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Castle of Old Wick Timber: Scientific Dating Report

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Figure 1: Castle of Old Wick in its setting. Photo: C Mills (22.09.2021).

Introduction

This report outlines the work undertaken in the Castle of Old Wick Scientific Dating Project, undertaken by the Dendrochronicle team for HES through a grant from the Castle Studies Trust and with additional support from HES. Castle of Old Wick (NGR ND 36921 48834) is a HES PIC (Property in Care) and a Scheduled Ancient Monument (SM 90065). The castle is sometimes known by the name 'The Old Man of Wick' which is used in some local references especially.

The careful retrieval of the sole surviving timber in the tower was undertaken by Coralie Mills and Hamish Darrah on 22nd and 23rd September 2021 through Scheduled Monument Consent 3000047 for 'Dendrochronological analysis and conservation'. The timber was safely retrieved and brought back to Dendrochronicle's base in Edinburgh where it was carefully examined, recorded and then sub-sampled for dendrochronology, species identification and onward Bayesian radiocarbon dating ('wiggle match' dating) at SUERC. Given the species was identified as alder, it became clear that it would not be possible to provide a dendro-date and that 'wiggle match' radiocarbon dating would be required. The project was logged on OASIS as 'dendroch1-432532' (Castle of Old Wick – Scientific Dating Project), a necessary precursor to obtaining radiocarbon dating through the HES contract with SUERC. 'Wiggle-matching' radiocarbon dating of historic timber is undertaken where dendrochronology cannot work, to provide high precision radiocarbon dates. It uses a set of sub-samples of groups of annual tree-rings taken at known intervals across a tree-ring sequence, with the statistical Bayesian analysis taking into account the intervals in deriving the results by comparison with the 'wiggles' of the radiocarbon calibration curve.

Advice was taken from Derek Hamilton of SUERC in advance of sub-sampling the timber's tree-ring pattern for wiggle match dating; initially, three sub-samples were submitted via the HES radiocarbon submission portal and have the HES/SUERC sample codes 1041740, 1041741 and 1041742 and represent the inner 5 rings, the middle 5 rings and the outer 5 rings respectively of an 80-year tree-ring sequence (sub-samples CWK01-i, -ii & -iii, see Table 1 for details). Their SUERC radiocarbon date GU codes are respectively GU59237, GU59238 and GU59239.

It transpired that there is so little carbon surviving in this weathered timber that three successive rounds of sub-samples from these same positions in the ring sequence were submitted to SUERC under those GU code numbers (GU59237-GU59239), and eventually the radiocarbon dating results were produced in February 2022, but only one of the three, the middle rings sample (GU59238, for sub-sample CWK01-ii), returned a result (see Figure 8). This led to the further submission to SUERC of two more sub-samples (CWK01-iv and -v) in slightly different ring positions for the inner and outer samples (see Table 1) where a larger sub-sample could be obtained. These were logged in the SUERC system as GU60569 and GU60570, and their radiocarbon date results were used alongside the existing middle rings result (GU59238) to create a Bayesian radiocarbon date result for the Castle of Old Wick timber CWK01, albeit that the result from outer ring sample CWK01-v was ultimately considered by SUERC to have been unreliable and excluded in the final iteration of the Bayesian dating result (see Appendix 1). All stages of the radiocarbon dating results are reported in this V3.1 report, including the final Bayesian analysis result.

This updated report also considers what the timber and its date represent, with a new discussion section added, and has been used as a basis of our blog for CST. Further to this scientific dating work, HES commissioned Dr Will Wyeth to undertake historical and contextual research (Wyeth 2022), which was used to update the Statement of Significance (Historic Environment Scotland 2022) and for Dr Wyeth to prepare a 'parallel' blog for CST, building on the outcomes of this report.

Fieldwork summary

The fieldwork to inspect and retrieve the timber from the Castle of Old Wick (Figure 1) was undertaken on 22nd and 23rd September 2021, in dry, windy weather. Fortunately, the castle tower walls provided some shelter from the wind, and the timber, at approximately 2nd floor level, was accessed via a temporary scaffold structure inside the tower (Figure 2).

Figure 2 Clockwise from Top Left: Inspecting the timber, the scaffolding access, and the weathered outer face of the *in situ* timber before any intervention (Scale in 1cm intervals).
Photos: H Darrah and C Mills 22.09.21

The timber had been recorded as present as part of a RCAHMS survey of the castle in 2015, which is summarised in a Canmore entry of 2016, and reflected in the HES Statement of Significance (last updated 2020 at time of writing – available here - https://www.historicenvironment.scot/visit-a-place/places/castle-of-old-wick/history/).

The Dendrochronicle team were accompanied in the field by HES Cultural Resources Team staff Rachel Pickering (HES Project Manager for this project at that time) and Laura Harrison. Short films of the site work were made for and released by the Castle Studies Trust during these operations. A blog about the project was written by Rachel Pickering for the CST website in advance of the fieldwork. CST social media coverage went live during the site work and was amplified by the team during and after the fieldwork.

The *in situ* timber was inspected on the afternoon of 22nd Sept 2021, and then carefully retrieved on 23rd September. This involved first gauging how fragmented and how long the timber could be before any attempt was made to remove it. Firstly, we pinned temporary labels on the outer face to what looked like three separate parts of the timber, in case it fragmented on extraction (so we would know how to put them back together again if necessary – it proved not to be necessary), then we used long thin metal pins to probe the loose sediments around the sides of the timber, as it had become embedded in loose 'debris' or possibly 'packing' (a combination of loose stone and possibly mortar) around all four long faces within the socket. This showed that the socket and the timber was more than 38 cm deep. We carefully excavated the loose material around the sides of the timber, in stages, to free it, and to be able to better gauge its length and degree of fragmentation/intactness. The loose material was bagged, as agreed in advance with HES, and that material is being forwarded to HES Collections with the timber (Bag 1 is from the outer zone ie nearer the internal face of the tower wall, Bag 2 is from the inner zone, deeper into the socket).

