Radiocarbon dating archaeobotanical remains from Pudding Lane, Barley

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This report aims to establish a secure chronology for the charred plant remains recovered during excavations at Pudding Lane, Barley (Herts) by Pre-Construct Archaeology in 2018. The archive report states that the excavations revealed 'a complex of late Saxon to early medieval (AD 900–1100) features, comprising boundary ditches, quarry and rubbish pits, possible structural features, and a well-preserved crop-drying oven' (Woolhouse 2018, 5).

The environmental samples considered in the present study come specifically from the excavation site with code HPLB18, and their archaeobotanical contents were originally analysed by Kath Hunter Dowse (in Woolhouse 2018, 78–91). This archaeobotanical analysis included material from 13 environmental samples, representing 12 contexts and four different features.

<table>
<tr><th>Sample</th><th>Context</th><th>Feature</th><th>Phase</th></tr>
<tr><td>5</td><td>152</td><td>Ditch 1</td><td rowspan="2">Late Saxon (Phase 2)</td></tr>
<tr><td>12</td><td>172</td><td>Ditch 4</td></tr>
<tr><td>24</td><td>221</td><td rowspan="11">Oven 206</td><td rowspan="4">Late Saxon (Phase 3)</td></tr>
<tr><td>25</td><td>229</td></tr>
<tr><td>23</td><td>228</td></tr>
<tr><td>21</td><td rowspan="2">220</td></tr>
<tr><td>22</td><td rowspan="7">Early Medieval (Phase 4)</td></tr>
<tr><td>20</td><td>227</td></tr>
<tr><td>19</td><td>214</td></tr>
<tr><td>17</td><td>212</td></tr>
<tr><td>16</td><td>210</td></tr>
<tr><td>15</td><td>207</td></tr>
<tr><td>14</td><td>192</td><td>Ditch 5</td></tr>
</table>

The excavation report describes how 'finds, stratigraphy and four AMS radiocarbon dates allow four phases of activity to be identified within this timeframe, the earlier two dating to the 10th century and the latter two to the 11th century, possibly continuing into the early 12th' (Woolhouse 2018, 5). These four phases are defined as follows:

- Phase 1: Late Saxon (c. AD 900–950) – including Ditch 7 and Pits 177, 205, 219, 233, 235 and 237.
- Phase 2: Late Saxon (c. AD 950–1000) – including Ditch 4 and Ditch 1.
- Phase 3: Late Saxon (c. AD 1000–1050) – including Ditch 6, Animal Bone Pit 1, and Crop-Drier 1 (i.e. Oven 206).
- Phase 4: Early Medieval (c. AD 1050–1100+) – including Ditch 5. Some contexts associated with Crop-Drier 1 (i.e. Oven 206) are also assigned to this phase because they form part of a sequence of fills overlying the collapsed oven structure/lining (228), which itself is assigned to the Late Saxon Phase 3. Context 220 is also assigned to the Late Saxon Phase 3 but it is stated to form part of the post-collapse sequence (Woolhouse 2018, 44).

In addition to the four radiocarbon dates obtained by Pre-Construct Archaeology, the Feeding Anglo-Saxon England project (FeedSax) submitted four additional samples to the Oxford Radiocarbon Accelerator Unit for radiocarbon dating in 2019. The grains dated by the FeedSax project were selected and photographed by the author at the University of Oxford, prior to submission for dating. The photographs are included in the project's photographic archive (McKerracher *et al.* in prep.).

The results from all nine radiocarbon dates, plus one submission which failed because insufficient carbon was available, are summarised in the table below. The results have been calibrated using IntCal20 (Reimer et al. 2020) and OxCal 4.4.2 (Bronk Ramsey 2009), as shown in the table below and in the figures at the end of this report.

Results

context	sample	material	lab. code	age BP	calibrated date AD (confidence)
176	30	wheat grain	SUERC-80281	1080±28	893–931 (29.6%), 941–1023 (65.8%)
221	31	rye grain	GU47942	failed	-
	37	charcoal (*Fraxinus excelsior*)	SUERC-81880	1040±28	956–1039 (90.5%)
153	32	cattle pelvis	SUERC-80282	1076±28	893–931 (27.2%), 942–1024 (68.3%)
108	33	wheat grain	SUERC-80283	951±28	1030–1160 (95.4%)
229	25	3 x barley grains	OxA-38652	922±21	1038–1175 (95.4%)
214	19	3 x wheat grains	OxA-38649	918±20	1040–1178 (92.9%)
227	20	3 x wheat grains	OxA-38703	985±20	1020–1050 (41.1%), 1080–1154 (52.6%)
207	15	3 x wheat grains	OxA-38650	915±20	1040–1180 (90.6%)
			OxA-38651	906±20	1045–1086 (38.1%), 1120–1215 (54.0%)

The excavations also produced a small ceramic assemblage which contributes some further chronological information (Sudds in Woolhouse 2018, 56–60), as detailed in the following table.

Context	Context type	Fabric	Date range
152	Ditch fill	Early medieval iron-rich gritty ware	1000–1225
153	Pit fill	Early medieval sandy ware micaceous	1000–1225
		Medieval sandy greyware (micaceous)	1150–1400
172	Ditch fill	Early medieval sandy ware micaceous	1000–1225
181	Ditch fill	Early medieval sandy ware micaceous	1000–1225
191	Ditch fill	St Neots-type ware	875–1100
192	Ditch fill	St Neots-type ware	875–1100
200	Ditch fill	Early medieval gritty ware	1000–1225
207	Oven	Early medieval sandy ware micaceous	1000–1225
		Early medieval grog-tempered ware?	1000–1200
214	Oven	St Neots-type ware	875–1100
		Developed St Neots-type ware	1050–1250
227	Oven	St Neots-type ware	875–1100

The dating evidence in its stratigraphic context

Pit 177 is beneath the southern terminus of Ditch 7, which is itself truncated by Ditch 4. Grains from the lower fill of this pit (176) returned a radiocarbon date range of cal. AD 893–1023 (with 95.4%

probability; SUERC-80281). This pit, the earliest directly dated feature, is assigned to the Late Saxon Phase 1.

