RESEARCH REPORT

EVALUATION OF THE IRISH OAK CHRONOLOGY AND ITS LINKAGE

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ABSTRACT

We present an independent interpretation of the raw data used to build the Irish oak tree-ring chronology and report a possible error in one of the chronology's key links.

INTRODUCTION

In 1984, a continuous oak tree-ring chronology for western Europe, which spanned more than 7000 years, was announced as completed (Pilcher et. al. 1984). In 1995, M.G.L. Baillie (Queen's University Belfast, QUB) described the history behind this chronology from an Irish point of view in the book *A Slice Through Time*. In 2010, the complete QUB raw data was published on the Internet, unsynchronized and undated. The publication allowed us to check the consistency of the Irish oak chronology according to the references mentioned.

METHODS

We retrieved the QUB measurement series and synchronized them using our program CDendro. CDendro is optimized for handling large data sets and for search of matches in large tree-ring data bases. A number of well-tried algorithms for crossdating and normalization are available, among others Baillie-Pilcher and Besançon index E. We usually

look at several methods simultaneously and require a high score from all of them to accept a match. Crossdating can be done under interactive supervision with graphical tools and quality check functions.

When building our master references, we followed the advices given by QUB on their web page in connection with the publication of the raw data, and the methods described in *A Slice Through Time*. When building site collections, samples shorter than 100 years, with an overlap less than 70 years, or with a t-value less than 6 were generally excluded.

RESULTS

We were able to synchronize the well-matching material, without any pre-dating, to form three chronologies:

- BelfastAD, a chronology covering the recent two millennia.
- LateBC, a chronology - floating in time - roughly covering the first millennium BC.
- BelfastLong, a floating bog-oak chronology covering 4615 years before the first millennium BC.

The three chronologies do not crossdate among themselves. Each of the three had to be separately dated against published data.

The youngest ring of BelfastAD can be dated to AD 2006 via an ITRDB collection from Tollymore Forest Park, North Ireland (Brown et.al., ITRDB brit057). With this dating, BelfastAD spans the time AD 25 to 2006. Our Teeshan collection, which is part of BelfastAD, gets the same end date as reported by Baillie (1995: p.58): AD 581.

The oldest part of LateBC consists of a collection from north-eastern England, at a site called Swan Carr. The oldest tree-ring of Swan Carr is dated to 1155 BC by Baillie (1995: p.43).

With this dating, LateBC spans the time 1155 to 69 BC. The youngest ring of our Navan collection, which is part of LateBC, gets the same end date as reported by Baillie (1995: p.58): 95 BC.

The BelfastLong chronology, which is all-Irish, actually consists of two parts with a 75-years gap between them. The gap, however, is confidently bridged by an English collection from Croston moss (1442 years long with almost equal overlaps on both sides of the gap, corr. 0.30, t=8.4 and corr. 0.39, t=10.6, respectively). A 761 years long ITRDB collection from Thorne Moors in Yorkshire, England (Boswijk, ITRDB brit036), dated 3777 to 3017 BC and matching BelfastLong with corr. 0.27, t=7.7, results in a dating of 5452 to 837 BC for BelfastLong.

Full details of our work are available on our web site (www.cybis.se). The site also includes our synchronized mean value curves and our dating reports at single sample level.

With the above dating, BelfastAD and LateBC do not overlap: there are no tree-rings between 69 BC and AD 25. We were able to convincingly extend LateBC towards modern time with English Roman raw data kindly provided by Cathy Tyers, Sheffield University/English Heritage. The correlation of the English data series towards BelfastAD was much weaker. Though we could reconstruct the proposed linkage (see Pilcher et.al., 1984), we do not regard this as a proof that the link is correct, as we never reached t-values higher than 5.1.

LateBC and BelfastLong do indeed overlap 316 years, but with a very unsatisfactory correlation (corr. 0.17, t=3.0). This means that some deeper analysis of this link is required.