As soon as enough of the debris near the outer face of the timber had been removed, we wrapped bandaging securely around the circumference of the outer edge of the timber as a precautionary measure to help to hold it together during extraction and while further debris deeper into the socket was removed. It eventually became possible to feel the upper top left back edge of the timber by hand just within reach towards the rear of the socket. This showed it would be a manageable length to extract by hand, not nearly so long as the five feet thickness of the wall. It was also possible to gently wiggle the timber, which moved as one piece, showing that despite the weathered and fragmented appearance of the exposed end, the timber was likely to be removeable intact. After several hours of careful work to free the timber within the socket, we were able to remove it, one person gently pulling it out of the socket while the other cupped it to support it from underneath. It came out in one piece , and on removal the timber was immediately placed into a strong wicker basket lined with plentiful layers of cotton sheeting and with some additional bubble wrap support placed underneath where needed. After measurement of the dimensions, it was then wrapped in the soft fabric to secure it for transportation. This retrieval process was captured on film and shared by CST on social media.

The dimensions of the timber were taken on site after retrieval; it was 46 cm long and had a maximum height of 19.5 cm at the exposed face, tapering to 6 cm at the inner end. It was 12 cm wide. The top left corner of the timber, as observed at the exposed face while the timber was still in the socket, looked like waney edge (that is the sub-bark surface) and to touch it felt like the curved smooth edge one expects at sub-bark surface back along much of the length of the timber within the socket. This is an important observation for determining the precision of the dating and the relationship of any date to the felling date. It was confirmed as waney edge in the tree-ring sample under the microscope (see below).

It is important to note that the socket in the masonry is deeper than the timber (which is 46cm long); there was a partial void immediately behind the timber, and the socket is at least 70cm deep, at which position it appears to have been accidentally blocked by what look like fallen pieces of stone from within the five feet thick wall (Figure 3). Thus, we do not know the full depth of the socket, but it is worth noting that MacGibbon & Ross plans show 'all the way through' narrow apertures at ground and first floor levels (ie at lower levels than this socket) at about the same position as this socket in this NW wall (pers comm Will Wyeth – his annotated M&R plans have been copied to Rachel Pickering at HES). The timber's socket was subsequently closed by the HES works team (ie later on the same day as our retrieval of the timber, on the 23rd September 2021) to prevent birds roosting in it. It could be reopened of course if the socket depth or form required further investigation.

Figure 3 The socket after removal of the timber (note, the wooden wedge to top right is ours, and was placed in temporarily to lift stones off the top of the timber during extraction). It was removed prior to the socket being closed up by HES works team. Photo: C Mills 23.09.21.

Recording and analysis after retrieval

The timber was taken back to the Dendrochronicle base in Edinburgh where it was subject to closer inspection and record photography shots were taken (Figure 4) before taking the necessary slice sample from it, as had been planned from the start, including in the SMC, for dendrochronological analysis and for dating, the primary purpose of this project.

Figure 4: Record shots of the four side faces of the Castle of Old Wick timber. Black and white grid on scale is at 1cm intervals. Photos: Hamish Darrah 30.09.21.

The outer face of the timber (Figure 2) was so weathered that we could not tell whether it had originally been worked. As can be seen in some of the record photos (Figures 4 & 5) the timber has an axe-cut 'notched' slightly faceted face on the better-preserved inner (narrower) end. This feature had no apparent structural function and was just sitting 'free' within the void towards the rear of the socket. It did not abut anything else and has no clear joinery evidence such as a mortise or trenail. This narrower end of the timber is also very knotty, and this is interpreted as the upper end of a tree stem where the branches have been axed off to tidy it up resulting in this notched faceted effect. Other than this notched feature, the only other woodworking evidence is of axe marks on some of the long faces, an axe having been used to shape the timber from the round into a rectangular form. The axe marks are not well preserved due to the condition of the timber.

Figure 5 Record photographs of the inner end of the timber, showing axe-cut notched/faceted end. Photos: Hamish Darrah 30.09.21.

After taking record photographs with the timber intact, the best location for taking the cross-section for dendrochronology was identified, at the mid-section where the timber was least fragmented and the waney edge was thought to be present (Figure 6). The intended section was then bound with strong adhesive tape to keep it together while sawn, prepared and the ring width data measured.

Figure 6: The pink tape marks position of slice sample taken for dendrochronology. Photo: C Mills

We had already noticed how light weight the timber was, and on sawing it became immediately clear that this is not oak, as was first thought, but a much less dense wood altogether, the saw going through it like a hot knife through butter. Subsequent microscopic wood species identification of a small sub-sample by Hamish Darrah showed this timber is alder (*Alnus glutinosa*), a common native tree of wetter places which would have been readily available in the north of Scotland historically.

Dating the timber

Unfortunately, there are no alder tree-ring reference data for the later medieval period anywhere in Scotland, and no alder reference data for northern Scotland at all. Therefore, while the Castle of Old Wick's timber tree-ring width data have been measured (Dendrochronicle Lab Code CWK01: see Figure 7, Table 1 and Appendix 2) there is no prospect of obtaining a tree-ring date currently.

Figure 7 Castle of Old Wick slice sample CWK01 transverse section, as prepared by razoring for tree-ring width sequence measurement and for radiocarbon sub-sampling (see Table 1). Scale in 1cm blocks. Photo: C Mills.

