Current Developments in the Scientific Dating of Wood

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The date of a given piece of furniture is often a crucial factor in a full appreciation of the object, and this has traditionally been assessed on the basis of style and patina, along of course with any historical records for the ownership of the item that may be available. Occasionally there may be some doubt over the authenticity of claims for the age of an object, or there may be conflicting stylistic issues that mean that some form of independent dating technique is needed to establish its *bona fides*. Another factor that may be of interest is the growth area origin of the wood used, and in some instances it may be possible to indicate this to a greater or lesser extent.

In the case of wood, a number of techniques may be used to establish age, all of which have their advantages and disadvantages. This article sets out to give a basic introduction to these specialist techniques and some of their limitations. The best available technique is probably dendrochronology, as this can establish the date of a ring sequence with annual resolution, whilst also giving an indication of geographical provenance of the growth area of the tree used. Yet it has many drawbacks, as we shall see below. Radiocarbon dating is an established technique that is evolving rapidly and will be useful for many wood types where dendrochronology is not an option, and isotopic dating is another area that is rapidly becoming a possible third option.

DENDROCHRONOLOGY

Tree-ring dating relies on the fact that trees of the same species growing over a wide geographical area will usually have annual ring widths which vary from year to year in a similar way as a result of major external growth influences, such as temperature and rainfall. It is important to remember however that each individual tree will have its own unique growth pattern depending on its immediate environment and general health, so that a diseased tree, one hit by lightning or damaged by a falling neighbour, one suddenly experiencing a growth spurt as the result of the felling of neighbouring trees, or managed in some way by human activity, may have a growth pattern that is atypical of its wider geographical location.

For dendrochronology to work, it is necessary to have a plentiful source of historic wood from overlapping periods, such that a reference sequence can be constructed that will allow comparisons of a new sample with this 'master curve'. This means that dendrochronology is restricted to a few species, in Britain mostly oak and imported pine, and it requires some way of deriving a sequence of ring widths with a minimum of 60–80 rings, and preferably several sequences from different timbers, to establish a date. It has proved particularly useful with objects like oak chests and for panel paintings on oak boards, and when dating is successful, the individual chronologies with which matches can be established give an indication of where the source trees may have grown (dendroprovenancing).[1]

In many cases not only will long sequences not be available, but when they are, they may not be visible, and it may be necessary to use specialist micro-borers, clean the edges of boards (rarely acceptable), or derive ring-width sequences from X-ray photographs.[2] A further, major problem here, as with methods other than dendrochronology, is that in many instances there is no indication of sapwood, making it very difficult to know how close to the outside (felling date) of the tree a piece of wood may be. Experience shows that for boards it is common to waste very little outer wood, and clustering of the end dates of several boards from one item may suggest that minimum amounts of trimming of the outer heartwood have been employed.

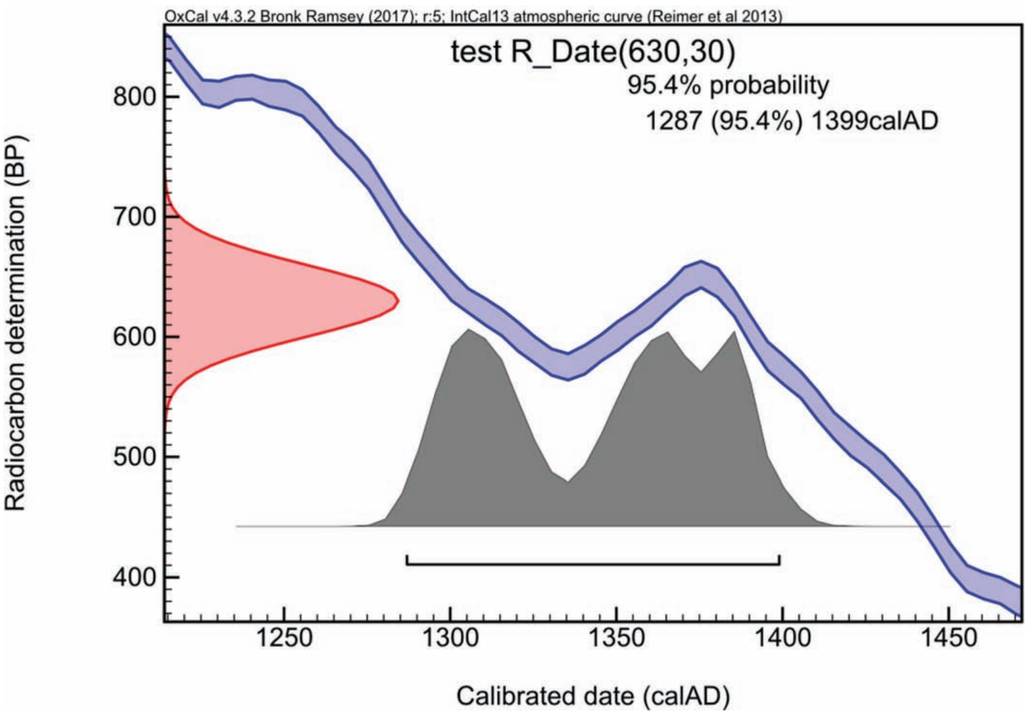
When one compares a derived ring-width sequence with the database of reference chronologies, it is generally accepted that those giving the strongest statistical matches are likely to be from the same geographical area as the growth area for the trees used. It would be wrong to focus on individual matches since in many cases it cannot be proven that the trees in a given chronology were actually from the area immediately around the site. For example, sometimes building timbers were transported over long distances, especially for grander buildings. It is important therefore to look at the geographical spread of the matches. Over long distances this is less of a problem, so one may deduce that boards used were from trees grown in Germany or Poland, but at finer resolution it may only be possible to give a region, such as south-west England or north-east England.

