_2	Mantle	91 535-190 Feature 718	Early	*Zea mays*	-7.9	1.0	335	35

VERA-6214	Mantle	159 435-180 Feature 427	Early	*Zea mays*	-8.5	0.5	357	36
VERA-6214_2	Mantle	159 435-180 Feature 427	Early	*Zea mays*	-6.5	1.1	351	34
VERA-6215	Mantle	166 400-200 Feature 492	Mid-Late	*Zea mays*	-8.6	0.8	370	38
VERA-6215HS	Mantle	166 400-200 Feature 492	Mid-Late	*Zea mays*	-5.7	0.6	333	34
VERA-6215_2	Mantle	166 400-200 Feature 492	Mid-Late	*Zea mays*	-8.9	1.2	281	34
VERA-6216	Mantle	126 530-165 Feature 709	Late	*Zea mays*	-11	0.8	316	34
VERA-6217	Mantle	36 465-125 Feature 1238	Very Late	*Zea mays*	-10.9	0.7	296	33
VERA-6217HS	Mantle	36 465-125 Feature 1238	Very Late	*Zea mays*	-10.1	0.7	344	33
VERA-6218	Mantle	164 370-185 Feature 238	Mid-Late/Late?	*Zea mays*	-8.2	0.7	342	36
VERA-6219	Mantle	40 450-120 Feature 1237	Late	*Zea mays*	-11.1	0.6	312	38
VERA-6220	Mantle	183 425-135 Feature 468	Late	*Zea mays*	-13.4	0.7	389	35
VERA-6220HS	Mantle	183 425-135 Feature 468	Late	*Zea mays*	-10	0.9	351	39
VERA-6221**	Mantle	207 335-180 Feature 156	Very Late	*Zea mays*	-15.7	0.6	324	35
VERA-6222#	Mantle	20 495-160 Feature 927B	Multiple	*Fragaria virginiana*	-29.5	0.7	361	34
VERA-6223Cu	Mantle	21 495-165 Feature 934	Multiple	*Zea mays*	-12	0.6	369	37
VERA-6223	Mantle	21 495-165 Feature 934	Multiple	*Zea mays*	-13.5	0.8	318	35
VERA-6223HS	Mantle	21 495-165 Feature 934	Multiple	*Zea mays*	-10.2	0.7	326	38
VERA-6224Cu	Mantle	57 470-155 Feature 1005	Multiple	*Zea mays*	-10.4	0.8	373	36
VERA-6224	Mantle	57 470-155 Feature 1005	Multiple	*Zea mays*	-12.1	0.7	326	37
VERA-6225HS#	Mantle	20 495-160 Feature 927B	Multiple	*Fragaria virginiana*	-29.7	0.7	408	33

2. Over-Compression of Site Durations

We raise the issue in the main text that in certain circumstances short `Phases` with increasingly intense dating information yield overly compressed calendar age estimates and site durations. We provide here discussion of five examples as relevant to the time period of this paper to illustrate the observation and its potential relevance.

To begin, we choose a straightforward period with no major reversal/plateau in the ^{14}C calibration curve. We consider a village site that was occupied either (i) 1420-1450 (31 total years) or (ii) 1430-1450 (21 total years). We have ^{14}C dates on short-lived samples from the site and so date it as a uniform probability `Phase` within `Boundaries`. We consider sets of ^{14}C dates of differing dating intensity equally distributed across the lifetime of the village in each case (sets of 62, 31, 16, 11, 7 and 4 dates for (i) and sets of 42, 21, 11 and 6 dates for (ii)). We assume 'perfect' dating accuracy/precision, and so draw the data from IntCal20 itself. **Figure S1** (a and b) shows the results for a `Date` query and an `Interval` query for each site `Phase`. We may observe as the number of dates per `Phase` increases that we end up with a compressed `Date` range for each `Phase`, with the 68.3% highest posterior density (hpd) estimates substantially less than the 'known' site duration. In a real-world situation, the dates are also unlikely to be evenly distributed within the `Phase` – this will potentially accentuate such narrowing if a number of the dates are, for example, more from one portion of the overall site occupation `Phase`. The `Interval` query results, however, exhibit a wider range. The question then is the effect of a constraint on the `Interval` query? **Figure S1c-f** shows the same models but with the `Interval` query applied with constraints of `N(20,10)` and `LnN(ln(20),ln(2))`. The constraint clearly tidies up the modelled distributions. In all cases the 68.3% range for the `Date` query is less than the known range, and, once the number of dated samples becomes high, even the 95.4% range can be a little less than the known range. The `Interval` query now produces ranges that are all within the expected range. It can be observed in addition that as the number of dated samples rise the `Interval` query results become a little too short. The 95.4% ranges all include the known value, but the 68.3% range becomes shorter with more dates and in the most intensively dated instances fails to include the known value. The results from the `N(20,10)` and `LnN(ln(20),ln(2))` constraints are very similar (as noted in Manning et al. 2020).

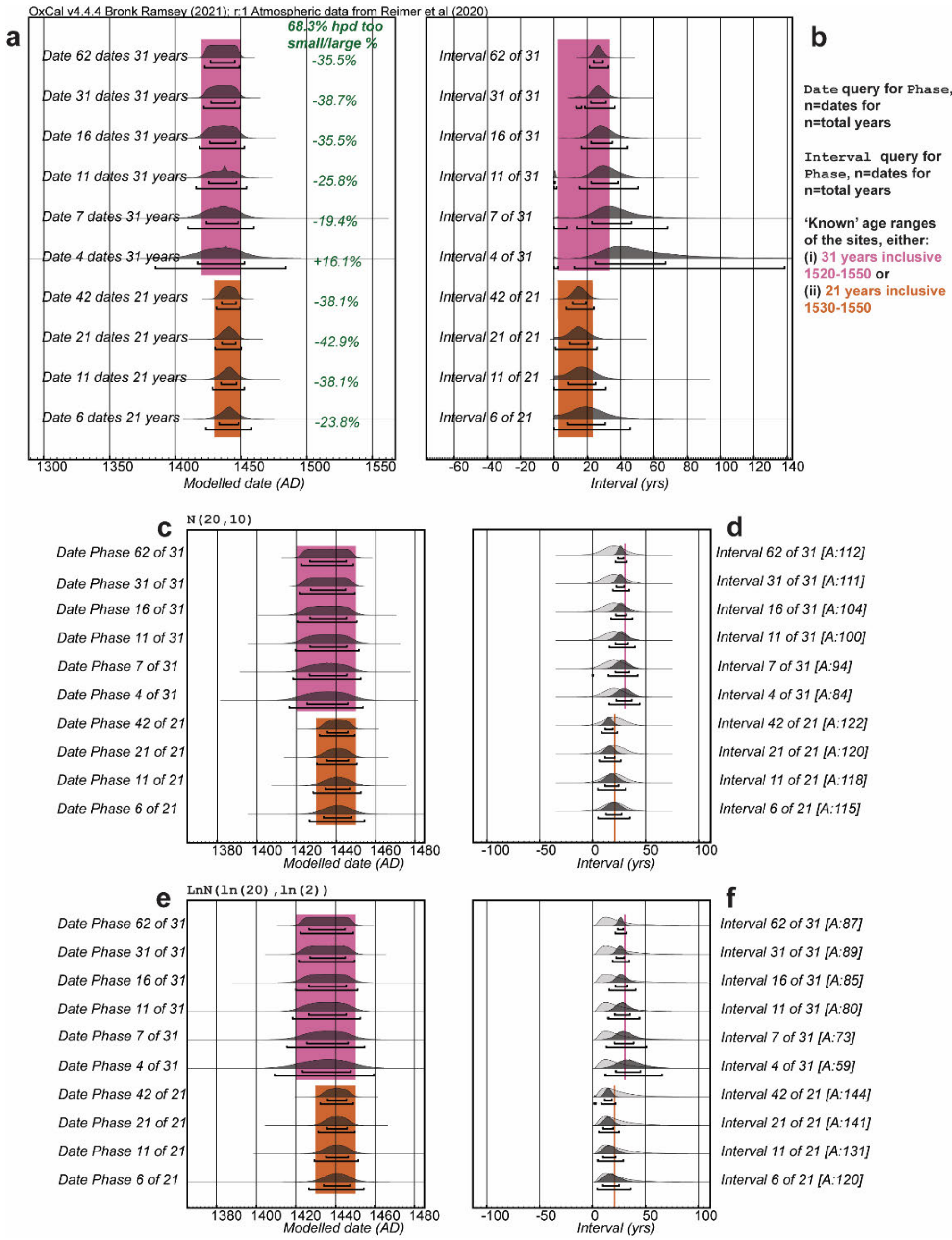

Figure S1*. Hypothetical extremely high-resolution dating models for sites of 'known' age (i) 1520-1550 (31 years in total) and (ii) 1530-1550 (21 years in total) representing a long-lived Late Woodland village. a. The sites are variously dated by (i) 4, 7, 11, 16 , 31 and 62 dates and (ii) 6, 11, 21, 42 dates evenly distributed across the site Phase with the ^{14}C dates drawn from the IntCal20 curve for the known year (so effectively a perfect result in each case). The dates are analyzed in a uniform probability Phase in each case. The results of a Date query are shown and compared with the known answer (colored bars). b. An Interval query applied to the Phase in is shown and are compared with the known answer. c. and d. The model re-run with N(20,10) and e and f LnN(ln(20),ln(2)) constraints applied to the Interval query in each case applied to the site Phase. For the Interval queries the light gray plot represents the constraint and the dark gray plot shows the modelled probability.*

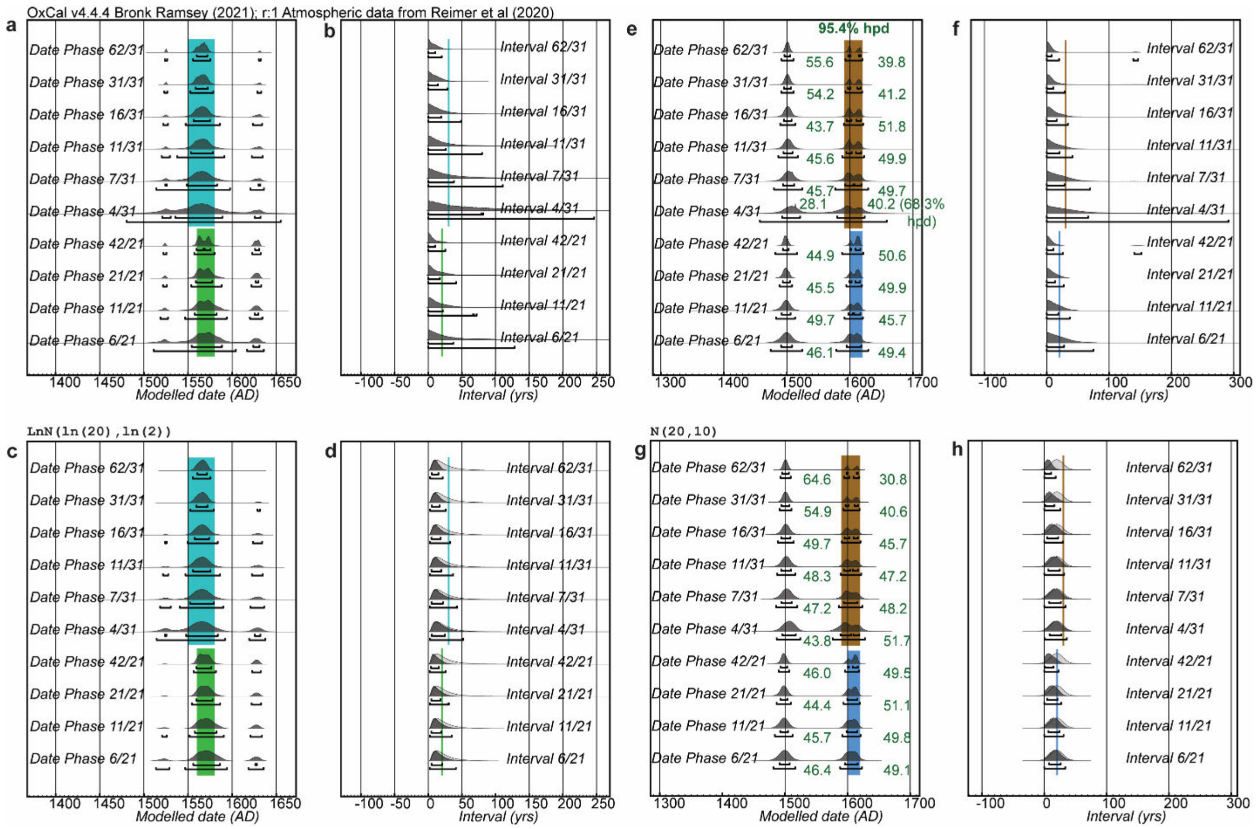

***Figure S2. a-d**. Models as in Figure S1 but for sites of 'known' age (i) 1550-1580 (31 years in total) and (ii) 1560-1580 (21 years in total). c. and d. show results of the model re-run with a LnN(ln(20),ln(2)) constraint applied to the Interval query. **e.-h.** The same but for 'known' ages of (iii) 1590-1620 (31 years in total) and (iv) 1600-1620 (21 years in total). **e.** and **f.** show results with no constraint applied to the Interval query applied to the site Phase whereas **g.** and **h.** show results with a N(20,10) constraint applied to the Interval query.*