Ditch 4 truncates Ditch 7. In Slot 174 in this ditch were found four sherds of the same early medieval micaceous sandy ware jar (AD 1000–1225). This ditch (4) is assigned to the Late Saxon Phase 2. Ditch 1 was added at right angles to Ditch 4 and contained six sherds of gritty early medieval ware pottery (AD 1000–1225). Ditch 4 is phased by its stratigraphic relationships to the earlier Pit 176 and the later Pit 155 and Crop-Drier 1. Ditch 1 is not stratigraphically related to a dated feature but is assigned to this phase on the basis of its ceramic assemblage and its 'apparent spatial relationship (perpendicular to/terminating beside) with Ditch 4' (Woolhouse 2018, 41). It may have persisted into the next phase.

In Phase 3 (Late Saxon), Animal Bone Pit 1 and Crop-Drier 1 'were located along the line of the boundary of the preceding phases', i.e. stratigraphically above Ditches 7 and 4. This boundary was replaced by one immediately to the east: Ditch 6 (which did not contain any datable ceramics). In the middle fill of Animal Bone Pit 1 (context 153) was a cattle pelvis radiocarbon dated to cal. AD 942–1024 (with 68.3% probability; SUERC-80282), and an early medieval sandy ware sherd (1000–1225); a later medieval sherd in this context is assumed to be intrusive. Above the clay lining of Corn-Drier 1 was an ash-rich deposit, comprising contexts 221 in the oven chamber and 229 in the stokehole. Radiocarbon dating of rye grains from context 221 failed, but dating of charcoal succeeded (SUERC-81880: cal. AD 956–1039 with 90.5% probability), and barley from context 229 was dated by FeedSax to cal. AD 1038–1175 with 95.4% probability (OxA-38652). Although the charcoal date range is distinctly earlier than that obtained from the grain, it remains possible that the two deposits were contemporary, if the charcoal represents wood which was already older than the grain at the time of burning, i.e. if the discrepancy is due to an 'old wood effect'.

The excavation report describes how these ash-rich deposits 'were overlain by a long sequence of fills representing parts of the collapsed oven structure/lining (228), followed by periods of disuse and natural infilling with washed-in silt and weathered chalk ((220), (216), (213), (211), (210), (209) and (208)), interspersed with dumps of ash ((227), (217), (214), (212) and (207))' (Woolhouse 2018, 44). These fills are assigned by the excavator to Phase 4 (Early medieval). Other finds from these contexts include a small St Neots Ware sherd (875–1100) from fill 227, from which context also comes a radiocarbon date of cal. AD 1020–1154 with 93.7% probability, obtained from wheat grains (OxA-38703). Small sherds of St Neots Ware (875–1100) come from fill 214, along with wheat grains which have been radiocarbon dated to cal. AD 1040–1178 with 92.9% probability (OxA-38649). A small possible 'Developed St Neots Ware' (1050–1250) sherd from this context is described as 'very small and not particularly diagnostic'. A few early medieval ware sherds, including fragments from a grog-tempered rounded dish (1000–1200), come from uppermost fill 207, along with wheat grains which have returned two radiocarbon dates: OxA-38650 (cal. AD 1040–1180 with 90.6% probability) and OxA-38651 (cal. AD 1045–1215 with 92.1% probability).

It is notable that the radiocarbon dates for the grains from these successive fills are closely comparable to that obtained for the 'ash-rich deposit' which lay immediately above the oven's clay lining (as discussed above). Allowing for the possibility of an 'old wood effect' influencing the radiocarbon date of the charcoal sample from context 221, the date ranges obtained for all of Crop-Drier 1's contexts fall largely between the 1030s and 1160s. At the earlier end of this range, grain from one of the stratigraphically earliest fills (227) returned a date range (OxA-38703), with a probability distribution as follows: cal. AD 997–1003 with 1.7% probability, 1020–1050 with 41.1% probability and 1080–1154 with 52.6% probability. By a very small margin, AD 1050 could therefore

be considered the most likely *terminus ante quem* for this deposit (in context 227) – and therefore also for the stratigraphically earlier contexts 221 and 229. In this case it would be possible to argue that all three contexts may belong to a short phase, roughly between c. AD 1040 and 1050. In more general terms, this interpretation would serve to reassign context 227 from Phase 4 to Phase 3.The succeeding fills, which would remain assigned to Phase 4, could then date from any time between AD 1050 and the 1160s, but the apparently rapid succession of fills would support a date towards the earlier end of this range, i.e. between 1050 and 1100, as originally proposed by the excavator.

Ditch 5 represents the latest re-cutting of the NW-SE boundary. In the words of the excavation report (Woolhouse 2018, 46): 'Ditch 5 contained a few small sherds of late Saxon to early medieval pottery, including early medieval micaceous sandy ware [1000–1225], gritty ware [1000–1225] and St Neots-type ware [875–1100]. The best-stratified were the St Neots-type sherds in the lower two fills of Slot [193], which are most likely to be 10th-/11th-century. A wheat (*Triticum* sp.) grain from the lower fill of Slot [109] (108) provided a calibrated radiocarbon date of AD 1024–1155 with 95.4% probability. Overall, an 11th-century date seems most likely, with final infilling in the early to mid-12th.' None of the new dates presented in this report provides any reason to question this interpretation.