The back-up plan from the outset had always been to use Radiocarbon Bayesian ('wiggle match') dating, because even if this timber had been oak, there is very little oak tree-ring reference data in northern Scotland, and a single timber is always a challenge to dendro-date, as noted in the original project design stages. Therefore, the CWK01 tree-ring sequence was sub-sampled for radiocarbon wiggle-match dating, following advice from Derek Hamilton of SUERC, initially to use three sub-samples of five consecutive rings from the inner, middle and outer parts of the 80-year ring sequence (Sub-samples CWK01-i, -ii, and -iii). The precise ring count positions of those three sub-samples are given in Table 1 alongside the summary of the tree-ring data and the SUERC laboratory code for each sub-sample.

The ring width pattern in the slice sample of the timber was measured for dendrochronology across the two most intact radii (CWK01a and CWK01b, Table 1) to allow identification of precise ring positions for taking the radiocarbon sub-samples.

Table 1: Castle of Old Wick timber: Details of tree-ring data and radiocarbon sub-samples

Sequence	No. rings	Inner end	Outer end	Comments & Radiocarbon sub-samples
CWK01a Spans relative rings 3-80	78	Pith (centre a)	Waney edge (99% certain)	Radius CWK01a spans relative rings 3-80 compared to radius b. The radiocarbon sample **of the middle 5 rings (Dendrochronicle sub-sample CWK01-ii ; HES Sample ID 0141741 ; SUERC lab code GU59238 – Result code SUERC-102339)** were taken from Rings 36-40 of Radius 01a (representing the absolute middle rings 38-42 of the overall 80 year sequence derived from both radii). The radiocarbon sample of the **outer 5 rings (Dendrochronicle sub-sample CWK01-iii ; HES ID 1041742 ; SUERC lab code GU59239 – returned a null result)** was taken from Rings 74-78 of Radius 01a (representing Rings 76-80 of the overall 80 year sequence derived from both radii)
CWK01b Spans relative rings 1-67	63	Pith (centre b)	Not near waney edge (axed edge)	Radius CWK01b spans relative rings 1-63 in comparison to radius a. **The inner 5 rings (Dendrochronicle sub-sample CWK01-i ; HES ID 1041740 ; SUERC lab code GU59237 – returned a null result)** of radius CWK01b were sampled for radiocarbon (representing Rings 1-5 of the overall 80 year sequence derived from both radii
CWK01 combined sequence of radii 01a & 01b	80	Pith	Waney edge (99% certain)	CWK01 is the combined ring-width sequence when the data from CWK01a and CWK01b are combined as a 'new raw' series.
ADDITIONAL SUB-SAMPLES SUBMITTED TO SUERC 28.02.22 after null results on CWK01-i and -iii				
CWK01-iv	Rings 6 to 10 out of 80 of CWK01			Rings 6-10 were taken because there is a greater surface area presented than on Rings 1-5 which were sampled three times for the first round of C14 dating – and even cumulatively returned a null result. New sub-sample CWK01-iv was given Sample ID code 1042095 by the HES radiocarbon application system, SUERC lab code GU60569 and result code SUERC-103825
CWK01-v	Rings 71-75 out of 80 of CWK01			Rings 71-75 were taken because there is a greater surface area presented than for Rings 76-80 which were sampled three times for the first round of C14 dating – and still returned a null result. New sub-sample CWK01-v was allocated Sample ID code 1042096 by the HES radiocarbon application system, SUERC lab code GU60570 and results code SUERC-103826

Alder tree ring patterns are much less obvious than in oak (alder has a diffuse porous ring pattern while oak is ring porous) and only after preparing the sample's transverse section surface by razor for ring width measurement, did it become apparent that there are two centres in the mid-section of the timber where the slice sample was taken. Thus, the tree-ring widths of two radii, a and b, were measured starting from each of these two centres. By comparing the measurements from two radii statistically, it was evident that Radius CWK01b starts two years earlier than the centre (aka 'pith') on CWK01a at the slice sample position but does not extend out to the waney edge (sub-bark surface) having a total of 67 rings measured (Table 1). The centre ('pith') of radius CWK01a starts 2 years later than CWK01b. This radius has 78 rings present and is intact to waney edge; it therefore spans relative years 3-80 for the sample as a whole when the two radii are considered together at their relative matching position (Table 1). That waney edge is present in only one small corner of the timber, included in the line measured for radius CWK01a. However, CM is confident that it is waney edge from the overall form of the timber as well as inspecting the final ring structure under the microscope. That curved edge at that corner runs back along much of the length of the timber and feels like waney edge as well as looking like it.

Radii CWK01a and CWK01b match each other with a strong t-value of 6.75 and when combined they provide a ring-sequence CWK01 of 80 years from pith to waney edge (Table 1 and Appendix 2). The ring-width data (Appendix 2) have been stored and will be checked against any relevant alder reference data which become available in future.

The first three radiocarbon sub-samples were submitted to SUERC on 12.10.21 and the HES approval for supporting the radiocarbon dating work was given on 14.10.21. The details of each radiocarbon sample including ring position, HES sample code and SUERC lab code are given in Table 1. SUERC notified CM of their admission into their laboratory programme on 19.10.21.

After receiving the first round of radiocarbon dating results from SUERC on 10.02.22 (see below), and after discussion with SUERC and HES as to the next steps, the two additional radiocarbon sub-samples (CWK01-iv and CWK01-v, see Table 1), from slightly different ring positions for the inner and outer samples, were submitted to SUERC on 28.02.22. The HES approval for supporting the additional radiocarbon dating work was given on 02.03.2022 (Application ID: 1018117 / Application Title: Castle of Old Wick - Scientific Dating Project / Approved Sample Ids: 1042095, 1042096).

