14C WIGGLE-MATCH DATING AND THE STRUCTURAL SEQUENCE AT CULTS LOCH 3

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Introduction

Between 2012 and 2015 Scottish Universities Environmental Research Centre (SUERC) undertook a project to evaluate the potential of the radiocarbon wiggle-match dating technique (Bronk Ramsey *et al* 2001) in the context of Scottish wetland settlement. Wiggle-match dating of timbers takes advantage of the fact that each tree-ring has a radiocarbon signature of the year in which it was formed and hence it is possible to date multiple rings or groups of rings from throughout the length of the timber and obtain a picture of a small section of the past radiocarbon trend. This trend can then be fitted to an internationally ratified calibration curve (at the time of the project this was IntCal13; Reimer *et al* 2013) and because the number of places where the two will match is limited, the precision of the date will improve. In the context of the wiggle-match dating project, the uncertainty regarding the relationship between ST1 and ST2 (see Chapter 2a) provided an opportunity to evaluate whether the technique can cope with not only providing dates for construction events, but also work as a means of resolving questions on site formation that could be used on other sites.

The analysis took place in two steps. In the first step a model that described the relationship of material within the structures, but made no assumptions about their mutual relationship, was built. This served to identify plausible scenarios without imposing any specific order upon the data. Then, in the second step, these scenarios were expressed as site models including all the available data and compared to one another, so as to evaluate their plausibility and implications for the interpretation of the sequence of events at Cults Loch 3. What follows is a summary of these parts of the wiggle-match dating project that are of immediate importance to the interpretation of the site; for further detail and the underpinning data see Jacobsson *et al* forthcoming. forthcoming paper by Jacobsson et al.

Method

All of the timbers used for wiggle-match dating were pre-treated using a modified pre-treatment protocol (Hoper *et al* 1998). The main modification lay in the reduced concentration of the alkali used during the AAA part of the process (2% rather than 17.5% NaOH). This is motivated by the difficulty in retaining sufficient sample material for analysis when using the strong alkali. The pre-treated cellulose was then combusted, graphitized and measured using the techniques summarized in Chapter 6. The charcoal samples have been pre-treated using the acid-alkali-acid technique as described by (Stenhouse & Baxter 1983). The dendrochronological determinations within the models are identical to Crone (see above) and, where possible, use is made of the relative alder chronologies. All of the statistical analyses were conducted in OxCal 4.2 (Bronk Ramsey 2009) using the IntCal13 calibration curve (Reimer *et al* 2013).

Results

The model of the first step included information on the relationships within the structures, the data from dating the settlement mound timbers and an overall assumption that the three groups of data developed as a part of the same process (Illus Xa). Within ST1 sufficient dating evidence was available only from the sub-floor and the primary floor (timbers T41, T44, T901, T966 and T967 and the single radiocarbon determination SUERC-27664). Within ST2 three timbers were sampled from the deposits relating to the original construction

(T24, T36 and T37), the two stakes T59 and T64 from subsequent activity and two determinations on short lived samples from context [602] (SUERC-34786, -59317). The mound was dated based on three timbers T963, T60 and T48, of which T963 comes from a deposit deep within the mound, T60 is a stake from underneath ST2 and T48 is a stake from underneath ST1. These were dated to ensure that any dates among the timbers from the two structures that were 'too early' could be identified as such. Indeed, the wiggle-match dates for T36 and T37 are earlier than the date for T60 and T48, and so are included in all the models as *tpqs* only, as they may have been recycled from some earlier building. Information on the relative alder chronological relationships is available for two pairs of timbers, T60 and T48 (ALSP1x10), as well as T59 and T64 (ALSP3x2), and implemented in the model.