The oldest part of LateBC consists of an English collection from Swan Carr, which shows a good match towards the rest of the chronology at 312 BC (corr. 0.30, t=8.0). Lifting off this

collection reveals that the all-Irish parts of BelfastLong and LateBC overlap by 111 years but do not match (corr. 0.10, *t*=1.0), see Figure 1.

An even closer look shows that the mismatching overlapping collections nevertheless are from the same site, Ballymacombs More (county Antrim). This was not expected! Baillie (1995, p.35) reported that the Long chronology and LateBC do not overlap and that there is a one-year gap between the two meeting Garry Bog/Ballymacombs More collections, the collection in the Long chronology ending at 949 BC and the collection in LateBC starting at 947 BC. We find 947 BC as the oldest ring in our Ballymacombs4 (of LateBC), but 837 BC instead of 949 BC as the youngest ring of our Ballymacombs3 (of BelfastLong).

A look into our Ballymacombs3 site collection makes clear what has happened. There is a 380 years long oak curve (Q10705) extending the collection by 112 years. And while the rest of the collection was measured long ago (Q2203 to Q2272, youngest ring at 949 BC which is the same as Baillie's dating), the huge oak was measured in 2009 and therefore was unknown when the Belfast chronology was linked together in 1983 (Baillie et.al., 1983).

DISCUSSION

Q10705 was measured several times with very similar results. It fits the rest of Ballymacombs3 with a convincing corr. 0.53, *t*=10.0, but there is no match towards Ballymacombs4 (corr. 0.13, *t*=1.4 at 111 years overlap, see Figure 2). Maybe this mismatch is not sufficient proof that the link is wrong, but we cannot find any dendrochronological evidence that the link is right!

Moreover, there are no acceptable alternative matching positions between Ballymacombs3 and Ballymacombs4, and if we add SwanCarr to LateBC again and look for matches which are better than "as conventionally dated", the first viable alternative would mean inserting 179

years into the gap. Better alternatives emerge more than 200 years off. But there is no chance to definitely point out a matching-point with the material we have at our disposal, the overlaps become too short and the sample depth too shallow. When the crucial link first was reported (Baillie et.al., 1983), it was described as "tentative", but as the only possible alternative because "no other consistent match exists."

The linkage across the 948 BC gap is also discussed in a recent QUB paper (Brown & Baillie, 2012). Q10705 is not mentioned though it was measured before the submission of the paper; therefore the link Garry Bog/Ballymacombs More towards Swan Carr still has 206 years overlap and the same sample composition. For this link, Brown and Baillie (2012) report a t-value of 7.6. That value can be compared with 4.7/3.6 (Baillie et.al., 1983) and 4.9 (Pilcher et.al., 1984). We get the following t-values with different normalization methods: 2.7 (Hollstein), 2.8 (Baillie-Pilcher), 2.8 (P2Yrs), 3.0 (Cross84), 3.1 (COFECHA), 3.9 (Besançon index E). In our opinion, this is not a dependable match, even if we ignore the case of Q10705.

The German oak chronology that was announced at the same occasion (Pilcher et.al., 1984) appeared to be fully dependent on the linkage of the Irish/English oak chronology. An expansion of the gap at 948 BC would therefore be possible without problems, as apparently only SwanCarr connects the recent three millennia of the European oak chronology to the prehistoric past. Though it is claimed that the Hohenheim chronology now confidently bridges the so called "Hallstatt gap" at 500 BC (Friedrich et.al., 2004), this is nothing we can verify as all its raw data still is unpublished and unavailable.