The details of each of these final radiocarbon sample including ring position, HES sample code IDs and SUERC lab code are given towards the end of Table 1, above. SUERC notified CM of their admission into their laboratory programme on 08.03.22, allocating codes GU60569 and GU60570. The individual date results were returned on 20.04.22 and the Bayesian 'wiggle match' date report provided by Derek Hamilton of SUERC on 29.06.2022 – that report is included here as Appendix 1.

Radiocarbon dating results

The first round of radiocarbon dating results were provided by SUERC on 10.02.2022. Despite the provision of three successive lots of material for each sub-sample, the inner and outer rings sub-samples (GU59237 and GU59239 respectively) produced null results due to insufficient carbon, while the middle rings sample GU59238 (CWK01-ii, Rings 38-42 out of 80) returned a Radiocarbon Age BP of 381 ± 16 years (SUERC-102339). That is the uncalibrated date. When calibrated this result produces a bi-modal distribution and a large age range, as shown in Figure 8. The true age of sub-sample CWK01-ii could lie anywhere between the later 15th century and the early 17th century, and we must remember it is for wood which is some 40 rings earlier than the position of the outer edge of the timber, ie we should be adding another 40 years onto these date ranges for the likely felling date of this timber CWK01. Although imprecise, clearly this date range for CWK01-ii is later than previous estimations of the construction date for the Castle of Old Wick, stated on Canmore as 'Previously considered to be probably 14th century, the keep is now ascribed to the 12th century'. This is, of course, a simplification of the complex issues surrounding the dating of this and similar towers in northern Scotland which Will Wyeth has researched in great depth (Wyeth 2018).

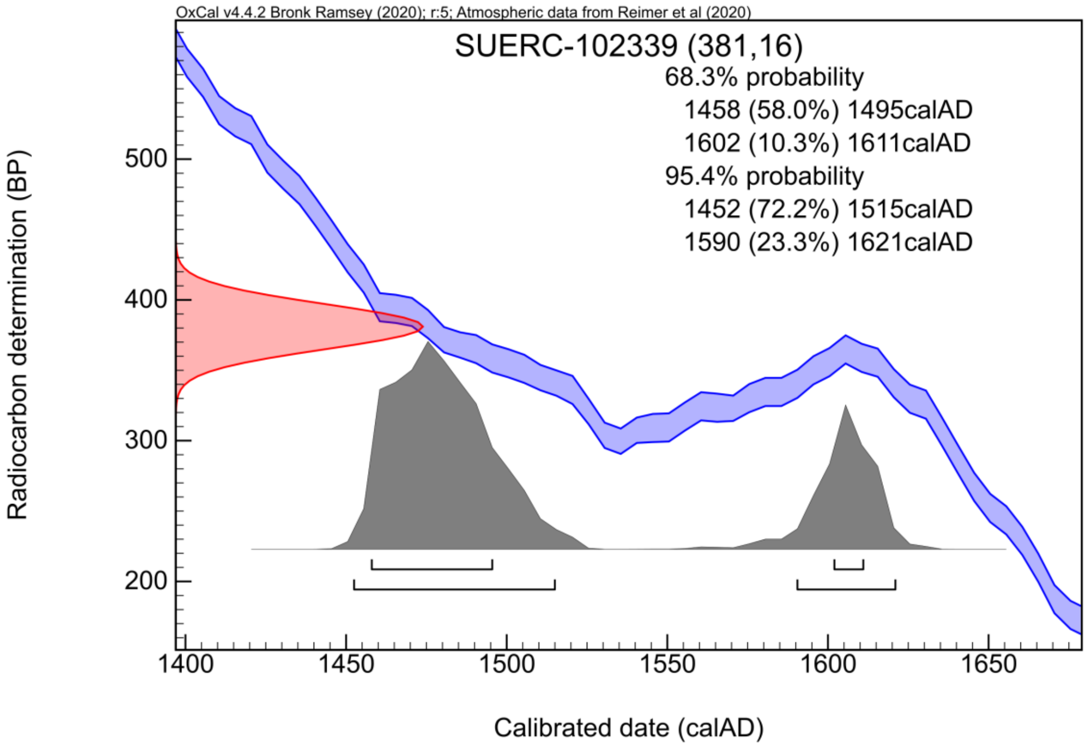

Figure 8: The radiocarbon dating calibration for the middle rings sample CWK01-ii (SUERC-102339; GU59238) from the alder timber from Castle of Old Wick.

The additional two sub-samples (CWK01-iv and CWK01-v) submitted to SUERC on 28.02.22 were dated individually as follows (Figures 9 and 10)