Interpretation of the evidence

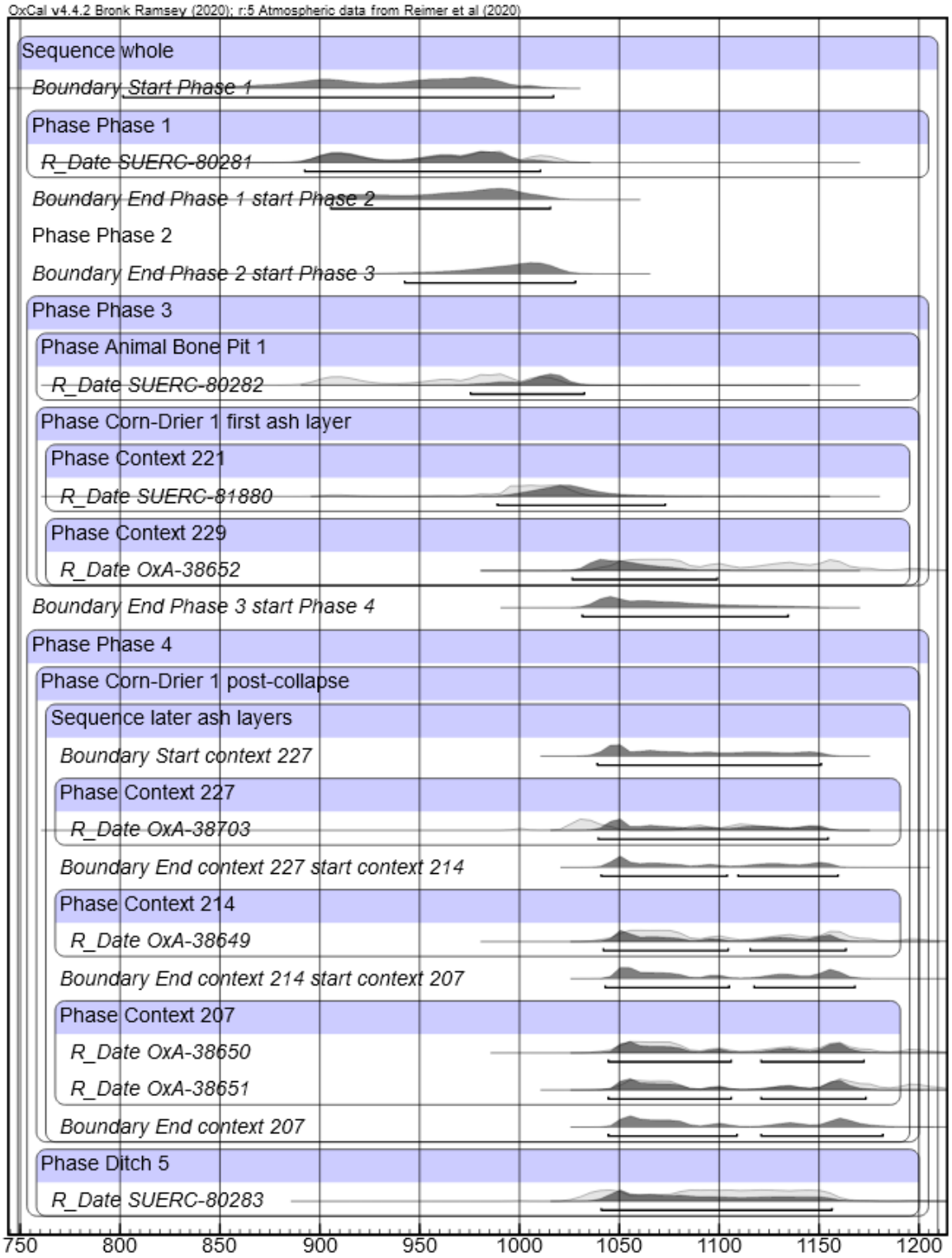
The spatial and stratigraphic relationships outlined above have been used in combination with the associated dating evidence to produce a Bayesian statistical model in OxCal 4.3.2 (Bronk Ramsey 2009). An outlier model is applied to SUERC-81880, obtained from charcoal, to allow for the possibility of an 'old wood effect'. The model is presented below in CQL2 code, followed by the results in graphic and tabular forms, which together bear out the interpretations offered above, demonstrating that the additional radiocarbon dates obtained by the FeedSax project fit well with the chronology outlined by the excavator. The only proposed adjustment is, as argued above, the likely reassignment of context 227 from Phase 4 to Phase 3. Otherwise, however, the preferred interpretation in this report is to reaffirm the phasing originally proposed by Woolhouse:

- **Phase 1:** Late Saxon (c. AD 900–950)
- **Phase 2:** Late Saxon (c. AD 950–1000)
- **Phase 3:** Late Saxon (c. AD 1000–1050)
- **Phase 4:** Early Medieval (c. AD 1050–1100+)

Chronometric model in CQL2 code

```
Plot() {
 Outlier_Model("Charcoal",Exp(1,-10,0),U(0,3),"t");
 Sequence("whole") {
  Boundary("Start Phase 1");
  Phase("Phase 1") {
   R_Date("SUERC-80281", 1080, 28);
  };
  Boundary("End Phase 1 start Phase 2");
  Phase("Phase 2") {
  };
  Boundary("End Phase 2 start Phase 3");
  Phase("Phase 3") {
   Phase("Animal Bone Pit 1") {
    R_Date("SUERC-80282", 1076, 28);
   };
   Phase("Corn-Drier 1 first ash layer") {
    Phase("Context 221") {
     R_Date("SUERC-81880", 1040, 28) {
     Outlier("Charcoal",1);
     };
    };
    Phase("Context 229") {
     R_Date("OxA-38652", 922, 21);
    } ;
   };
  };
  Boundary("End Phase 3 start Phase 4");
  Phase("Phase 4") {
   Phase("Corn-Drier 1 post-collapse") {
    Sequence("later ash layers") {
     Boundary("Start context 227");
     Phase("Context 227") {
      R_Date("OxA-38703", 985, 20);
     };
     Boundary("End context 227 start context 214");
     Phase("Context 214") {
      R_Date("OxA-38649", 918, 20);
     };
     Boundary("End context 214 start context 207");
     Phase("Context 207") {
      R_Date("OxA-38650", 915, 20);
      R_Date("OxA-38651", 906, 20);
     };
     Boundary("End context 207");
    };
   };
   Phase("Ditch 5") {
    R_Date("SUERC-80283", 951, 28);
   };
  };
  Boundary("End Phase 4");
 };
};
```