RADIOCARBON DATING

Radiocarbon (^{14}C) is made in the upper atmosphere as the result of cosmic rays colliding with the atmospheric gases. The resulting radioactive carbon mixes with the rest of the atmosphere and is then absorbed by all living things while alive, the living organism being expected to reach equilibrium with the amount of radioactive carbon surrounding it. The rate of decay of ^{14}C is known: the time taken to halve the amount present (the half-life) is 5730 years. All of this means that one can measure the amount present in an object and work out the length of time that has elapsed since the organism was alive. This makes the method suitable for any organic material, so one is not restricted to certain species of tree, as with dendrochronology.

Sadly however, things are not that simple. The production of ^{14}C has not been constant in the atmosphere, but has varied through time. It is necessary therefore to know how this has varied, and this has been achieved by analysing dendrochronologically dated wood. For practical reasons, the calibration curve used has been based on ten-year (or occasionally five-year) blocks of rings. It can be shown that certain cosmic events may result in greater amounts of ^{14}C in a single year, and the international calibration curve in wide use now (IntCal13) should soon be replaced by a new one (IntCal20) that will have annual resolution at difficult parts of the curve.[3]

1 Bridge and Miles (2011); Cooper (2011); Bridge (2012).
2 For micro-boring see Bridge and Miles (2011).
3 For discussion of a short-term spike in ^{14}C see Güttler et al. (2015).



1 The red area represents the actual measured amount of radiocarbon in a sample, with its error spread. When extended across to the calibration curve (blue) at this particular position, several possible dates are derived, with the probability for any given calibrated date shown by the grey area.

Certain periods are problematic in that more than one time may have the same concentration of ^{14}C. A line drawn across the graph from the derived concentration may intersect the calibration curve at more than one point. Added to this, the amounts of ^{14}C are always very small, so there is a small error term associated with determining the amount present, which increases the spread of possible dates derived.

An example of a radiocarbon dating graph is shown in Figure 1.[4] Here the amount of ^{14}C measured gives a value (based on the half-life) of 630 years BP, that is Before Present, or 1950 CE, the baseline for all radiocarbon measurements. This has an associated error term of ± 30 years. The red area on the left of the plot therefore represents the possible spread of the actual measured value. At this date, one can see that the red area continued across would intersect the blue calibration curve (itself having some width because of known errors in measurement) at several places, giving the probabilities of different calibrated dates, represented by the grey area. So in this example, at this part of the curve, radiocarbon is not very useful if one is trying to derive a narrow date range. At other times, however, as with the triangular stool

[4] This figure is derived from an online program called OxCal, written by Christopher Bronk Ramsey of Oxford University, widely used to derive calibrated radiocarbon dates.

discussed by Aidan Harrison in *Regional Furniture* 2018, there may be a much narrower range of possible dates.[5] This difficulty may be overcome to some extent by taking several samples a known number of rings apart, and then doing what is known as 'wiggle-matching' where the different values of known age separation can be superimposed on the calibration curve to find the position of best fit.

Where a sufficiently narrow date range is obtained, however, a further problem remains, as discussed in the case of the triangular Gothic stool: if there is no indication of sapwood, one cannot know if one has tested the outer rings just near the sapwood or the inner rings of a very old tree. In the example illustrated here, the felling might date to between around 1300 and around 1400 but the timber could also have been obtained from a tree in growth during the fourteenth century yet felled in a later century. Date of manufacture, therefore, is rarely available, though a result may be sufficient to show that historic wood has at least been used, as opposed to modern wood.

ISOTOPIC DATING

Work is currently proceeding in the Geography Department at Swansea University, in association with the Research Laboratory for Archaeology and the History of Art, Oxford University, on a chronology for oxygen isotope values (^{18}O) from oak pieces dated by dendrochronology.[6] The oxygen incorporated into wood as the tree grows is ultimately derived from ground water, and in Britain the precipitation that provides this varies in the proportion of that from westerly air-flow frontal rainfall in wet summers and convective rainfall in dry anticyclonic summers. This is passively recorded in the wood, and does not require the 'stress' that gives rise to varying ring width, making it suitable for dating fast-grown wood with little ring width variation. This technique appears to be having great success in dating oak of unknown age, using fewer rings than standard dendrochronology. It would appear that a forty ring sequence may be enough to derive a date. Several building timbers already dated by dendrochronology have been submitted as 'blind tests' and the isotope method appears to achieve the same accuracy as dendrochronology. The method only uses the summer wood in oak samples, and therefore narrow-ringed sequences rarely provide enough material to work on.

CONCLUSION

Overall the prospects for the scientific dating of wood are currently improving at a rapid rate, although the necessity of having sapwood to show that one is near the felling date of the tree used will always present limits to the interpretation of any dates derived, by whatever method.

5 Harrison (2018).
6 Loader et al (2019).

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