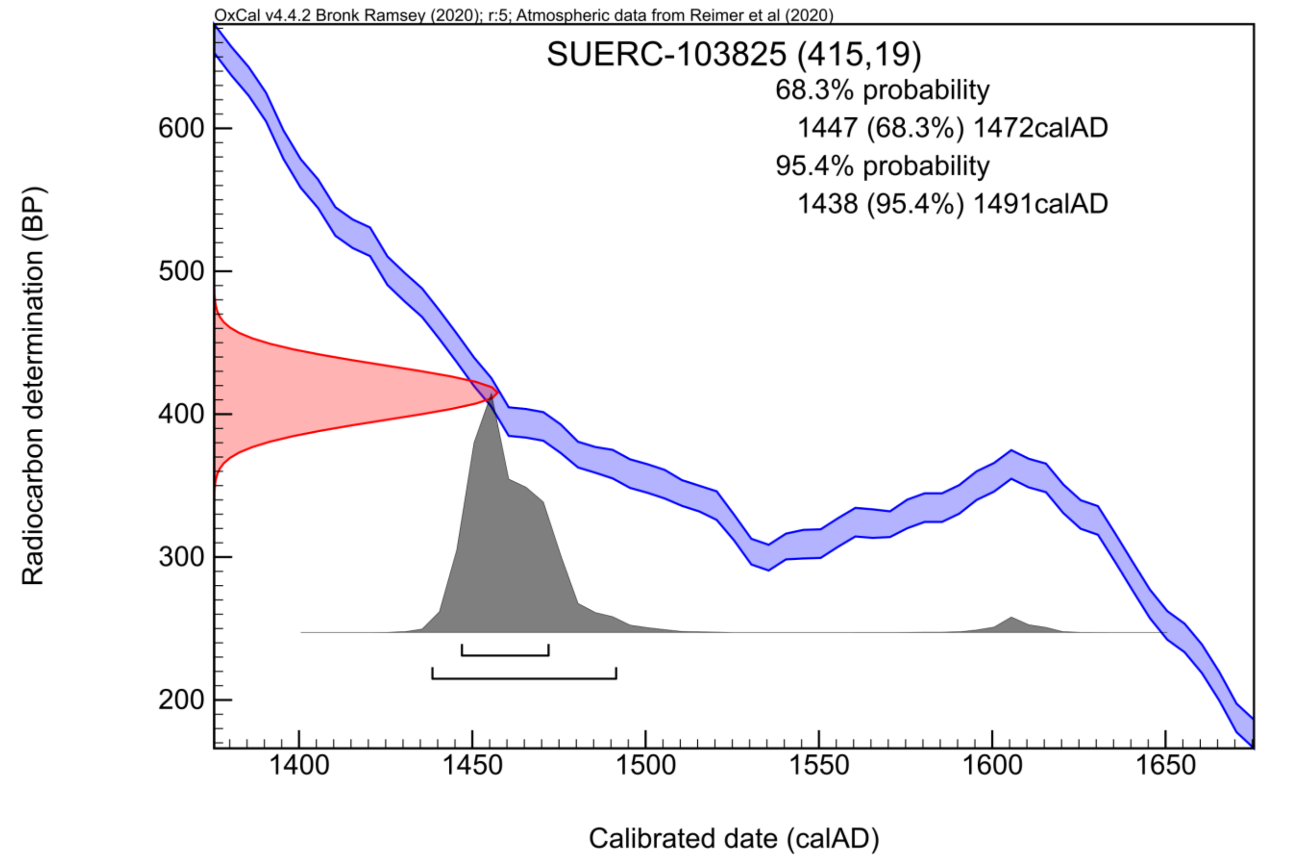

Figure 9 Individual radiocarbon date for CWK01-iv (SUERC)

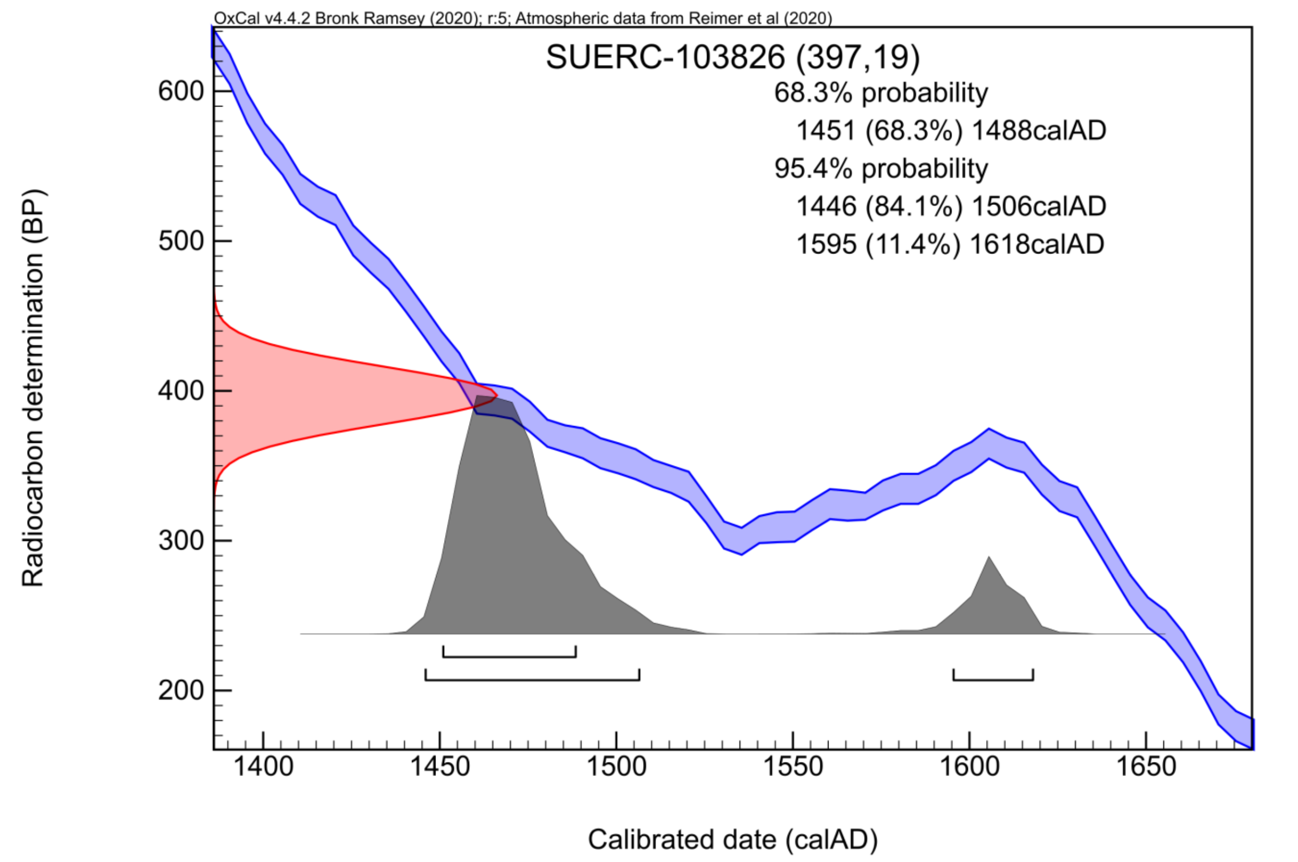

Figure 10 Individual radiocarbon date for CWK01-v (SUERC)