Graphic representation of chronometric model



Tabular representation of chronometric model

Name Show all Show structure	Unmodelled (BC/AD)			Modelled (BC/AD)			Indices A_{model}=72 $A_{overall}$=79.6				Select All Visible	Page break
	from	to	%	from	to	%	A_{comb}	A	L	P C		
Outlier_Model Charcoal				-66	3	95.4				99.9	37	
Exp(1,-10,0)	-3.19	-0.05	95.4							99.4	2	
U(0,3)	2.21177e-17	3	95.4	3.59955e-17	2.298	95.4		100		99.2	3	
Sequence whole											4	
Boundary Start Phase 1				801	1017	95.4				98.7	5	
Phase Phase 1											6	
R_Date SUERC-80281	893	1023	95.4	892	1010	95.4		99.2		99.6	7	
Boundary End Phase 1 start Phase 2				905	1015	95.4				99.7	8	
Phase Phase 2											9	
Boundary End Phase 2 start Phase 3				942	1028	95.4				99.9	10	
Phase Phase 3											11	
Phase Animal Bone Pit 1											12	
R_Date SUERC-80282	893	1024	95.4	975	1032	95.4		94.6		99.9	13	
Phase Corn-Drier 1 first ash layer											14	
Phase Context 221											15	
R_Date SUERC-81880	897	1039	95.4	989	1073	95.4		109.4		99.9	16	
Phase Context 229											17	
R_Date OxA-38652	1038	1175	95.4	1026	1099	95.4		91.3		99.7	18	
Boundary End Phase 3 start Phase 4				1031	1134	95.4				99.5	19	
Phase Phase 4											20	
Phase Corn-Drier 1 post-collapse											21	
Sequence later ash layers											22	
Boundary Start context 227				1039	1151	95.4				99	23	
Phase Context 227											24	
R_Date OxA-38703	997	1154	95.4	1039	1154	95.4		44.5		99.1	25	
				Warning! Poor agreement - A= 44.5%(A'c= 60.0%)								
Boundary End context 227 start context 214				1041	1159	95.4				99.2	26	
Phase Context 214											27	
R_Date OxA-38649	1040	1202	95.4	1042	1163	95.4		105.5		99.1	28	
Boundary End context 214 start context 207				1043	1168	95.4				99	29	
Phase Context 207											30	
R_Date OxA-38650	1040	1206	95.4	1044	1172	95.4		111.7		98.9	31	
R_Date OxA-38651	1045	1215	95.4	1044	1173	95.4		101.4		98.9	32	
Boundary End context 207				1044	1182	95.4				98.8	33	
Phase Ditch 5											34	
R_Date SUERC-80283	1030	1160	95.4	1041	1156	95.4		97.7		98.9	35	
Boundary End Phase 4				1045	1227	95.4				97.8	36	