Figure S2a-d considers a similar comparison but on a period with a reversal in the ^{14}C calibration curve (i) 1550-1580 (31 total years) and (ii) 1560-1580 (21 total years) and compares models with and without a `LnN(ln(20),ln(2))` constraint applied to an `Interval` query. Here, where the possible date ranges are more spread out and potentially ambiguous, a `LnN(ln(20),ln(2))` constraint makes a more obvious small improvement in the `Date` query ranges. The probabilities for the two ambiguous alternative ranges (earlier and later than the known range) are slightly reduced in all cases. The `Date` query range for the known site date period is improved a little for the cases with few samples. The `Date` queries with or without the `LnN(ln(20),ln(2))` constraint are a little compressed once the number of samples dated rises in both cases. The estimates of site length are more appropriate in the cases with smaller numbers of samples with the `LnN(ln(20),ln(2))` constraint applied, but slightly accentuate a trend to indicate too short ranges as the number of dated samples in the `Phase` increases.

Figure S2e-h does the same again but for the periods (i) 1590-1620 and (ii) 1600-1620 and compares models with and without a `N(20,10)` constraint applied to an `Interval` query.

With or without the `Interval` constraint, the `Phase` becomes compressed as the number of dates increase. In 15 of the 20 cases the 68.3% hpd range for the `Interval` query does not include the known site duration (of 21 or 31 years). The `N(20,10) Interval` constraint only makes a modest difference, but does increase the compression within the `Phase` a little. More particularly, it increases the probability for the incorrect earlier date range possibility. It is interesting that the longer, 31-years, `Phase` is rather more likely to achieve the incorrect date range with increased numbers of dates and with the addition of the `N(20,10) Interval` constraint. It is salutary to observe that a perfectly and very intensively dated site dating 1590-1620 (2 dates on samples from each and every year of the 31 years of site occupation), will in fact indicate a 55.6% probability for the ca. 100-years earlier incorrect age range within the 95.4% hpd (and 47.2% probability within the 68.3% hpd range) with no modelling beyond a uniform `Phase` (**Figure S2e**). This incorrect probability increases to 64.6% within 95.4% hpd if an `N(20,10) Interval` constraint is applied (**Figure S2g**). Hence, the correct dating of a short-duration site affected by this dating ambiguity, very much requires an additional constraint(s). An intra-site `Sequence` may well not be sufficient if it lies within a ca. 2-3 decade total site duration.

Finally, let us consider the same modelling approach applied to a site dating (i) 1570-1600 (31 total years) and (ii) 1580-1600 (21 total years): **Figure S3**. There is compression of the time durations for each of the alternative possible ranges whether with or without the `Interval` query constraints. However, the striking observation is that a 'perfectly' and intensively dated 21-year duration `Phase` with a known-age of 1580-1600 is mis-placed to an earlier possibility quite strongly as dating intensity increases across all three scenarios (from ≥11 evenly spaced dates). In the case of two dates per year for each of the 21 years of a site, there is in fact no dating probability at 68.3% hpd for the known age. This suggests that, when there is reasonable dating intensity, it may actually be quite challenging to resolve a site of around or less than 20-years in duration that dates ca. 1580-1600 without additional constraining information. Since it is generally argued that many of the larger later Late Woodland sites from the late 16th through earlier 17th century are of shorter total duration than those from the previous centuries (e.g. Warrick 1988), this could be a real issue requiring mitigation strategies via additional constraints. Developing techniques to resolve ambiguous or incorrect dates here is especially critical given that, within Iroquoian archaeology, 1580 has been established as a threshold for the early contact period, representing a "convenient" date for the onset of the formal French fur trade in northeastern North America (Chapdelaine 2016:151; Fitzgerald et al. 1993:45). Sites with few European derived metal finds and glass beads are typically assigned to the 1580-1600 Glass Bead Period I (Fitzgerald 1990). While historical documents and inscriptions establish a French and Basque presence in the St. Lawrence estuary at this time (Turgeon 1998; Plourde 2016), the differential nature and timing of the transmission of European goods and influences to communities further inland remains a contentious issue. Even those who maintain 1580 as a "key milestone" acknowledge that archaeological confirmation or refutation of this threshold is lacking (Chapdelaine 2016:151). Hence this investigation highlights the likely importance of TPQ information from wood-charcoal samples in such cases, which can hopefully expand the relevant time window being compared with the calibration curve sufficiently to overcome the ambiguity, or the taphonomic biases created by the calibration curve.

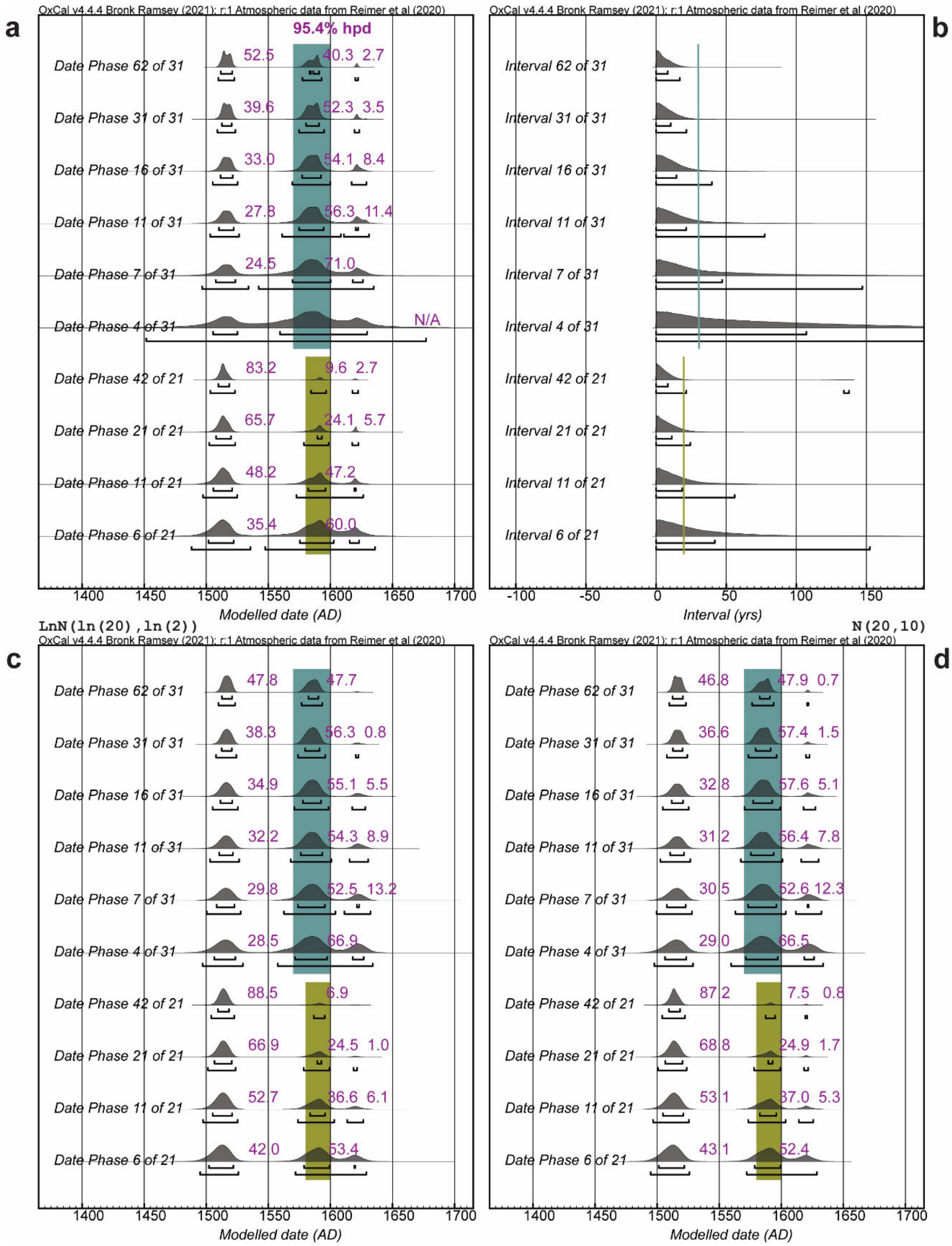

Figure S3. *Model as in Figure S1 for sites of 'known' age (i) 1570-1600 (31 years in total) and (ii) 1580-1600 (21 years in total). a. and b. show the model results for Date and Interval queries with no Interval constraint applied. c. shows the Date query results if a LnN(ln(20),ln(2)) constraint is applied to the Interval query, and d. the same if a N(20,10) constraint is applied to the Interval query.*

The model results shown in **Figures S1-S3** use the ‘perfect’ IntCal20 data and errors. The latter at about ±10 ^{14}C years are about two-thirds to half those for standard AMS ^{14}C dates run today (around ±15 to 20 ^{14}C years for this time period). The smaller errors accentuate the patterns observed, but, re-running with ±20 ^{14}C years measurement errors on all data nonetheless achieves generally similar characterizations. Thus even in the real world the issues of compression and probability bias noted remain as sampling intensity increases. For example, the incorrect earlier range probabilities with the `N(20,10) Interval` constraint in **Figure S2g** at 95.4% hpd change from (n=62/31) 64.6% to 54.4% or (n=31/31) 54.9% to 49.2% or (n=16/31) 49.7% to 48.1%, but continue to assign majority probability to the incorrect age range. The incorrect earlier range probabilities for the 21-year duration case in **Figure S3a** (no `Interval` constraint) change at 95.4% hpd from (n=42/21) 83.1% to 65.6% or (n=21/21) 65.7% to 46.3%, but again assign the majority of the probability to the incorrect range. The n=11/21 case sees a change with the larger errors. Probability changes from 48.2% to 33.1% for the earlier range and it is no longer the most likely range (1557-1632 receives 62.3% probability). The `LnN(ln(20),ln(2))` constraint case in **Figure S3c** sees a similar result. The probabilities favoring the incorrect early date range for the 21-year case at 95.4% hpd continue to do so, but reduce: from n=42/21 at 88.5% to 68.3% or (n=21/21) 66.9% to 50.2%. The switch occurs again with the larger errors in the n=11/11 case where probability changes from 52.7% to 39.7% for the incorrect early range, and the correct later range is part of the main probability range of 1569-1629 with 55.7% of hpd.