The outer sample result (for CWK01-v) indicated to SUERC probable issues with exogenous carbon infiltrating the outer rings while in the building, and so this result was excluded from the final Bayesian analysis by Derek Hamilton of SUERC (see Appendix 1 for full details). This led to a Bayesian analysis (see Appendix 1 and Fig 11) based on the dates from CWK01-iv (inner rings 6-10) and CWK01-ii (middle rings 38-42) only which provides a calibrated date range for the final ring (at the Ring 80 position) of cal AD 1515–1550 (95% probability), with highest single-year probabilities in the range cal AD 1515–1535 (68% probability).

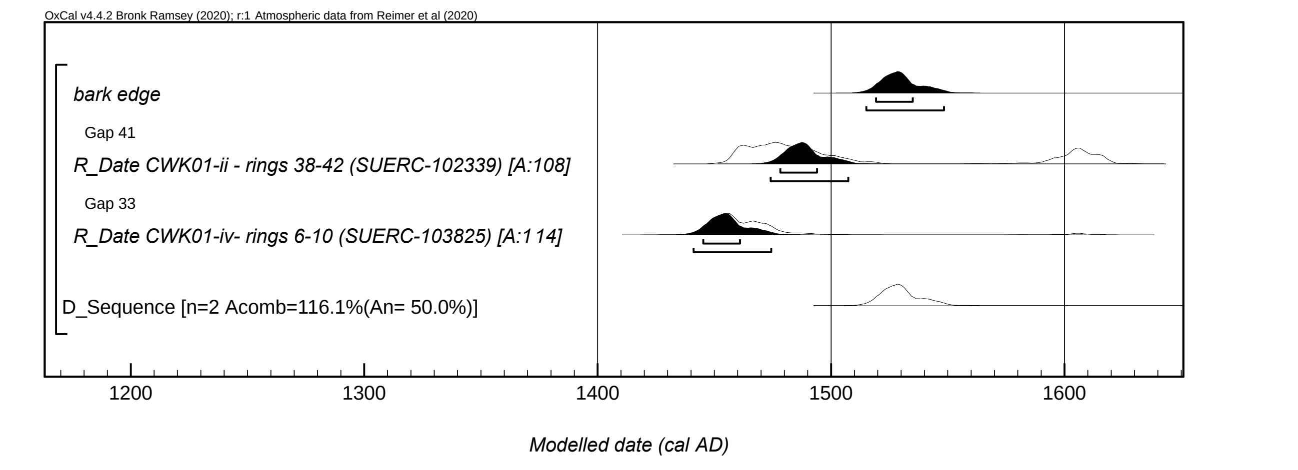

Figure 11 The Bayesian radiocarbon dating result from SUERC for sub-samples from the Castle of Old Wick timber CWK01. See Table 1 and Appendix 1 for full details.

Discussion

Sub-samples from the alder timber CWK-01 retrieved from the Castle of Old Wick have provided a Bayesian radiocarbon ‘wiggle match’ date (see Appendix 1) of cal AD 1515–1550 (95% probability), with highest single-year probabilities in the range cal AD 1515–1535 (68% probability). The results are calculating the date of the bark edge position (ie Ring 80) to represent the felling date of the timber. Thus, this alder timber was felled in the first half of the 16th century, almost certainly (95% probability) between AD 1515-1550 and, with 68% probability, in the twenty years between AD1515 and 1535. There is also a possibility this is naturally storm-thrown material being used rather than a stem being felled for the job, in which case the date is the death date of the stem, but either way it is unlikely this stem was dead for long before it was worked.

We should consider the physical evidence from the timber to inform the interpretation of the dating result. This is a short irregular length of timber, 46cm long, 12cm wide and a maximum height of 19.5cm at the exposed face, tapering to 6cm at the inner end. The outer face is heavily weathered, and we cannot tell how far the timber projected originally or whether that face was worked. At the better-preserved inner end, the timber has an axe-cut notched, faceted face which had no structural function in the socket and was just sitting free within the void behind the timber. It has no clear joinery evidence such as a mortise or trenail. Therefore, our preferred interpretation is that the notched end is the consequence of axing off the branchy top of the stem, but we cannot rule out the possibility that it represents a re-used timber. If the notched end is seen as a deliberate feature, then it may have been designed to allow this timber to be propped against another element of a structure, perhaps in something temporary like scaffolding, and could signify re-use of the timber in this context. Other than this notched feature, the only other woodworking evidence is of an axe being used to shape the timber from the round into a rectangular form.

Alder is often naturally multi-stemmed and can also be coppiced. However, eighty years is well beyond the stem age expected in any coppicing system. This is more probably natural unmanaged material. Based on the overall form, the double centre, the direction of knots and the taper on the timber, we do not think this timber is cut from a managed coppice stool or the base of a tree but rather from the upper branching top of a substantial stem. Therefore, the stem could have been a good bit older than 80 years when felled, as any tree stem will have more rings near the base than at the top. The stem must have been several metres tall after 80+ years of growth. Therefore, while we do not know how long the original timber was, this surviving short length of timber may be an offcut, with the bulk of the stem used for another purpose.