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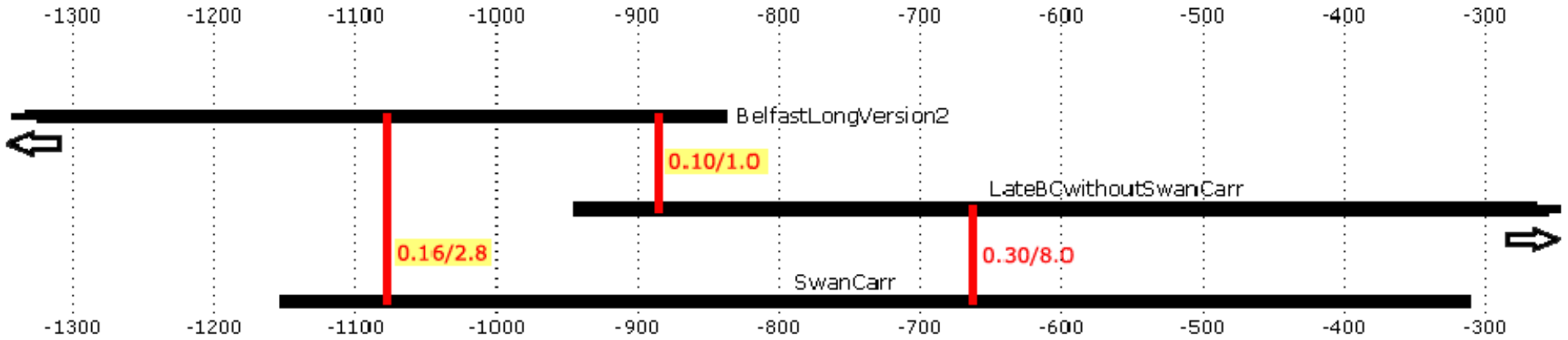

Figure 1. Linkage between BelfastLong and LateBC.

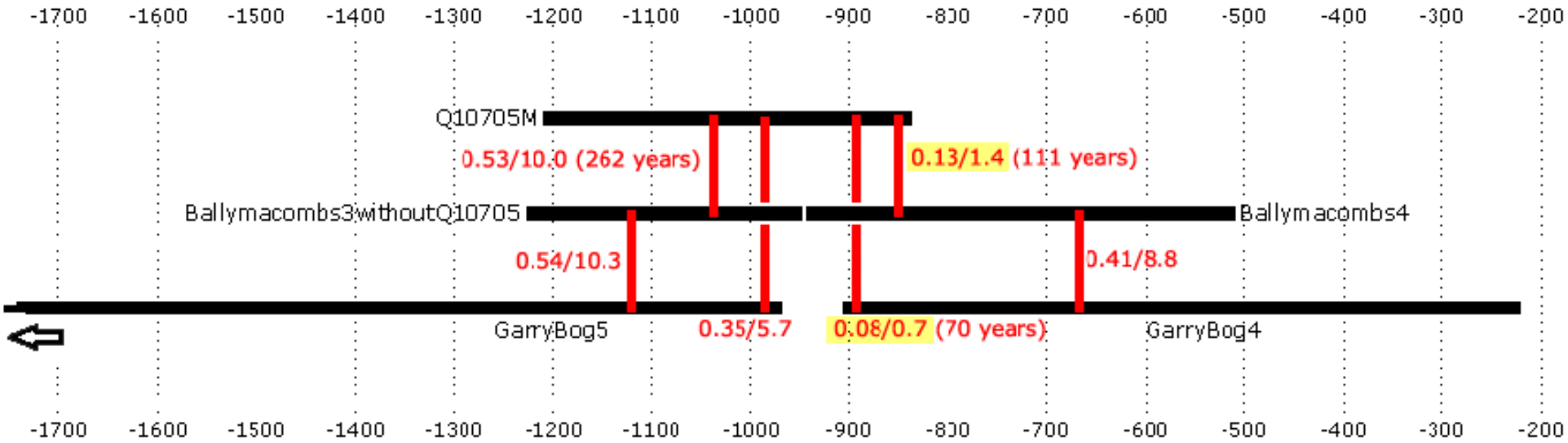

Figure 2. Details of linkage across the 948 BC gap, Garry Bog and Ballymacombs More only.