In general terms, a slight tendency to overly narrow the site duration range is a minor issue, but at high-resolution, and for a short site `Phase`, it can be a problem, particularly in ambiguous cases like **Figures S2e** and **S2g** and **S3**, where modest changes in probability allocation can create major differences in most likely modelled date placements. The more the site dataset is compressed in terms of calendar spread, the more we lose the benefits of any time-series shape within the site data helping to identify a specific ‘best fit’ versus the calibration curve (earlier versus later `Phase`, TPQ versus earlier versus later `Phase`, and so on). Thus, for example, a site with a hypothetical occupation period of e.g. 21 years length 1494-1514 and with wood-charcoal samples representing at least the previous 30 years would exhibit a start to end time-series running from 393±10 to 341±9 ^{14}C years BP if the data perfectly reflected IntCal20 with a clear decreasing trend in values over time of around 50 ^{14}C years. A similar time series for a site dated 1605-1625 is quite different. The TPQ data should cover 330±10 to 366±10 ^{14}C years, an increasing trend, and in reverse the earlier to later site data will potentially see as much as a ca. 30 years decrease from around 366±10 to 329±10 ^{14}C years BP. There are two distinct stories here, and, with adequate resolution, a specific match with the calibration curve could become evident. However, as series length is compressed, we lose these identifying properties. In the two cases just mentioned, the average value for the 21-year overall site occupation is the same at around 351 ^{14}C years BP, and all distinction is lost without the wider timeframe information.

Therefore, in light of these concerns and complications, wherever possible, it should be part of dating strategy when working with short-duration sites to include (i) the intra-site `Sequence` if one is available, and (ii) ‘post’ information via a TPQ from wood-charcoal in order to improve the prospects of ruling out alternative short calendar periods represented by otherwise similar ^{14}C ages. Both these strategies also help defend against over-compression of the site timeframe which exacerbates the same ambiguity problem – an inherent issue with short-duration sites where there are higher numbers of dates with good precision and accuracy. Indeed, we may hypothesize that deliberately dating tree-rings that are *not* among the most recent available, but which therefore accentuate the 'post' in the TPQ, and make the derived TPQ a TPQ for the entire site `Phase` (dated by the short-lived samples) can be very useful. The issues noted above all apply to J-BL.

3. Descriptions of the Models in Figures 1 to 12 and S1 to S5

Figure 1: Draper model. Data from Manning et al. (2018a: Table S1) The OxCal Charcoal Outlier_Model is applied to the dates on wood-charcoal. The OxCal General `Outlier_Model` is applied to dates on short-lived plant remains. The site is modelled as a single `Phase` between a start and an end `Boundary`. A `Date` query is applied to the site `Phase`. This yields a description of the dating probability for the site `Phase`, between the start `Boundary` and the end `Boundary`. No further constraints are applied.

Figure 2: Jean-Baptiste Lainé (J-BL) (Mantle) short-lived plant remains only. Data from Manning et al. (2018a: Table S1). These models use only the radiocarbon dates on short-lived plant material. Multiple dates on the same sample are combined. The OxCal General `Outlier_Model` is applied to the weighted averages or the single dates on short-lived plant material. In **Figure 2a** only those dates associated with the intra-site `Sequence` are considered (following Manning et al. 2018a) (generally for a discussion and details of the archaeologically identified and described intra-site phasing of the site, see Birch and Williamson 2013: 65-77; ASI 2012) and the site is modelled as a `Sequence` with successive `Phases` all within `Boundaries`. A `Date` query is applied to each `Phase`. In **Figure 2b** all the dates available on short-lived plant remains are considered (adding those not associated with the intra-site `Sequence`) within a single site `Phase` within a start and an end `Boundary` and with a `Date` query applied to this site `Phase` (so ignoring the intra-site `Sequence`). No further constraints are applied.

Figure 3: Warminster. The dates on short-lived plant material are combined into weighted averages. Date from Manning et al. (2018a: Table S1). To maintain consistency with past published work, as in the Manning et al. (2018a; 2019) papers, an additional 8 ^{14}C years error is added to each `R_Combine`. There is a single site `Phase`. The radiocarbon dates on specific sets of annual-growth tree-rings from a series running from rings 1-57 (Relative Years, RY, 1-57) from the wood post sample are wiggle-matched using the `D_Sequence` function with the known (tree-ring defined) `Gap` command applied between the `R_Date` for each sample. The OxCal SSimple `Outlier_Model` is applied to each date within the `D_Sequence`. A `Date` query is applied to estimate the last extant tree-ring (RY57). Since the wood post is missing its original exterior tree-rings (unknown number from several to a couple of decades or more), this last extant tree-ring sets a clear TPQ. A cross reference applies this TPQ via an `After` function to the site `Phase`. No further constraints are applied.

Figure 4: Jean-Baptiste Lainé (Mantle) radiocarbon dates (n=8) on wood-charcoal. **Figure 4a** shows the calibrated calendar age probabilities with no modelling and indicates the earliest date within each of the most likely 68.3% calibrated age ranges. **Figures 4b** and **4c** show the effects of in-built age modelling for the wood-charcoal dates from Jean-Baptiste Lainé (Mantle). We compare the application of the Charcoal `Outlier_Model` (Bronk Ramsey 2009b), the Charcoal Plus `Outlier_Model` (Dee and Bronk Ramsey 2014), and an exponential `Phase` model (using a `Tau_Boundary` paired with a `Boundary`), to allow approximately for the in-built age present and to quantify a dating estimate for an end `Boundary` for a `Phase` comprising these wood-charcoal dates. **Figure 4b** shows all three `Phase` models; **Figure 4c** shows the details for the respective end `Boundaries`.

Figures 5, 6, 7: in-built age incorporated into the simplified Jean-Baptiste Lainé (Mantle) intra-site `Sequence` (Early and Later `Phases`). The 'simplified' intra-site `Sequence` comprises just Early and Later `Phases` following the discussion of Birch and Williamson (2013: 65-77). In the Manning et al. (2018a) paper we employed additional `Phases` within the intra-site `Sequence` based on the detailed analysis of the site data from ASI (2012) as shown in **Figure 2a** (`Phases`: EARLY, MID-LATE, LATE, VERY LATE). We retain these designators in the labels for each sample for reference, but here we have placed all the MID-LATE to VERY LATE samples into one Later `Phase`. We do this in the current study as the Early to Later differentiation within the site history is very clear, whereas we accept that the additional sub-divisions involve more elements of inference and interpretation, and so might be considered too subjective under a strong skeptical gaze. The models in **Figures 5-7** thus use the **Figure 2a** model (short-lived plant remains that link with specific parts of the intra-site `Sequence` for the Jean-Baptiste Lainé (Mantle) site), but simplified as just outlined, and add in the 8 dates on wood-charcoal samples from Early contexts. In **Figure 5** the whole model is shown and the Charcoal `Outlier_Model` is applied to these wood-charcoal dates. In **Figure 6** a summary of the results with the same model but applying the Charcoal Plus `Outlier_Model` are shown. In **Figure 7** an exponential `Phase` containing the wood-charcoal dates—which are known to be exaggerating the in-built age offset and hence are before the site occupation period—is placed as *before* the `Sequence` with all the dates on Short-lived plant samples from the site.

Figures 8, 9: in-built age incorporated into models using all the Jean-Baptiste Lainé (Mantle) dates. As noted above, only 21 of the 33 radiocarbon dates on short-lived plant remains from the site are associated with a specific point within the intra-site `Sequence`. Twelve dates relate to contexts that are associated with multiple use periods within the intra-site `Sequence` and cannot be further refined. These samples are labelled as MULTIPLE in the Figures. We bring these samples into the analysis. **Figure 8** uses the **Figure 5** model but within an overall site `Phase` that includes, independently, a second `Phase` with the other site dates on non-specific (multiple) use contexts—with the wood-charcoal dates with the Charcoal Plus `Outlier_Model` applied also in this separate `Phase` (i.e. the wood-charcoal dates act as a Charcoal Plus `Outlier_Model` TPQ both for the intra-site `Sequence` and for the separate non-defined site `Phase` dates – the second use of these dates are labelled with extra preceding 'a' in the Multiple context `Phase`). A `Date` query applied to the overarching `Phase` offers a date estimate for the overall J-BL site. **Figure 9** uses the **Figure 7** approach but with the expanded site model with all dates on short-lived plant remains as in **Figure 8**. The TPQ

Boundary from the exponential Phase with the wood-charcoal dates is applied by a cross-reference to both the Phase with the dates from multiple contexts and to the Phase with the intra-site Sequence.

Figure 10: dating model for the Jean-Baptiste Lainé (Mantle) site placing all data (on short-lived samples and wood-charcoal) within a single site Phase (thus ignoring the intra-site Sequence) with the dates on wood-charcoal applying the in-built TPQ element involved via use of the Charcoal Outlier_Model.

Figure 11: This figure shows a summary of runs of simulation models for sites dated 1500 and 1600 with 10 simulated radiocarbon dates on short-lived samples and variously 1 to 10 dates simulated on wood-charcoal samples with the Charcoal Outlier_Model applied. The figure shows how many runs produced results with satisfactory Convergence values (≥95) with 10+% and 20+% probability assigned to an incorrect older or earlier date range within the 95.4% hpd ranges. For details of the models and some examples of these, see section 3 below.

Figure 12: This figure shows the probabilities of an (incorrect – see main text) too old (pre-1541) date within either the Start (S) Boundary or End (E) Boundary for J-BL under a range of scenarios with variously 1-8 wood-charcoal dates included progressively either from most recent (mR = GrM-13837) or oldest (vO = GrM-13844) or via a mixture from mR, 'middle' = M = GrM-13838, 'old' = O = GrM-13842 or vO using the Charcoal (CHAR) or Charcoal Plus (CHAR+) Outlier models or via the Tau_Boundary paired with a Boundary model with this End Boundary cross-referenced as the Start Boundary for the Site Sequence/Phase. Only data where the Convergence was ≥95 included. Where the 95.4% range included substantial probability (around or >50%) in the too old range but comprised a single range, then an arbitrary value of 60% was attributed. The figure shows the analysis both for the J-BL site data from secure contexts within the intra-site Sequence with the End Boundary treated as a TPQ and cross-referenced as the Start Boundary for the Site Sequence or Site Phase (A), and the case of the J-BL site data when treated as one single Phase and including all available ^{14}C dates (B). The grey bar in each case indicates probabilities of ≤10% for the 'early' date range within the 95.4% hpd ranges. The data come from OxCal and IntCal20 with calibration curve resolution set at 1 year.

Figures S1, S2, S3: investigation of Phase duration narrowing and the effects of Interval query constraints. **Figure S1a** and **S1b** show two illustrative models where sites with real dates (i) 1520-1550 (31 years in total) representing a long-lived Late Woodland village, and (ii) 1530-1550 (21 years in total) representing an 'average' Late Woodland village, are dated by differing numbers of evenly distributed radiocarbon dates from these years, with the radiocarbon dates taken from IntCal20 for the relevant calendar years. The dates are analyzed in a uniform probability Phase. The results of a Date query and an Interval query applied to the Phase in each case are shown and compared to the known answer. **Figure S1c** and **S1d** show the models in **Figure S1a** and **S1b** re-run but with N(20,10) and LnN(ln(20),ln(2)) constraints applied to the Interval query in each case. **Figure S2a-S2d** considers a second hypothetical case, on the same principles, but for a reversal/plateau period on the calibration curve (i) 1550-1580 and (ii) 1560-1580, comparing a model with no constraint applied to the

Interval query for each Phase, versus a model with the LnN(ln(20),ln(2)) constraint applied in each case. **Figure S2e-S2h** considers a third hypothetical case, again on the same principles, but for the period on the calibration curve (i) 1590-1620 and (ii) 1600-1620, comparing a model with no constraint applied to the Interval query for each Phase, versus a model with the N(20,10) constraint applied in each case. **Figure S3** considers the further case of (i) 1570-1600 and (ii) 1580-1600 on a similar basis.