The results of the first step of the analysis provide two plausible scenarios of events (Table X). The probabilities that ST1 timbers are older than the T24 from the original floor of ST2 are all in the range 8.14-20.55%, making it very implausible that T24 was felled after the construction of ST1. However, the two stakes T59 and T64, from a refurbishment of ST2, are both younger than the ST1 timbers with probabilities of 63.75-79.64%, thus suggesting that they were felled sometime after ST1 was built. This suggests that two scenarios are possible based on the radiocarbon information alone. In Scenario 1, Structure 2 was built first, abandoned for a period in which activity took place at Structure 1, after which time Structure 2 was re-built. Scenario 1 Structure 2 was built first, abandoned for a period in which activity took place at Structure 1, after which time Structure 2 was re-built. One possible explanation for this sequence could be that ST1 and ST2 formed a 'figure-of-eight' complex, although the probability of this being the case is slim given the technological constraints of timber roundhouses built on wetland mounds. In Scenario 2 all of the activity at ST2 took place after ST1 activity and all of the timbers dated from the floor of ST2 were re-used. Regardless of the scenario the cessation of activity at ST2 happened after the building of ST1.

To evaluate which one of the two scenarios is more plausible, models describing each of them were built (Illus Xb & Xc). Besides the information already included in the model from the first step, all the other available chronological data was added, including the stratigraphic progression elsewhere on the site, individual radiocarbon dates and dendrochronological determinations. The two alternative models were then compared to evaluate if any one of them is more plausible than the other.

The results for Model 1, built on the assumption that Structure 1 was built during a hiatus in Structure 2 activity, are as follows (Illus Y);

- The onset of activity in this sequence is estimated to *540-485 cal BC (95.4% probability)*
- The primary construction of ST2 is estimated to *520-480 cal BC (95.4% probability)*
- The construction of ST1 is estimated to *485-435 cal BC (95.4% probability)*
- The interval between the construction of ST2 and ST1 is *0-20 years (95.4% probability*)
- The estimate for the end of the archaeological activity is *395-315 cal BC* (*95.4% probability*), but see the comment below
- The interval between the construction of ST1 and the felling date of stakes T59 and T64 is *0-30 years (95.4% probability*)
- The model agrees with the data (Amodel= 83.9%)

Although Model 1 also includes a parameter for the end of the activity represented by the remains of ST1, ST2 and ST3, SUERC-59316, the only determination from ST3 has low individual agreement with the model (A = 46.1%). This might be the result of the imbalance in the distribution of the dating evidence, with the multiple dates and wiggle-matches on ST1 and ST2 exerting too great an influence on the only date from Structure 3. On account of this possibility, the end boundary parameter (*End Cults Loch 3 earlier IA Boundary*) ought to be treated with caution as it is probable that it is biased towards too early dates.

Model 2 was based on the assumption that ST1 was built first and that timber T24 from the original floor of ST2, which is older than all the ST1 timbers, is recycled. The results of this model are as follows (Illus Z);

- Onset of activity in this sequence is estimated to *540-480 cal BC* (*95.4% probability*)
- The construction date for ST1 is *510-430 cal BC* (*95.4% probability*)
- The construction date of ST2 cannot be estimated as all of the timbers from its first floor are believed to be recycled
- The interval between the construction of ST1 and felling date of the stakes T59 and T64 is *0-30 years* (*95.4% probability*)
- The estimate for the end of the archaeological activity in this sequence is *395-320 cal BC* (*95.4%*), but, as was the case in Model 1, ought to be treated with caution, as it might be biased towards too early dates
- The model is in agreement with the data (Amodel= 121.3%).

Discussion

As both models agree with the data and produce posterior distributions that are for the most part plausible, it is impossible to make a clear-cut choice of one scenario over the other. On the one hand, in Scenario 1, where ST2 was dismantled to make way for ST1 and then re-built, is difficult to conceive from a practical point of view. Having said that, the original floor of ST2 contains macroplant and insect evidence that suggests it might have been abandoned and flooded (floor (622/623) - see Chaps 2a & 2c. Furthermore, if Scenario 2 , in which ST1 was built first, is accepted, then all the structural activity between the construction of ST1 and the felling date of the stakes T59 and T64 had to take place within a period of 30 years at most (and in all probability much less), something that may bring into question the practicability of the roundhouses (but see Suter & Schlichtherle 2009, for evidence on high maintenance rates at Swiss lake dwellings). Therefore, there is little on which to choose between the two models and they ought to be considered of equal plausibility given the available information.