Acknowledgements

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References

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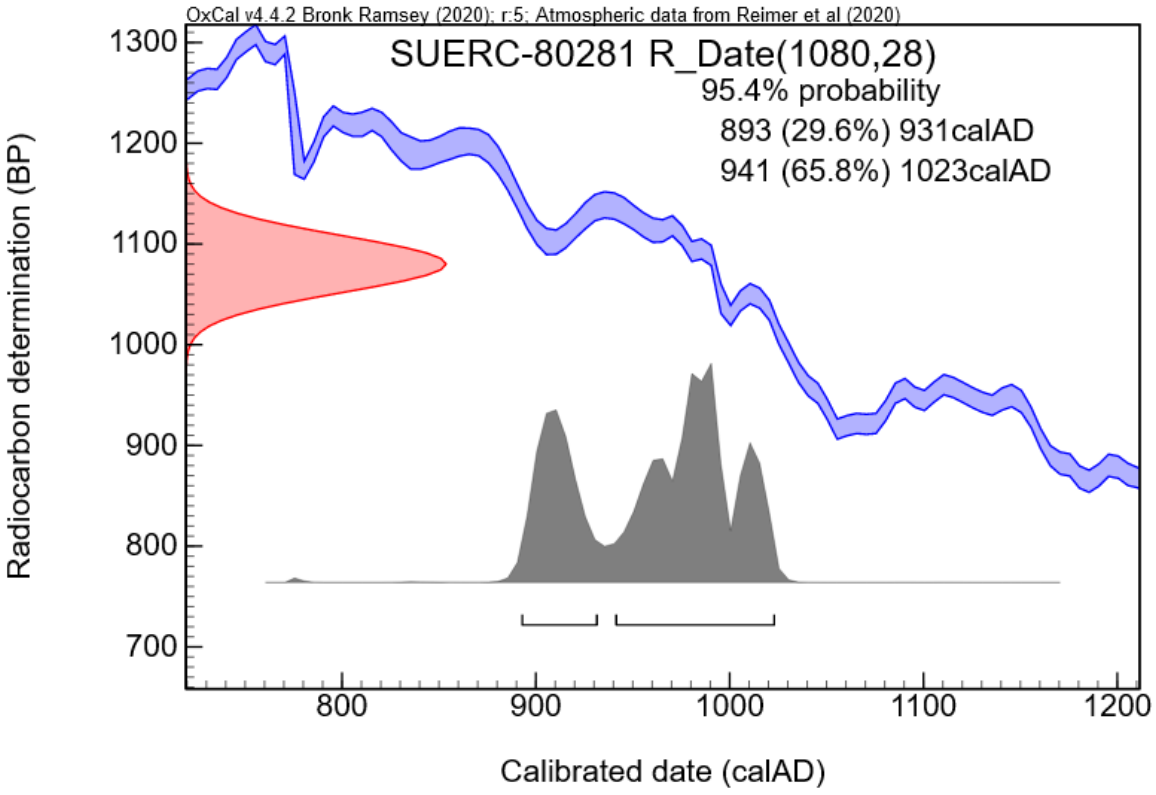