Figures S4, S5: examples of how complications can ensue and especially when over-compression of a Phase is an issue, but also how clear indications become evident for why we may reject this alternative date placement. **Figure S4** re-runs the **Figure 5** model but adds a N(20,10) constraint to the Interval query for the overall site Phase. **Figure S5** re-runs the **Figure 8** model (all site data) but adds a N(20,10) constraint to the Interval query for the overall site Phase. The OxCal Amodel/Aoverall values are very poor, well below the satisfactory threshold of ca. 60, and several individual elements show poor Agreement values.

4. Distinguishing Unsatisfactory Model Results

As noted in the main text, various runs, and use of other model variations, can lead to model runs that complete and even with satisfactory Convergence values and yet find the earlier date solution. But in such cases the $A_{model}/A_{overall}$ values are well below the satisfactory level and a number of individual samples exhibit poor Agreement values (see for two examples **Figures S4, S5**). **Figures S4** and **S5** show two such examples where models complete offering this solution: **Figure S4** uses just the dates from specific contexts within the intra-site Sequence and **Figure S5** uses all the data. **Figure S1** includes the wood-charcoal dates in the Early Phase of the intra-site Sequence but adds a N(20,10) constraint to a Difference query applied to the overall site duration (start and end Boundaries). **Figure S5** applies a N(20,10) constraint to an Interval query applied to the overall site Phase. In each case, the addition of the extra constraint acts very slightly further to compress the date range for the site Phase(s). This in turn allows the entirety of the dating information to be compressed into a common range in the first decades of the 16th century. In these two instances the elements of the models report satisfactory Convergence values (≥95): as noted, in a number of cases runs of various models offering either the older placement or a split either/or placements were characterized by—and ruled out because of—reporting poor Convergence values for a number of elements within the model. Of course, this older date range is the date range previously assigned to the site! However, is this plausibly a satisfactory solution even when the Convergence values are acceptable? As evident from the two cases shown in **Figures S4** and **S5**, it is in fact clearly problematic. The A_{model} values are both well below the satisfactory threshold value of 60 at 29 and 16 (the $A_{overall}$ values are respectively 32 and 16). As indicated by the arrows in **Figures S4** and **S5**, several of the elements (5 and 8 respectively) of the model offer poor individual Agreement values less than 60. In particular: two or three of the dates on wood-charcoal in each case. These data (GrM-13835, GrM-13837 and in **Figure S4** also GrM-13834) struggle to accommodate this early date range within their probability and instead point to a more recent age range. These models and results must therefore be regarded as unsatisfactory. The over-compression encouraged in **Figures S4** and **S5** (and similar cases) yields a result that is clearly not as compatible with the available radiocarbon data as the alternative models and solutions in **Figures 8-10**. From an archaeological-material perspective, this independently-derived early 16th century date range would also place J-BL earlier, or earlier to partly contemporary with, the independently-derived date range for the occupation of the Draper site (**Figure 1**). This would run against long-understood basic archaeological knowledge about materially-derived relative sequences and cultural process (Birch and Williamson 2013; ASI 2012).

Overall, the general observation is that models can complete and indicate the earlier date range. However, across the course of a number of runs of several different models and variations on these (some discussed or illustrated here), in all cases of models that incorporate appropriately the dates on wood-charcoal, those finding the early date solution (or an ambiguous solution) exhibit unsatisfactory A_{model} and $A_{overall}$ values and sometimes unsatisfactory Convergence values. We can thus reject all these models as unsatisfactory based on these criteria. In reverse, only models that resolve the more recent date range offered satisfactory diagnostic values. Hence we regard this recent date around 1600 as the robust date for the J-BL site.

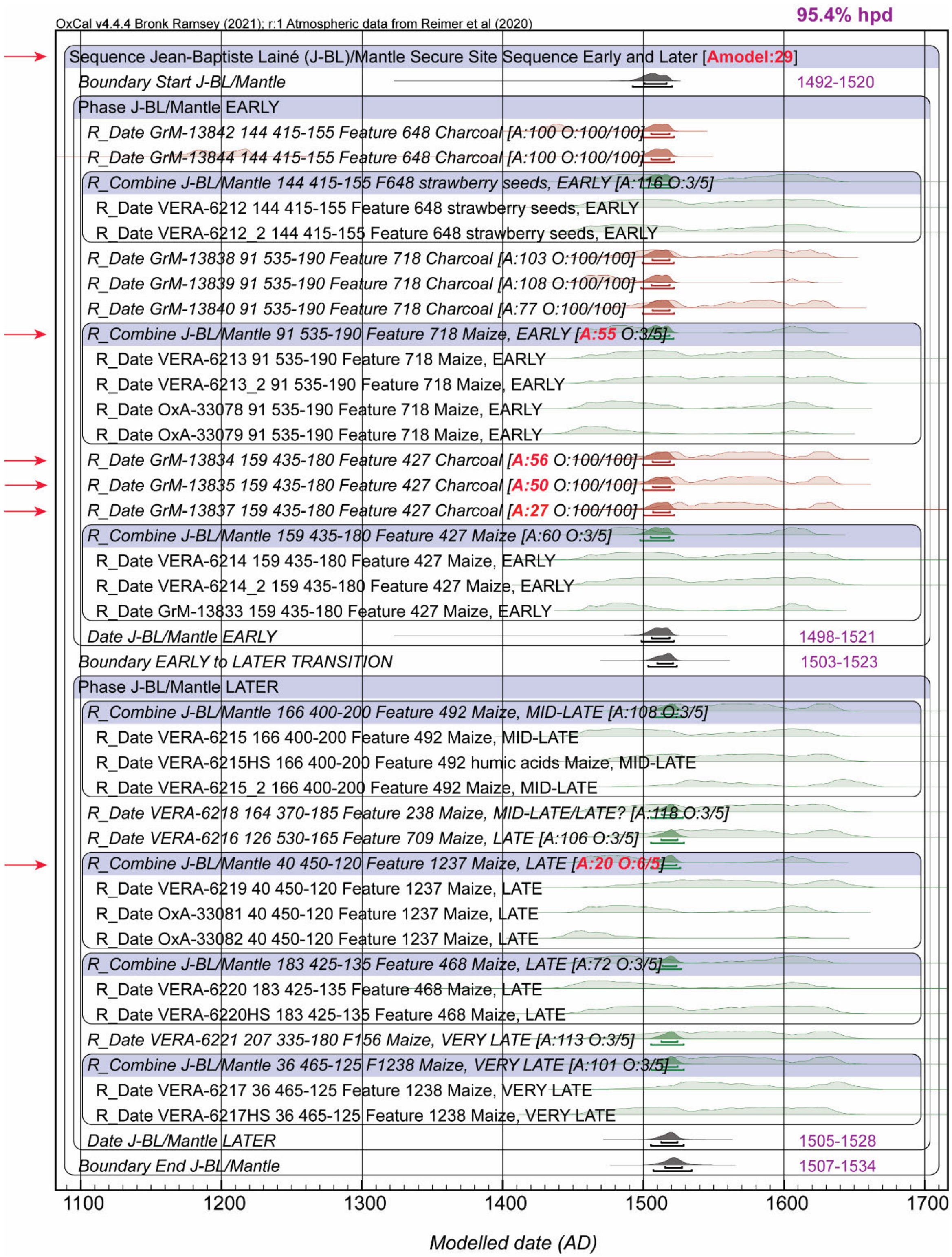

***Figure S4**. A re-run of the model in Figure 5 but adding a `N(20,10)` constraint to the `Interval` query for the overall site `Phase`. The elements of the model that have poor overall or individual agreement or are outliers are highlighted in red and with the arrows.*

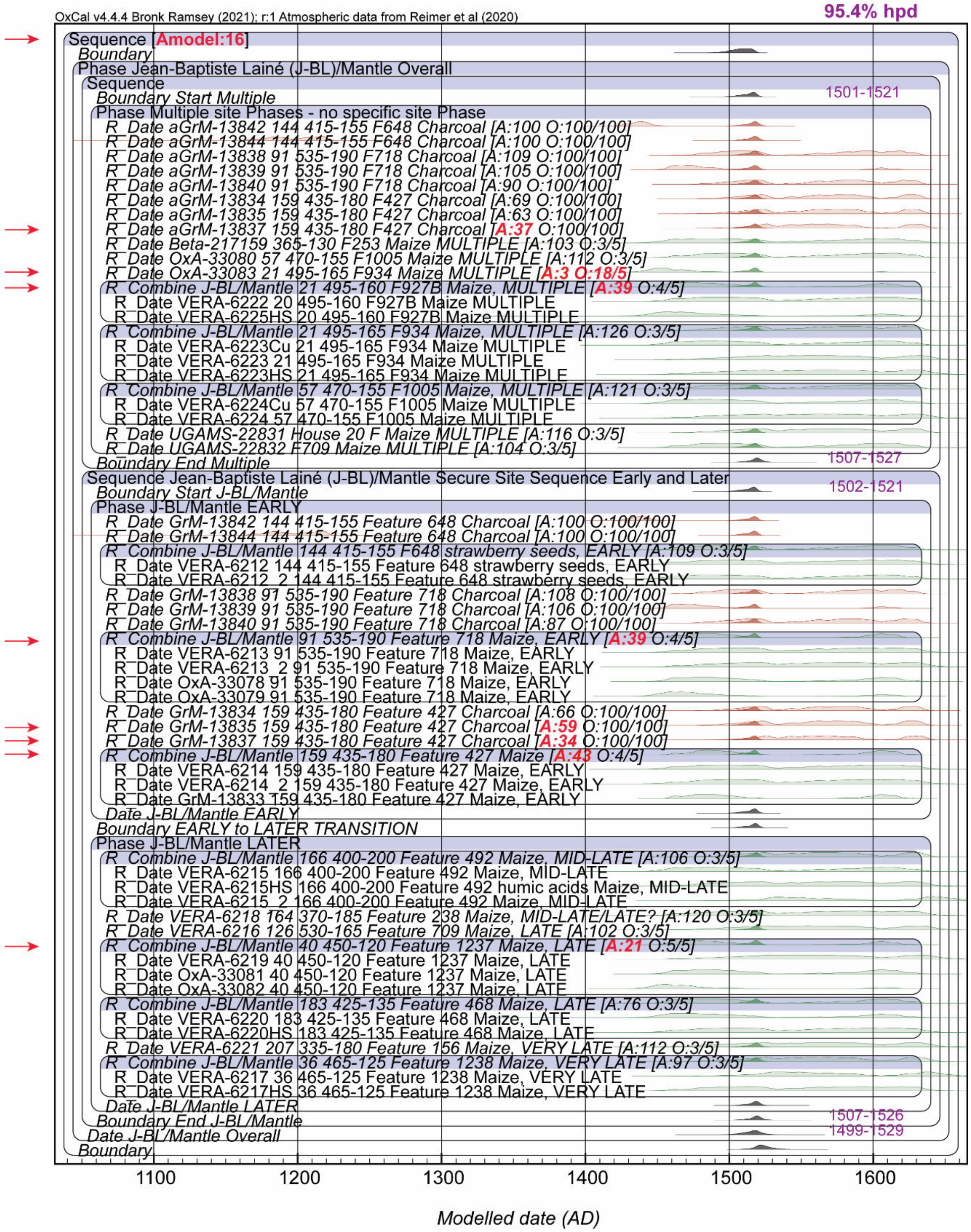

Figure S5*. A re-run of the Figure 8 model (all site data) but adding a* `N(20,10)` *constraint to the* `Interval` *query for the overall site* `Phase`*. The elements of the model that have poor overall or individual agreement or are outliers are highlighted in red and with the arrows.*