An alder timber is an unusual find in a high-status medieval building, and it dates to a period when much of Scotland has turned to imported Scandinavian oak for construction purposes, as occurs commonly after the mid-15th century (Crone & Mills 2012; Mills & Crone 2012). While we would expect oak or pine to be the most usual timbers deployed for larger structural purposes in high status medieval buildings, temporary structures like scaffold or smaller components of buildings could have been made from other 'lesser' native tree species, which would have continued to be available after the native oak supply faltered in Scotland. However, such minor components are rarely encountered or analysed and very few medieval structures have been investigated in Caithness, so it is difficult to gauge how unusual this find is. One would expect to find alder more frequently in vernacular buildings, including its documented use in crucks (Mills & Crone 2021; Ross 2009; 2012). Alder has also been found used as a sill beam in excavated buildings in medieval Inverness (Wordsworth 1982) and Perth (Murray 2010, 134), possibly selected for such a purpose because of its rot resistance. For this attribute, alder was commonly used in Iron Age and Early Medieval crannogs and other wetland structures in Scotland: see Anne Crone's work at Buiston Crannog for example (Crone 2000). There, waterlogged alder timbers have been sampled in large numbers and it has been possible to provide relative dendrochronological dates for some alder phases, principally through their relationship with calendrically dendro-dated oak components on the same sites.

The use of alder at the Castle of Old Wick should not be seen necessarily as indicating skimping on costs, because it may simply have been a locally occurring tree used for convenience for a modest purpose where the size and species were not critical and where local tree resources may have been scarce. It is even possible that the rot resistant properties of alder were recognised as an advantage. It does seem likely that it was obtained locally, for example along a watercourse, around a loch or in a wetland area somewhere in the hinterland of the castle.

The socket holding the timber is much deeper than the timber, at least 70cm deep, with packing around the timber and a void behind, suggesting the possibility that the socket was not built with the dimensions of this alder timber in mind and may be earlier than the timber, which would make the timber part of a secondary feature. The possibility that the socket is earlier than the timber is considered further by Will Wyeth in his separate report to HES (Wyeth 2022), along with the structural evidence for the possible function of the timber in the castle. The timber is seen as a probable fixture for a hanging lum, essentially a fireplace where the hearth and flue are built against rather than within a wall, an interpretation first proposed by Piers Dixon and expanded upon by Will Wyeth (2022). The timber is in the left hand (westerly) of two sockets at intermediate level between first and second floor levels on the NW interior wall of the tower, and there is a roughly made recess in the masonry between them which is perhaps related to a fireplace.

Based on our observations of the timber's position and character, it is clearly not a floor joist, and is more likely a fixture for a lost internal fitting or small structure, which seems likely to be a secondary feature. If the timber was used fresh in this context, our preferred interpretation, the dating results represent the time (between AD1515 and 1550) when this timber fixture was added to the castle. However, if the notch on the inner end is interpreted as evidence of timber re-use than the date is a *terminus post quem* (date after which) for this phase of alteration to the castle. The structural and historical evidence is considered further by Will Wyeth in his separate reporting for HES (Wyeth 2022).

Acknowledgements

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Appendix 1

Wiggle-match dating of a timber from Old Wick Castle
Derek Hamilton (SUERC), 29.06.22

A total of three samples from a timber in the fabric of Old Wick Castle were radiocarbon dated and wiggle-matched to produce a felling date of *cal AD 1515–1550* (*95% probability*), and with highest single year probabilities in the range *cal AD 1515–1535* (*68% probability*).

The samples were processed at the Scottish Universities Environmental Research Centre (SUERC) following methods outlined in Dunbar et al. (2016), with the wood samples reduced to the alpha-cellulose fraction. They were then graphitised and measured by accelerator mass spectrometry (AMS) following methods described in Naysmith et al. (2010). SUERC maintains rigorous internal quality assurance procedures, and participation in international inter-comparisons (Scott 2003; Scott et al. 2010) indicates no laboratory offsets; thus, validating the measurement precision quoted for the radiocarbon ages.

Conventional radiocarbon ages (Stuiver and Polach 1977) are presented in Table 1, where they are quoted in accordance with the Trondheim convention (Stuiver and Kra 1986). Calibrated date ranges were calculated using the calibration curve of Reimer et al. (2020) and OxCal v4.4 (Bronk Ramsey 1995; 1998; 2001; 2009).

The timber has been dated using the wiggle-matching approach (Galimberti *et al* 2004). The samples underwent pretreatment protocols to reduce the wood to its most basic structural component (alpha-cellulose), which in inert and generally does not exchange carbon with the surrounding environment. The measurements were made to high precision (<±20 ^{14}C years). All samples passed the internal QA measures, and so there is no reason initially to believe that any of the samples were contaminated.

The three samples are from rings 6–10, 38–42, and 71–75 of the 75+ ring sequence, where the lower ring numbers coincide with the heartwood rings and the pith. The wiggle-match separates these results by the number of rings between the mid-point and adds 7 years to the final result (SUERC-103825; rings 71–75) to arrive at the bark edge and so felling year.

The wiggle-match dating has poor agreement (Acomb=23.3%; An=40.8%) and suggests the outer sampled rings were not entirely free of exogenous carbon that made the measurement appear older than expected (Fig. 1). From previous experience with both waterlogged timbers and those recovered from standing buildings, the outermost sapwood rings are the most likely to suffer from potential contamination issues as that material is generally more delicate than the inner heartwood material. The result is that the pretreatment of those rings can sometimes err on the side of caution in an effort to minimise material loss.

In removing the final result from the wiggle-match and altering the length of the spaces between measurements to arrive the wiggle-match has good agreement (Acomb=116.1%; An=50.0%) and estimates a felling date of *cal AD 1515–1550* (*95% probability*; Fig. 2; *bark edge*), with highest single-year probabilities in the range *cal AD 1515–1535* (*68% probability*).