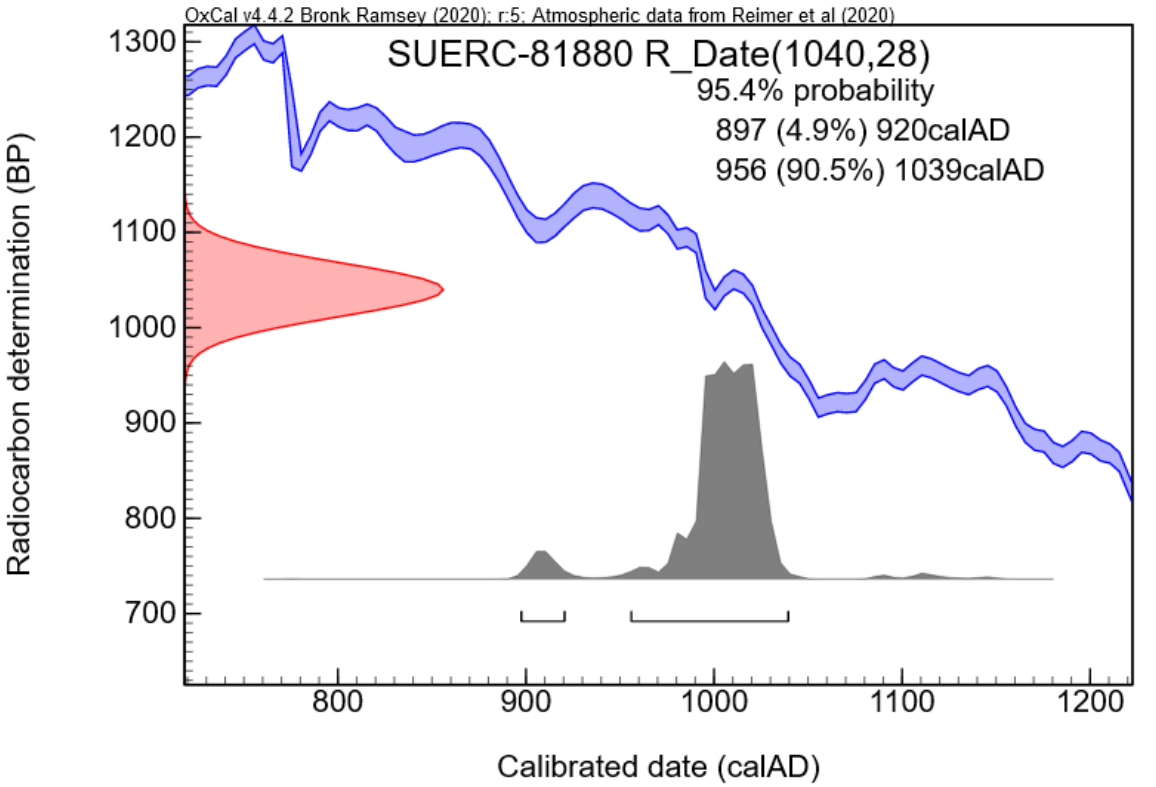
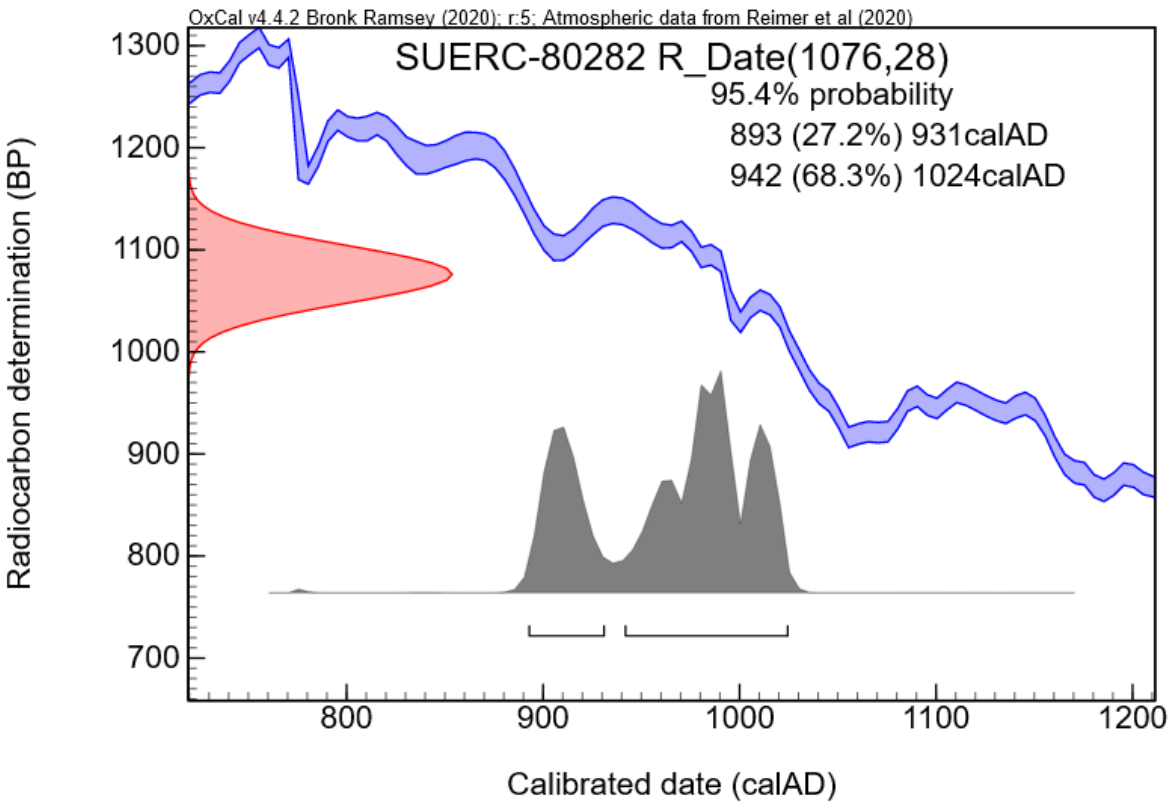
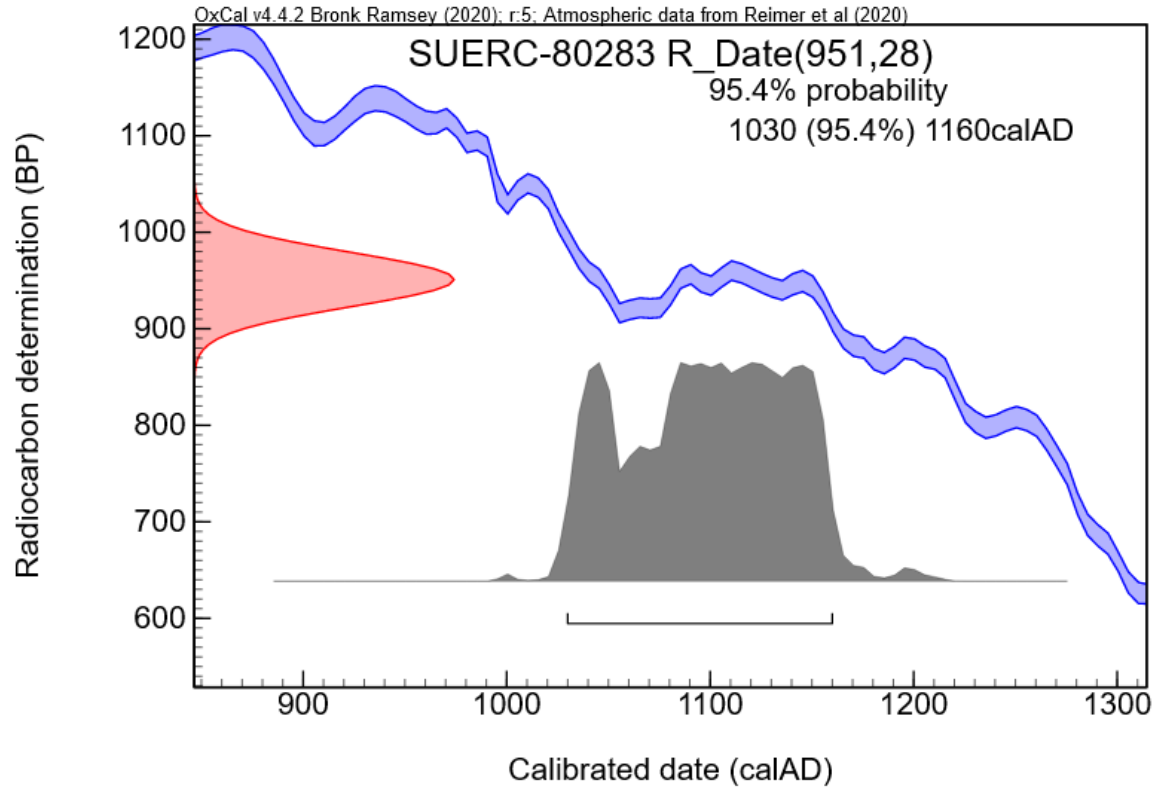
Calibration of radiocarbon determinations