5. Models used for Figure 11

The models employed for the simulations reported in **Figure 11** were of the forms below. We give examples for 10 wood-charcoal date TPQs and 3 wood-charcoal date TPQs for the 1500 case and 7 wood-charcoal date TPQs and 4 wood-charcoal date TPQs for the 1600 case. The wood-charcoal dates are labelled as 'C'. In each case the site is dated by 10 dates on short-lived (annual) samples (labelled 'S'). The OxCal Charcoal `Outlier_Model` is applied to each of the wood-charcoal dates. Calibration curve resolution was the OxCal default of 5 years and the default kIterations value was employed. See also **Figures S6-S9** below which show examples results for these instances. Note: the examples illustrated are chosen to show a range of the outcomes, from those that conform well with the 'known' age range (e.g. **Figure S6**) to those where the incorrect (in this case late) age range is instead found to be most likely (e.g. **Figure S7**). Note: in the re-run of the 1500 case with results summary shown in **Figure S10** we used the same model form but with 30 randomly simulated short-lived samples for 1500 in each site `Phase`. We also increased the kIterations value to 3000.

```
Plot()
 {
  Outlier_Model("Charcoal",Exp(1,-10,0),U(0,3),"t");
  Sequence("10 wood-charcoal dates")
  {
   Boundary();
   Phase("Site")
   {
    R_Simulate("1C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("2C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("3C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("4C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("5C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("6C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("7C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
```

```
    R_Simulate("8C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("9C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("10C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("S1",1500,15);
    R_Simulate("S2",1500,15);
    R_Simulate("S3",1500,15);
    R_Simulate("S4",1500,15);
    R_Simulate("S5",1500,15);
    R_Simulate("S6",1500,15);
    R_Simulate("S7",1500,15);
    R_Simulate("S8",1500,15);
    R_Simulate("S9",1500,15);
    R_Simulate("S10",1500,15);
    Date("Date Site10C");
   };
   Boundary();
  };
};


Plot()
 {
  Outlier_Model("Charcoal",Exp(1,-10,0),U(0,3),"t");
  Sequence("3 wood-charcoal dates")
  {
   Boundary();
   Phase("Site")
   {
    R_Simulate("1C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("2C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("3C",1500+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("S1",1500,15);
    R_Simulate("S2",1500,15);
    R_Simulate("S3",1500,15);
    R_Simulate("S4",1500,15);
    R_Simulate("S5",1500,15);
    R_Simulate("S6",1500,15);
    R_Simulate("S7",1500,15);
    R_Simulate("S8",1500,15);
```

```
    R_Simulate("S9",1500,15);
    R_Simulate("S10",1500,15);
    Date("Date Site");
   };
   Boundary();
  };
 };

Plot()
 {
  Outlier_Model("Charcoal",Exp(1,-10,0),U(0,3),"t");
  Sequence("7 wood-charcoal dates")
  {
   Boundary();
   Phase("Site")
   {
    R_Simulate("1C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("2C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("3C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("4C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("5C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("6C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("7C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("S1",1600,15);
    R_Simulate("S2",1600,15);
    R_Simulate("S3",1600,15);
    R_Simulate("S4",1600,15);
    R_Simulate("S5",1600,15);
    R_Simulate("S6",1600,15);
    R_Simulate("S7",1600,15);
    R_Simulate("S8",1600,15);
    R_Simulate("S9",1600,15);
    R_Simulate("S10",1600,15);
    Date("Date Site");
   };
```

```
   Boundary();
  };
 };


Plot()
 {
  Outlier_Model("Charcoal",Exp(1,-10,0),U(0,3),"t");
  Sequence("4 wood-charcoal dates")
  {
   Boundary();
   Phase("Site")
   {
    R_Simulate("1C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("2C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("3C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("4C",1600+(100*rand())*ln(rand()),15)
    {
     Outlier("Charcoal",1);
    };
    R_Simulate("S1",1600,15);
    R_Simulate("S2",1600,15);
    R_Simulate("S3",1600,15);
    R_Simulate("S4",1600,15);
    R_Simulate("S5",1600,15);
    R_Simulate("S6",1600,15);
    R_Simulate("S7",1600,15);
    R_Simulate("S8",1600,15);
    R_Simulate("S9",1600,15);
    R_Simulate("S10",1600,15);
    Date("Date Site");
   };
   Boundary();
  };
 };
```

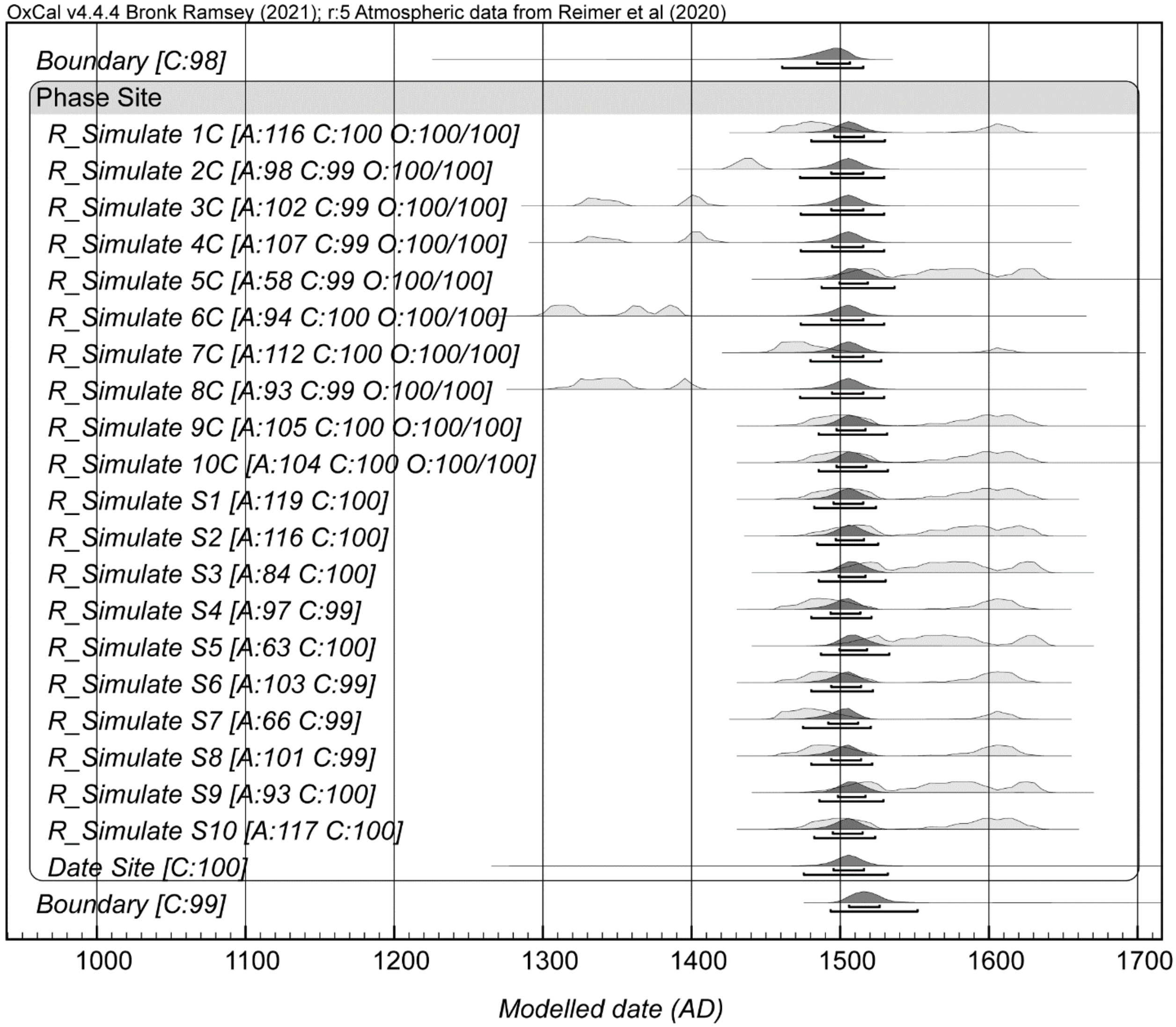

Figure S6. *Example of the 10 wood-charcoal dates TPQ 1500 model.*

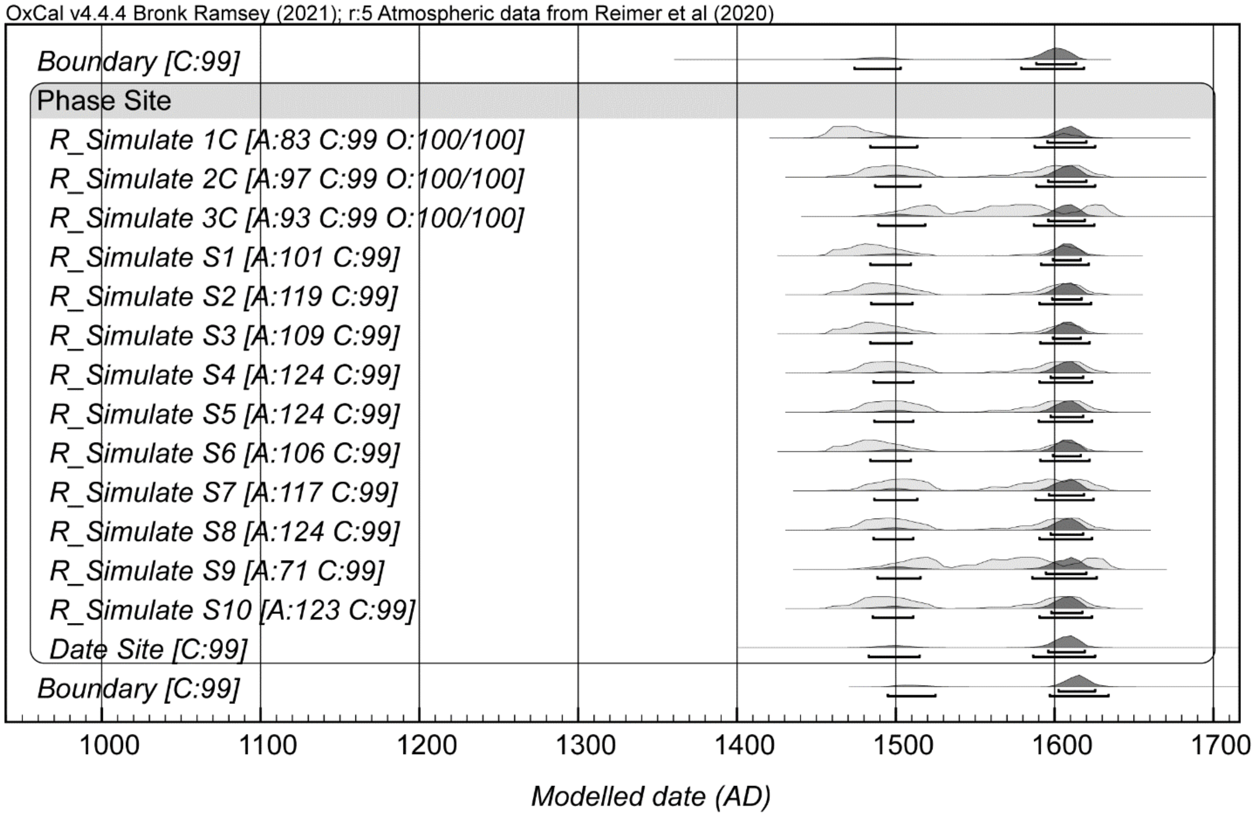

Figure S7*. Example of the 3 wood-charcoal dates TPQ 1500 model. Note also (extreme) example of incorrect outcome.*