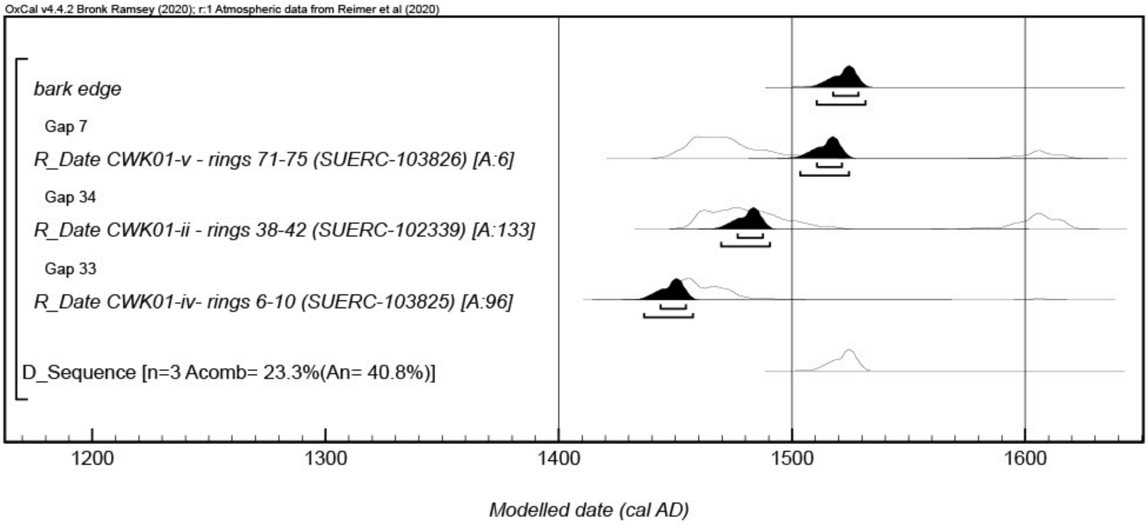

Figure 1: Initial radiocarbon wiggle-match of the timber from Old Wick Castle

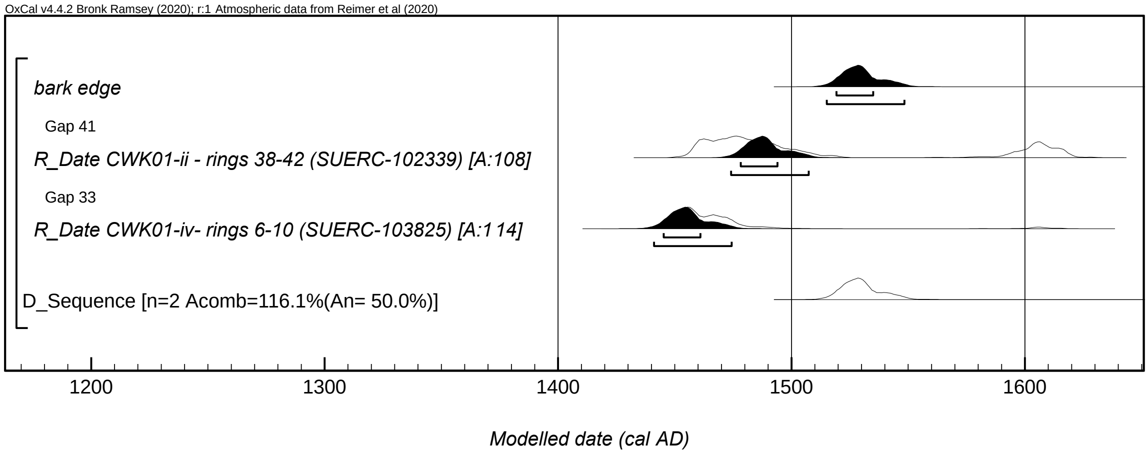

Figure 2: Updated radiocarbon wiggle-match of the timber from Old Wick Castle, after removing the outermost measurement (SUERC-103826)

Table 1: Radiocarbon results from tree-rings dated from Old Wick Castle

Lab ID	Rings	$\delta^{13}C$ (‰)	Radiocarbon Age (BP)	Calibrated Date (95% probability)
SUERC-103825	6–10	−27.5	415 ±19	cal AD 1435–1495
SUERC-102339	38–42	−27.4	381 ±16	cal AD 1450–1515 (72%) or cal AD 1590–1625 (23%)
SUERC-103826	71–75	−27.9	397 ±19	cal AD 1445–1510 (84%) or cal AD 1595–1620 (11%)

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Appendix 2 Tree-ring width data for sample CWK-01

File C:\DENDRO CURRENT\Dendrochronicle\Castle of Old Wick\CWK01.d
Title : Castle of Old Wick
Measurements by Coralie Mills 2021.
The data combine measurements from radii CWK01a and CWK01b as explained in Table 1
Raw Ring-width *Alnus* data of 80 years length
Undated; relative dates - 1 to 80
0 sapwood rings and bark surface
Average ring width 111.95 Sensitivity 0.32
Units of measurement 1=0.01mm
Ring 1 is at the centre and Ring 80 is at the outer edge which is at sub-bark surface (waney edge)

Rings 1-10	38	29	42	54	37	45	56	82	63	62
Rings 11-20	44	47	46	64	64	87	116	95	97	63
Rings 21-30	91	109	106	115	140	119	118	149	110	117
Rings 31-40	175	124	145	84	77	176	164	270	163	253
Rings 41-50	206	186	108	156	158	177	157	44	28	127
Rings 51-60	154	142	189	182	95	140	222	147	204	214
Rings 61-70	231	186	115	209	173	90	18	83	96	75
Rings 71-80	92	71	72	28	54	65	69	38	40	79