OxCal v4.4.2 Bronk Ramsey (2020); r:5; Atmospheric data from Reimer et al (2020)
SUERC-80282 R_Date(1076,28)
95.4% probability
893 (27.2%) 931calAD
942 (68.3%) 1024calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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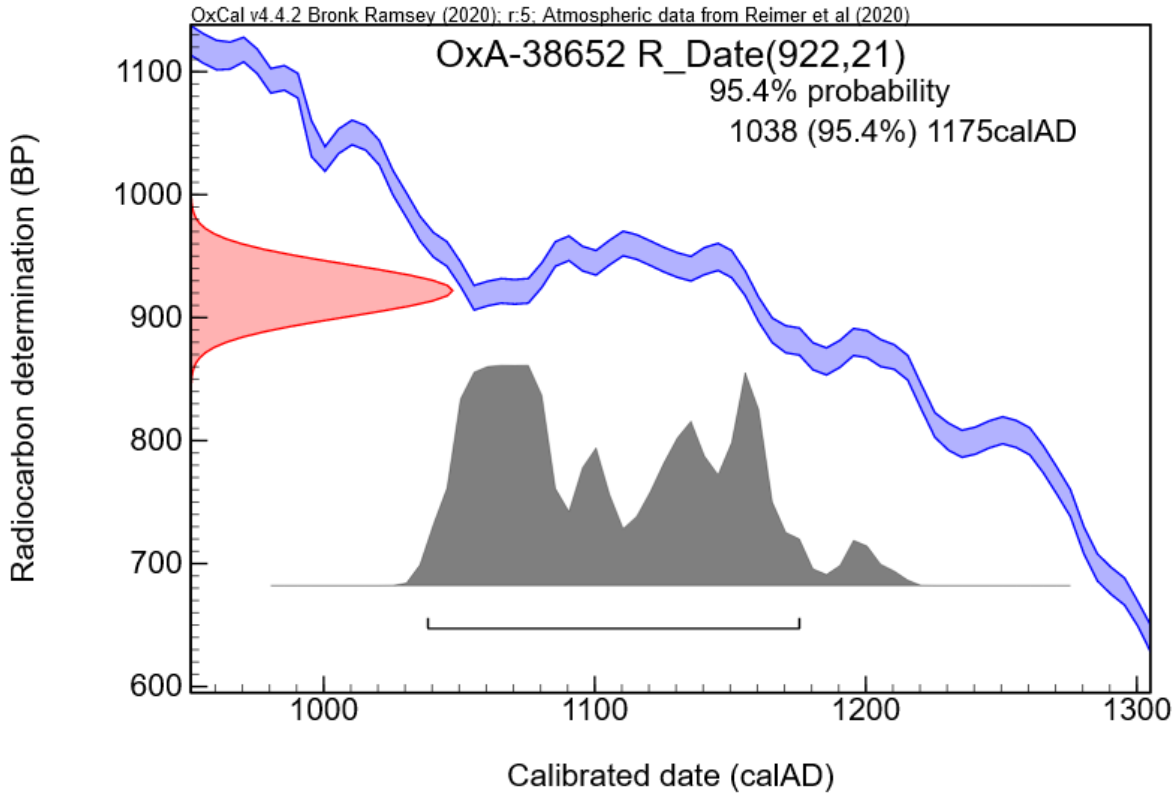
1030 (95.4%) 1160calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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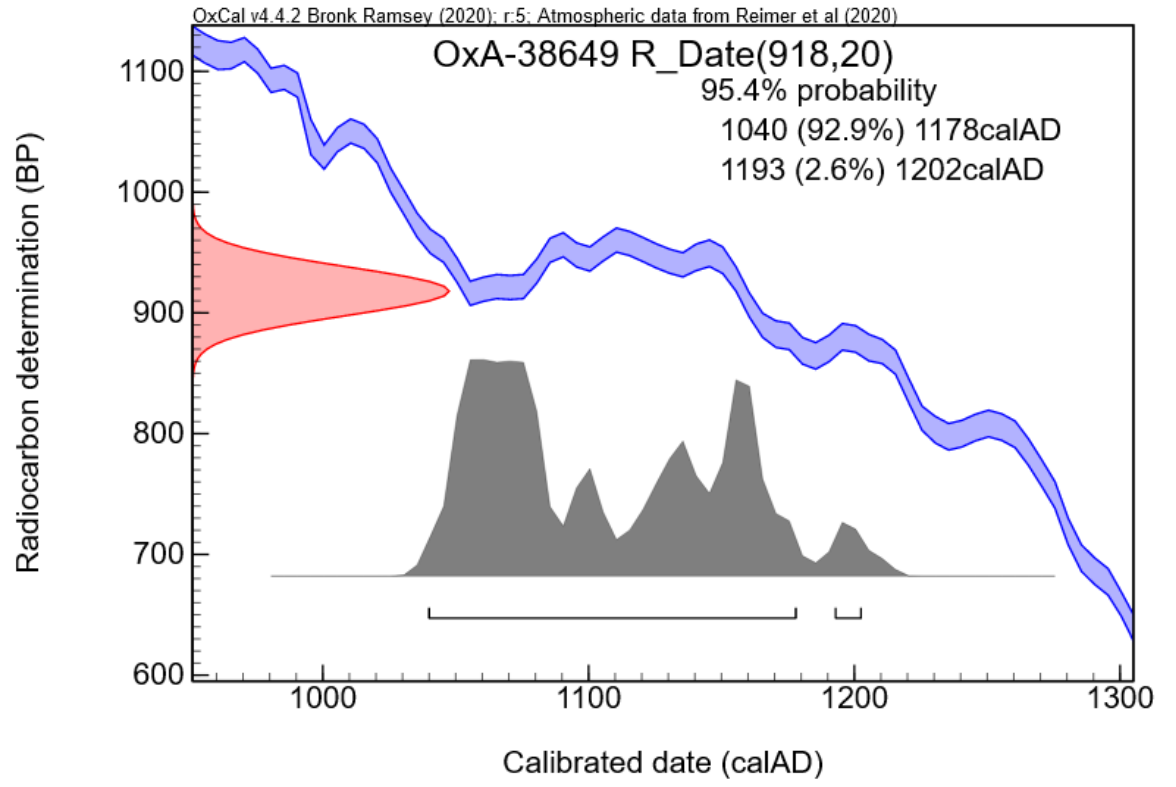
OxA-38652 R_Date(922,21)
95.4% probability
1038 (95.4%) 1175calAD
Radiocarbon determination (BP)
1100
1000
900
800
700
600
1000
1100
1200
1300
Calibrated date (calAD)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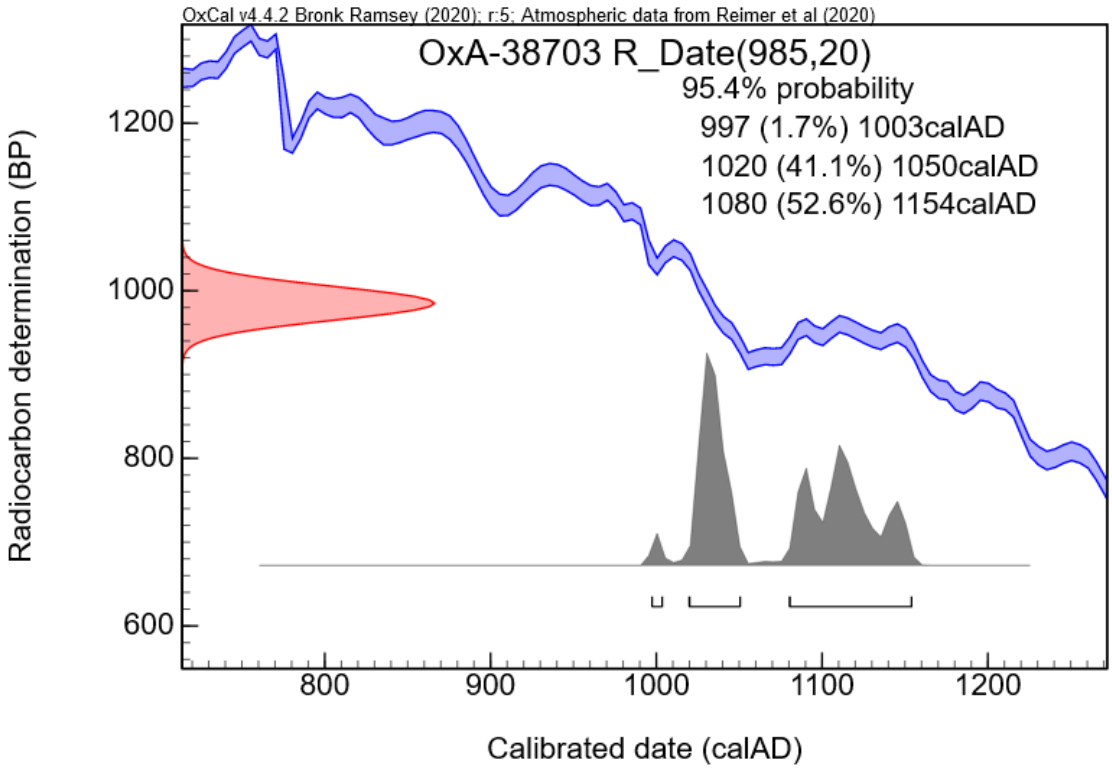
OxA-38649 R_Date(918,20)
95.4% probability
1040 (92.9%) 1178calAD
1193 (2.6%) 1202calAD
Radiocarbon determination (BP)
1100
1000
900
800
700
600
1000
1100
1200
1300