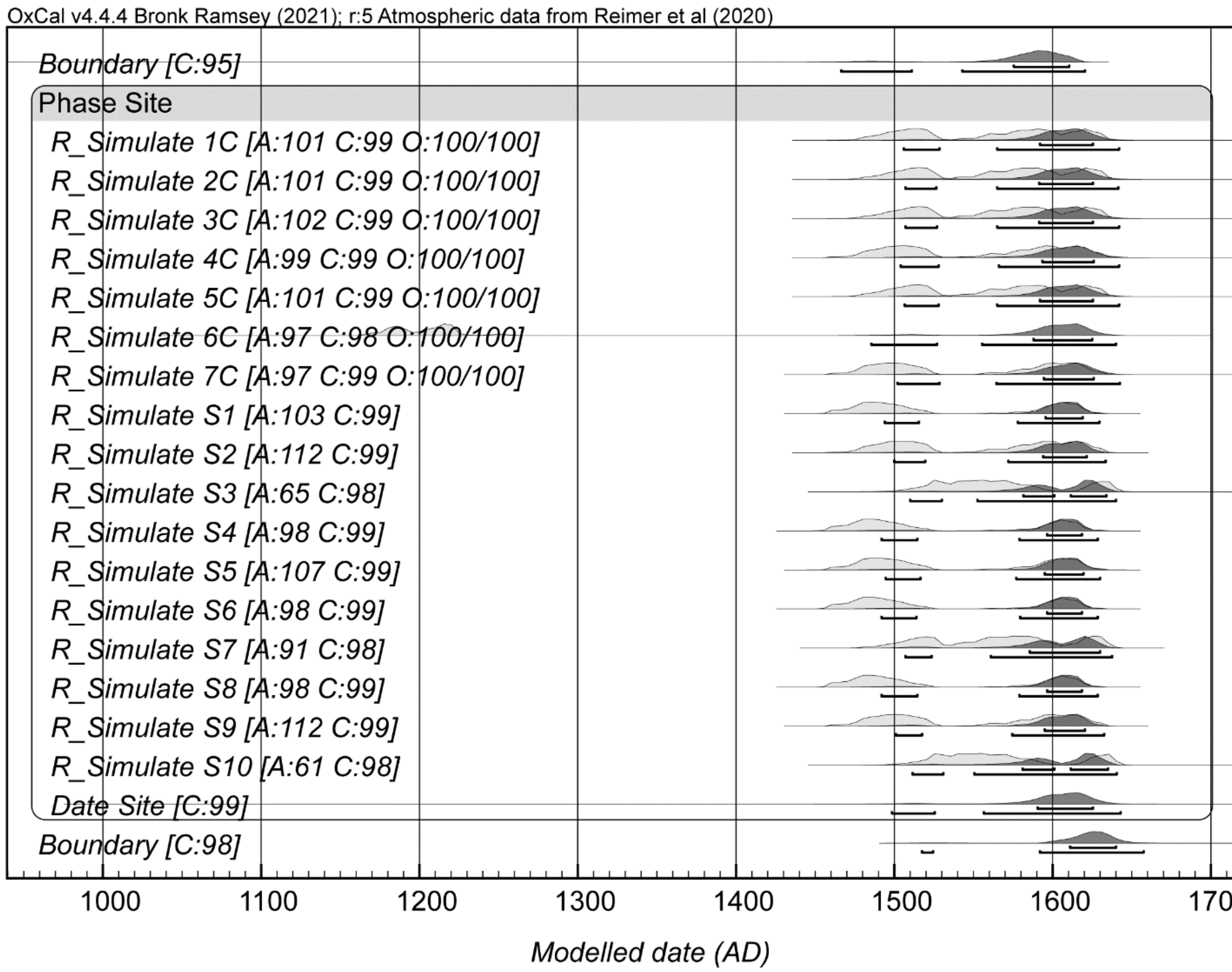

Figure S8. *Example of the 7 wood-charcoal dates TPQ 1600 model.*

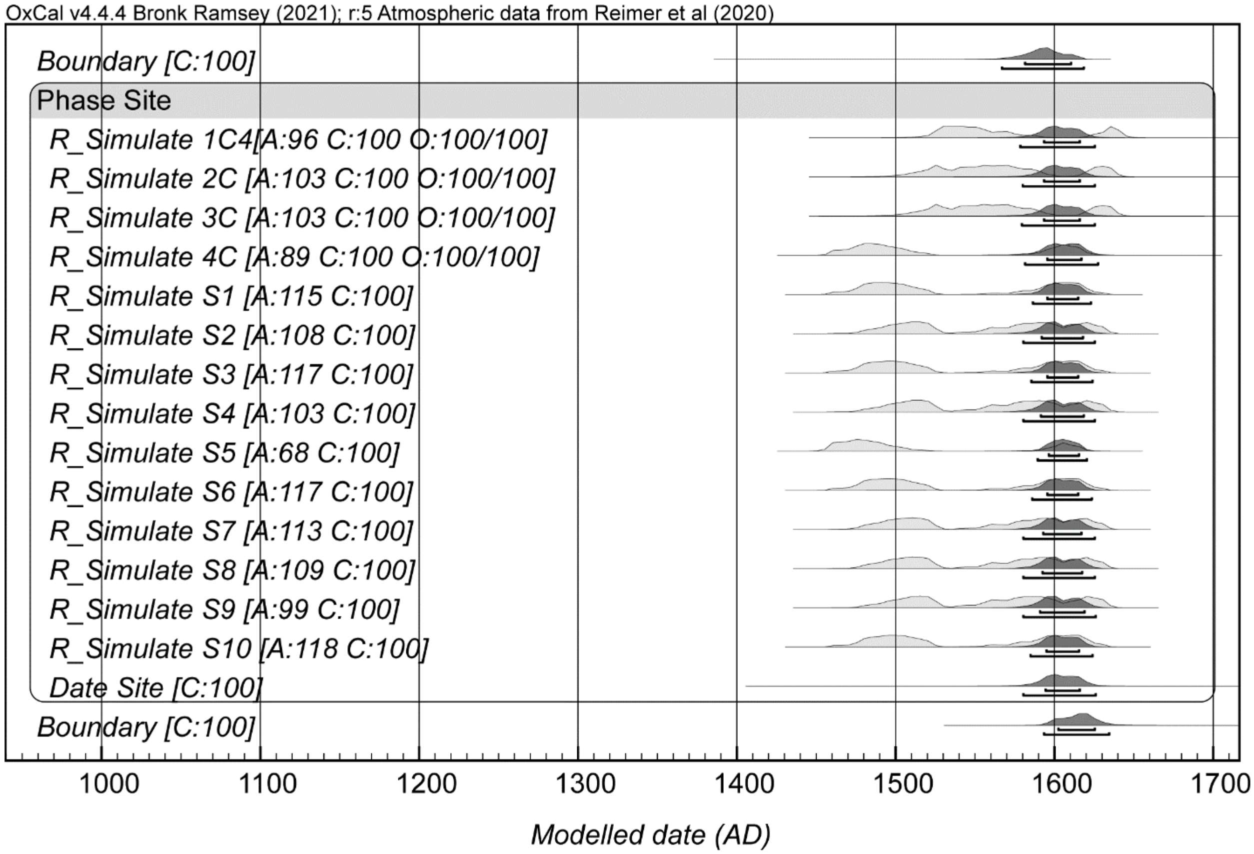

Figure S9. *Example of the 4 wood-charcoal dates TPQ 1600 model.*

6. **Re-run of 1500 models in Figure 11 with 30 simulated dates on short-lived samples in the site `Phase`**

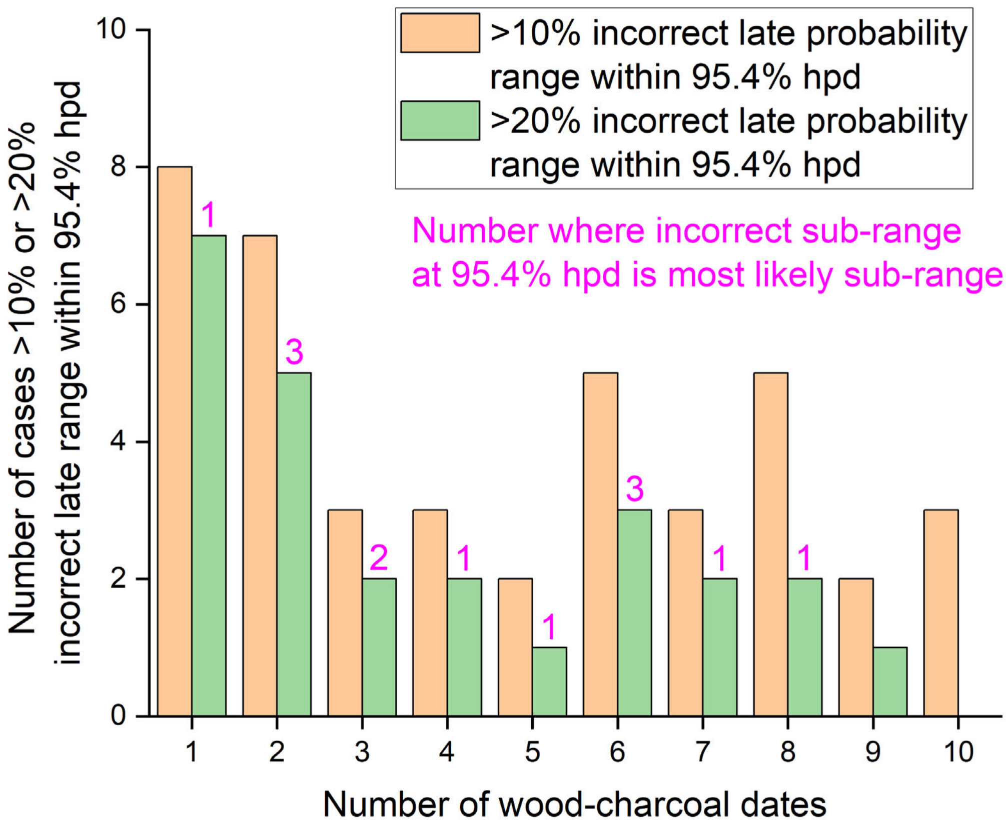

***Figure S10**. Summary of results from a re-run of the 1500 models in Figure 11 with 30 dates simulated on short-lived samples in the site `Phase` in each case. Calibration curve resolution 5 years. In this case the kIterations value was increased to 3000 (100x the default) since, at the default value, a large number of runs did not yield satisfactory Convergence, whereas with kIterations = 3000 only 6 of 100 runs failed. Only results for models that offered Convergence values ≥95 are included in the figure.*

We re-ran the analysis for the 1500 case reported in **Figure 11** but with 30 dates randomly simulated on short-lived samples for the site `Phase` in each case. A summary is shown in **Figure S10**. As in **Figure 11**, 1-10 wood-charcoal dates are randomly simulated and the Charcoal `Outlier_Model` is applied to each of these. While this increases the number of instances where 10+% or 20+% of the probability within the 95.4% hpd range offers an incorrect late calendar range (compared to the summary in **Figure 11** of cases with just 10 short-lived samples simulated), it remains the case that in only very few instances did the majority of the probability indicate the incorrect result: 11 of 94 satisfactory Convergence cases. Moreover, it is important to observe that in all these cases with more than 5 wood-charcoal dates the result reported was clearly ambiguous. For examples: for the 1 case with 8 wood-charcoal dates the `Date` query for the site `Phase` reported probabilities within the 95.4% hpd range of 40.5%

(early, correct) to 54.9% (late, incorrect); for the 1 case with 7 wood-charcoal dates the `Date` query for the site `Phase` reported probabilities within the 95.4% hpd range of 47.1% (early, correct) to 48.4% (late, incorrect); for the 3 cases with 6 wood-charcoal dates the `Date` query for the site `Phase` reported probabilities within the 95.4% hpd range of 47.4%/45.6%/41.0% (early, correct) to 48.1%/49.9%/54.4% (late, incorrect). A likely incorrect result for the `Date` query, for example where the probability favouring the incorrect result was at >70% within the 95.4% hpd range, occurred in only 3 cases of 94: for one 5 wood-charcoal samples case at 75.8%, and for two 3 wood-charcoal samples cases at 88.4% and 79.1%.