Calibrated date (calAD)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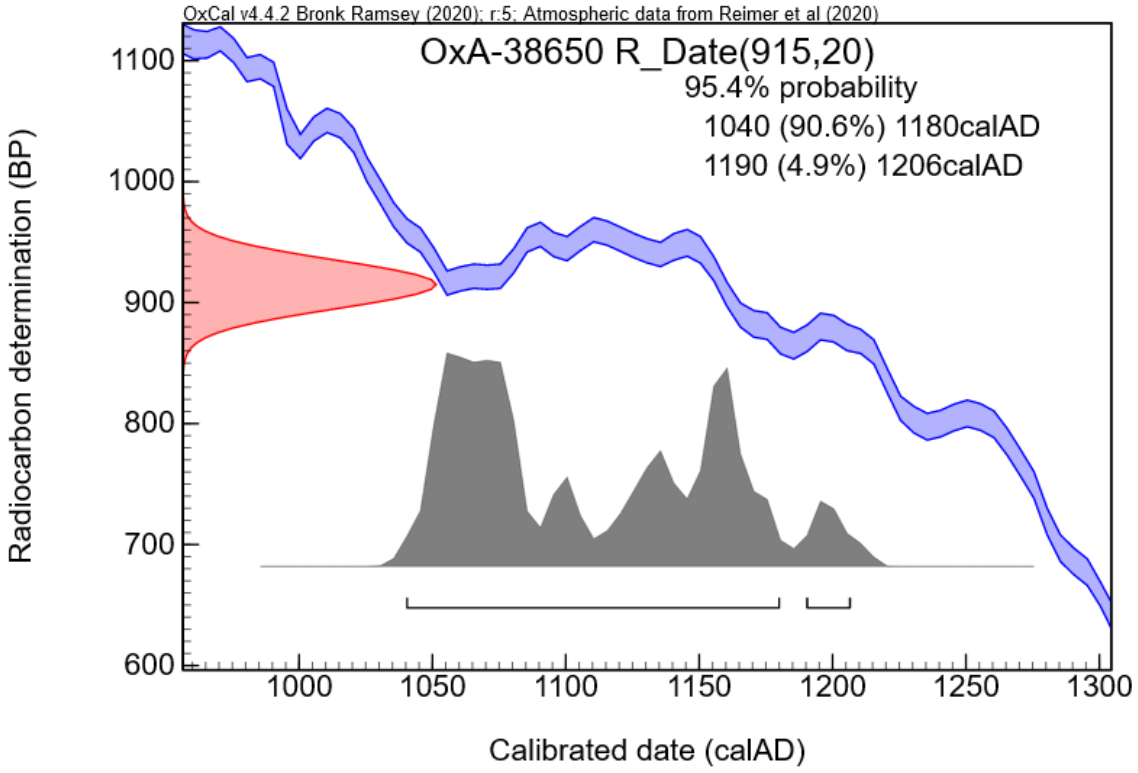
OxA-38703 R_Date(985,20)
95.4% probability
997 (1.7%) 1003calAD
1020 (41.1%) 1050calAD
1080 (52.6%) 1154calAD
Radiocarbon determination (BP)
1200
1000
800
600
800
900
1000
1100
1200
Calibrated date (calAD)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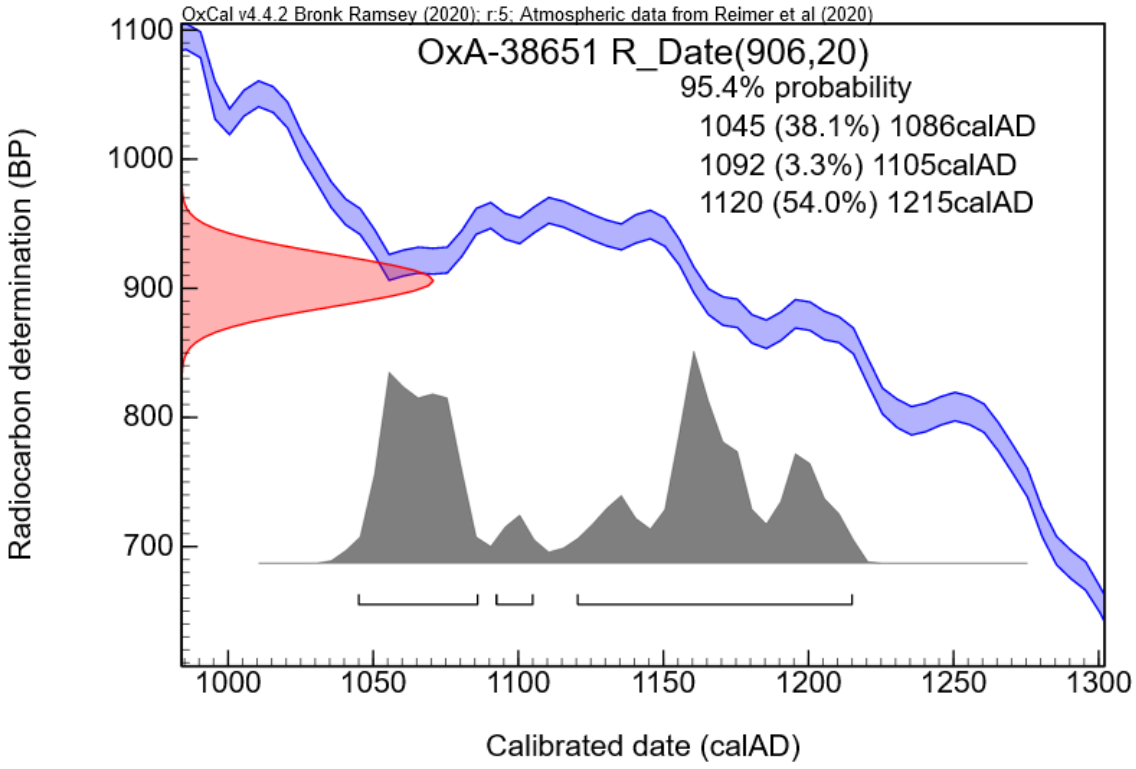
OxA-38650 R_Date(915,20)
95.4% probability
1040 (90.6%) 1180calAD
1190 (4.9%) 1206calAD
Radiocarbon determination (BP)
1100
1000
900
800
700
600
1000
1050
1100
1150
1200
1250
1300
Calibrated date (calAD)


OxCal v4.4.2 Bronk Ramsey (2020); r:5; Atmospheric data from Reimer et al (2020)
OxA-38651 R_Date(906,20)
95.4% probability
1045 (38.1%) 1086calAD
1092 (3.3%) 1105calAD
1120 (54.0%) 1215calAD
Radiocarbon determination (BP)
1100
1000
900
800
700
1000
1050
1100
1150
1200
1250
1300
Calibrated date (calAD)