Across all these models none showed a clear (i.e. non-ambiguous) result for a date around 1600 as resolved for J-BL in **Figures 5-10**; even the three 'likely' incorrect cases above appear more ambiguous than the clear results in **Figures 5-10**. More particularly, none of the models with ≥6 wood-charcoal dates offered a result in strong support of the incorrect date range. The majority incorrect probability cases for 6-8 wood-charcoal dates were all highly ambiguous outcomes with substantial probability both early and late. Again, this is in complete contrast with the models reported for J-BL in **Figures 5-10**.

It is instructive to examine the instances where an incorrect or ambiguous result occurred. **Figure S11** compares the two most extreme instances (the 8 wood-charcoal case giving a very ambiguous result and the 5 wood-charcoal case where the incorrect outcome was much more likely at 75.8% probability within the 95.4% hpd range) versus two typical non-ambiguous results from the same model on other runs. A key difference is evident. In the two 'ambiguous/incorrect' cases the randomly simulated wood-charcoal dates did *not* offer a range of TPQ dates from older to nearer the relevant TPQ. In the 5-date case (**Figure S11 c** and **d**) by chance (bad luck) all 5 of the simulated wood-charcoal dates in **c** fail to offer much of a real TPQ range and all fall in a very narrow and late range: the dates are simulated (rounded integer values cited here) for 1483, 1493, 1500, 1472 and 1498. In contrast, the successful case, **d**, has dates simulated for a larger TPQ range including some older as well as more recent TPQ values: 1490, 1461, 1444, 1497 and 1392. In the 8 wood-date case there is similarly a less than successful *range* captured within the simulated wood-charcoal dates in **a**. There is one extremely old date and then 6 within 0-35 years of 1500; in contrast, b has greater more appropriate range captured.

In the J-BL case we have a good range of TPQ values and we (deliberately) avoided very close TPQ instances. If we quote the median of the (non-modelled) calibrated age ranges (see **Figure 4a**), the 8 dates on wood-charcoal give a spread of about 1199, 1437, 1476, 1563, 1567, 1568, 1571 and 1572. Thus one very old, two older, and five in a likely several decades to closer TPQ range. We thus regard the J-BL modelling, as reported in **Figures 5-10**, as robust and non-ambiguous and in good support of a date for the site around 1600.

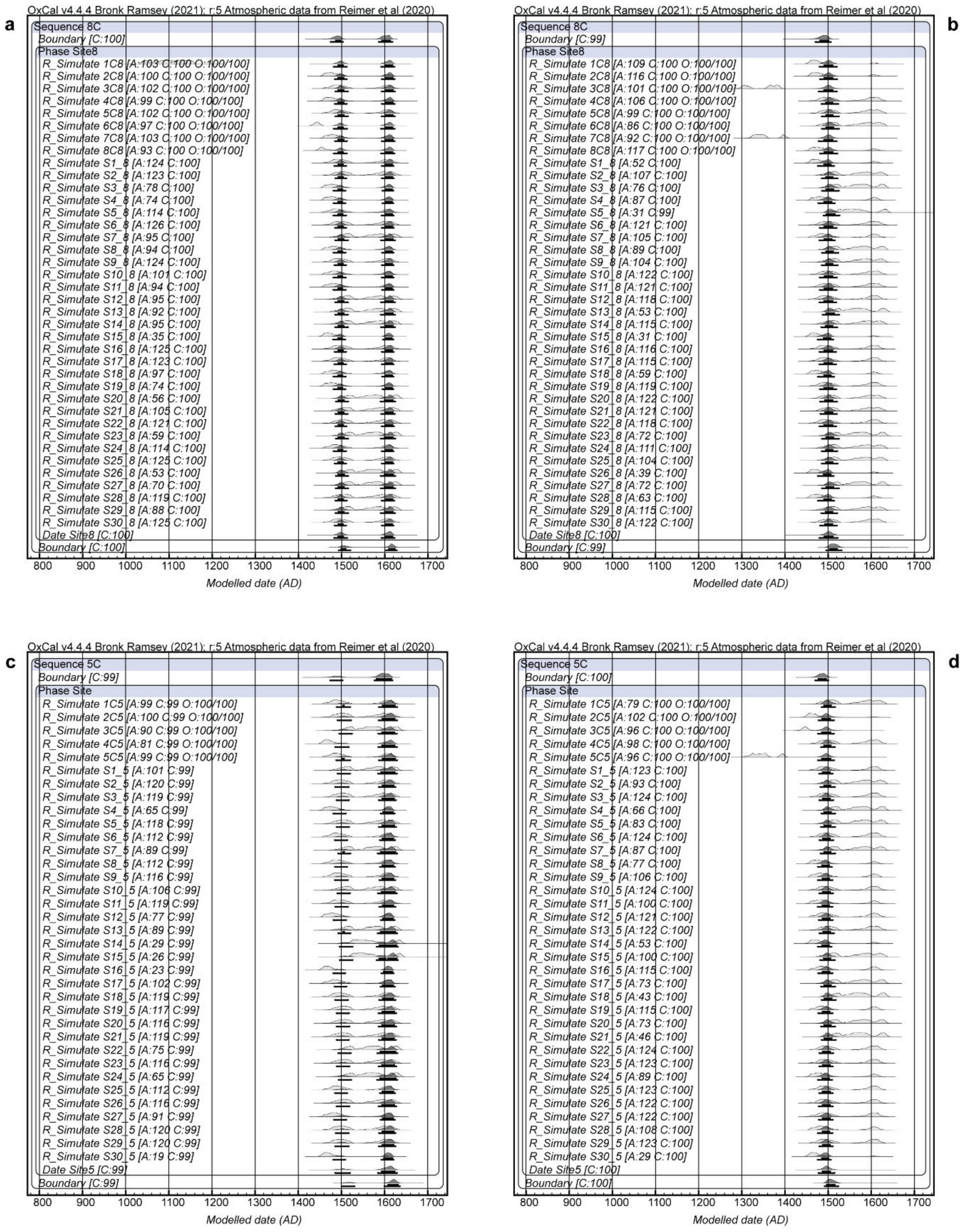

Figure S11. *Comparisons of two cases of ambiguous/incorrect results from the models reported in Figure S10 versus non-ambiguous/correct results from other model runs.* ***a*** *and* ***b*** *contrast the one instance of an ambiguous 8 wood-charcoal case versus a typical non-ambiguous case.* ***c*** *and* ***d*** *contrast the one likely incorrect (`Date` query 75.8%) 5 wood-charcoal case versus a typical non-ambiguous case.*

7. Ruling out two periods of occupation: one around 1500 and one around 1600

One of the reviewers of this paper asked the question whether it might be just possible for there to be two periods of occupation at J-BL, one early, around 1500, and one later, around 1600. The question behind this enquiry was whether this might allow an accommodation for both the previous conventional archaeological assessment and also the ^{14}C findings.

The position from the archaeological record appears clear: there was a single village occupation at J-BL that was excavated and studied in considerable detail. Yes, there was some intra-site phasing recognized, with earlier and then later contexts, but no evidence for a substantial hiatus nor any evidence for two discrete periods of occupation (Birch and Williamson 2013; ASI 2012).

In addition, the ^{14}C evidence available confirms this assessment. *If* there were two discrete periods of occupation, then the earlier `Phase` recognized archaeologically at the site would have to be the supposedly early occupation around 1500, while the later `Phase` would then form the second, later, occupation around 1600. There is therefore a simple test for the reviewer's query: does the ^{14}C evidence from the J-BL early `Phase` point to an earlier date around 1500 or does it instead point to a date around 1600?

We consider the three model forms as used in the main text, Charcoal `Outlier_Model`, Charcoal Plus `Outlier_Model,` and the `Tau_Boundary` and `Boundary` (as TPQ for the context), but applied to the data solely from secure J-BL Early `Phase` contexts. The models and results are shown in **Figures S12-S14**. In each case the model with the data from the Early `Phase` in isolation either very strongly supports a 'late' date around 1600 and provides little to negligible support for an 'early' date around 1500. Therefore, we may regard the suggestion/question of whether there might be two periods of occupation at the site with one (the Earlier `Phase`) around 1500 as highly unlikely. All the evidence points to one, relatively short period of occupation, and this period of occupation is placed around 1600 (as in **Figures 5-10**).

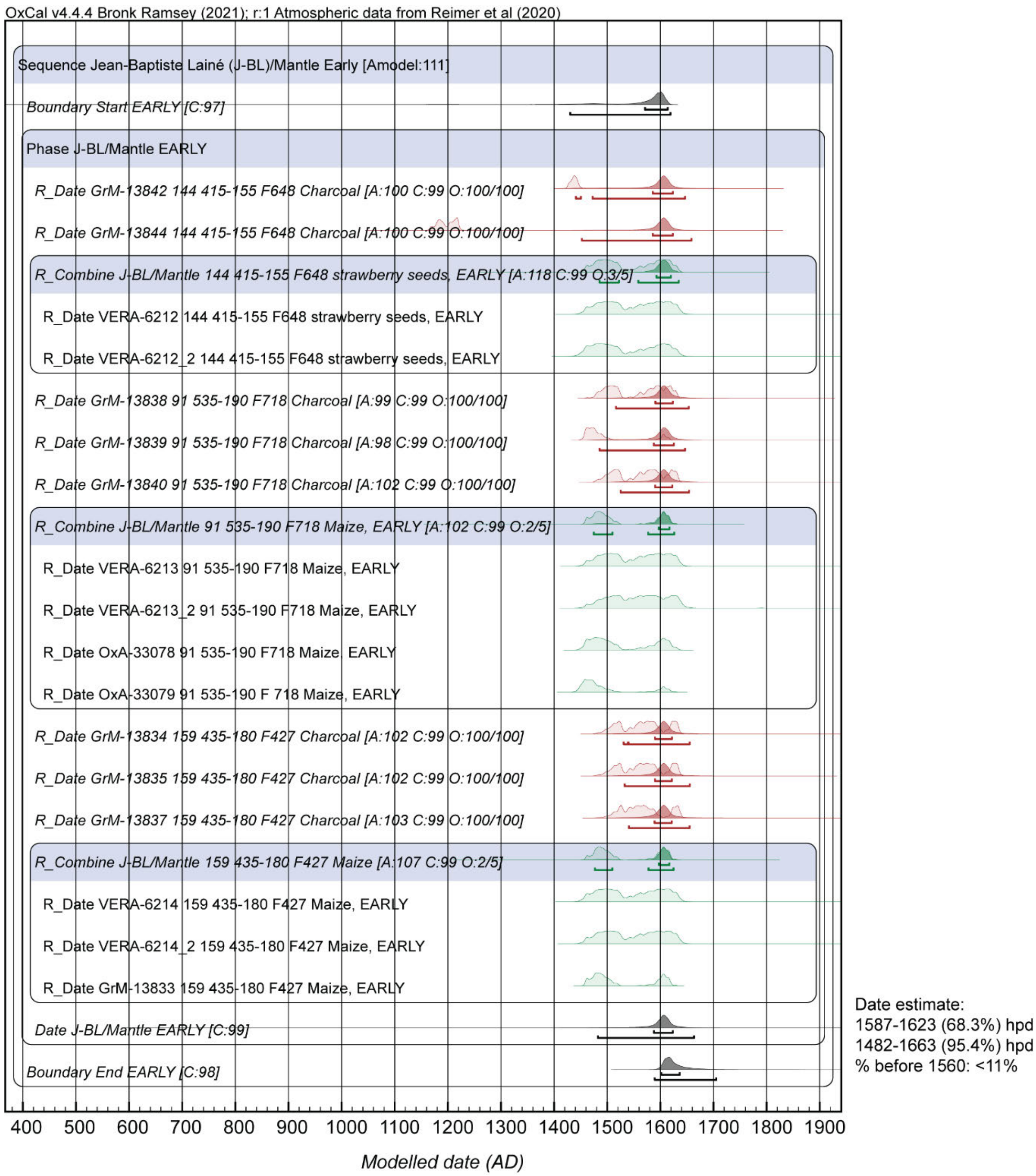

***Figure S12**. Model using just the samples/dates securely associated with the Early `Phase` at J-BL with the Charcoal `Outlier_Model` applied to the dates on wood-charcoal. Solid shaded distributions illustrate the modelled probability; light/hollow shaded distributions indicate the non-modelled probability. The upper and lower lines under the modelled distributions indicate the 68.3% and 95.4% hpd ranges respectively. We cite the `Date` query for the Early `Phase`. This offers an estimate for the period of time between the start `Boundary` and the end `Boundary` for the site `Phase` and hence offers a good estimate of site's date. The probability for a date before 1560 is very low (<11%). Both the start `Boundary` and the end `Boundary` for the site `Phase` only include probability around 1600 within their most likely 68.3% hpd ranges.*

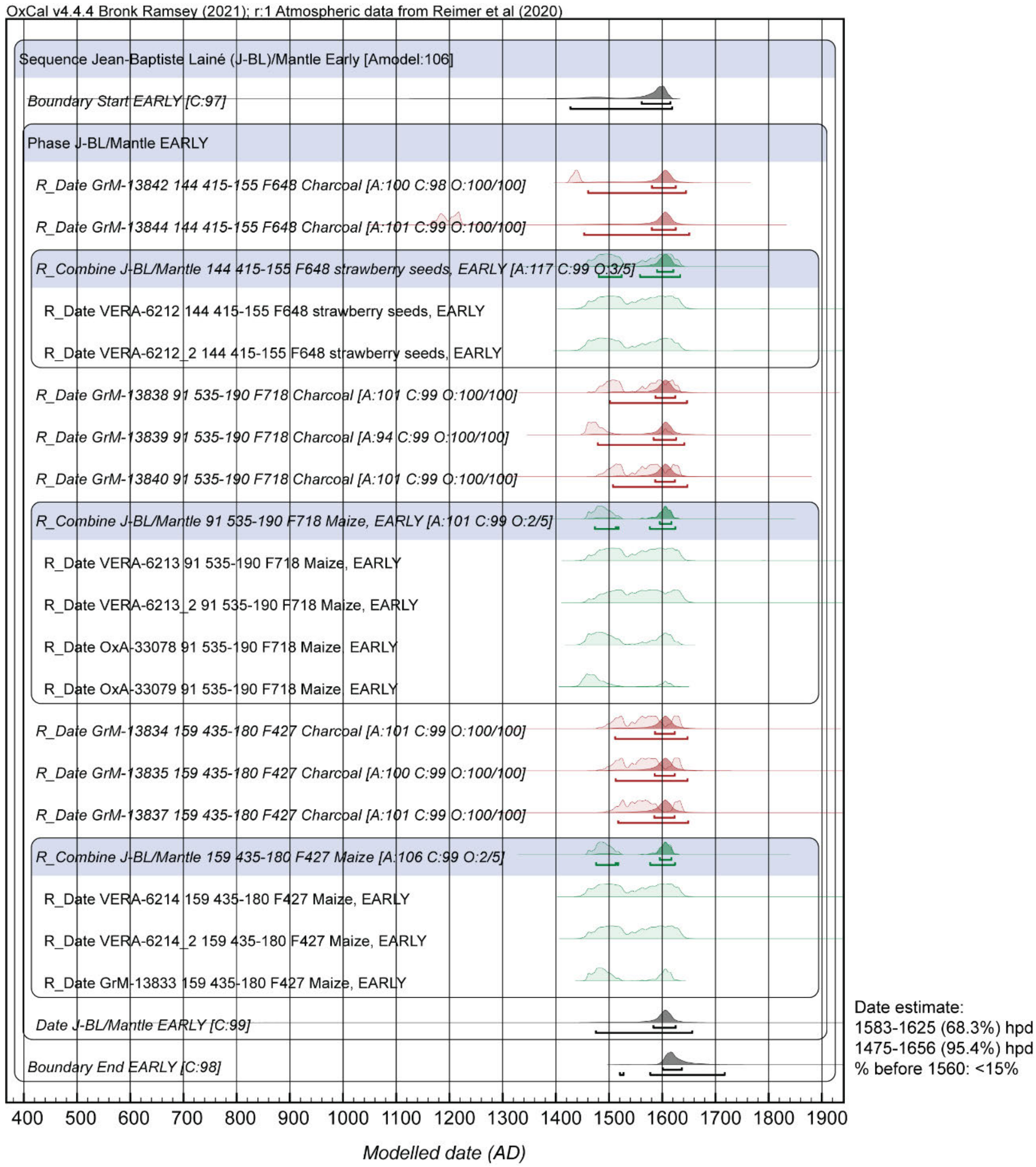

***Figure S13**. Model using just the samples/dates securely associated with the Early `Phase` at J-BL with the Charcoal Plus `Outlier_Model` applied to the dates on wood-charcoal. Solid shaded distributions illustrate the modelled probability; light/hollow shaded distributions indicate the non-modelled probability. The upper and lower lines under the modelled distributions indicate the 68.3% and 95.4% hpd ranges respectively. We cite the `Date` query for the Early `Phase`. This offers an estimate for the period of time between the start `Boundary` and the end `Boundary` for the site `Phase` and hence offers a good estimate of site's date. The probability for a date before 1560 is very low (<15%). Both the start `Boundary` and the end `Boundary` for the site `Phase` only include probability around 1600 within their most likely 68.3% hpd ranges.*

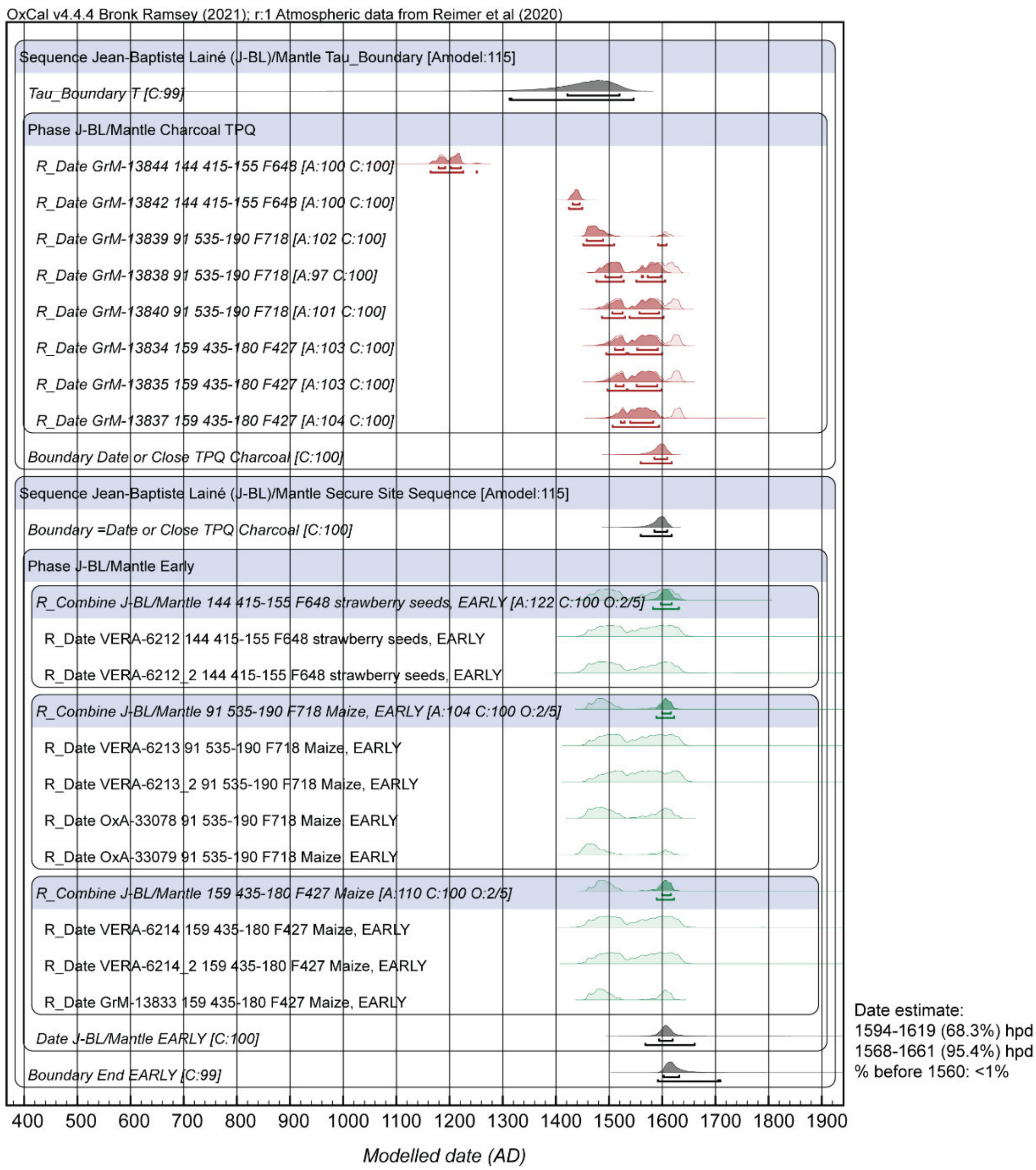

***Figure S14**. Model using just the samples/dates securely associated with the Early `Phase` at J-BL with the wood-charcoal dates regarded as all before (a firm TPQ) the site occupation period. The wood-charcoal dates are modelled as an exponential distribution using a `Tau_Boundary` paired with a `Boundary` and this end `Boundary` is treated (since a TPQ) as the start `Boundary` for the site `Phase`. Solid shaded distributions illustrate the modelled probability; light/hollow shaded distributions indicate the non-modelled probability. The upper and lower lines under the modelled distributions indicate the 68.3% and 95.4% hpd ranges respectively. We cite the `Date` query for the site `Phase`. This offers an estimate for the period of time between the start `Boundary` and the end `Boundary` for the site `Phase` and hence offers a good estimate of site's date. The probability for a date before 1560 is very low (<1%). Both the start `Boundary` and the end `Boundary` for the site `Phase` only include probability around 1600 within their most likely 68.3% and 95.4% hpd ranges.*

8. References cited in the Supplementary Material and not in the main text and references

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