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POTENTIAL OF DENDROCHRONOLOGICAL DATING OF WOODEN ARTEFACTS

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ABSTRACT

The dendrochronological method is based on a laminar wood structure consisting of layers of annual tree rings. Annual resolution of the material makes it datable within the accuracy of one year. Nevertheless, the artefact should meet several requirements in order to be subject to a dendrochronological analysis. Tree species of the artefact have to be the same as the reference chronology, and the geographical origin must also be the same. The number of tree rings in the artefact is to be sufficient for a statistical evaluation. The presence of the bark edge or the sapwood part is essential for the establishment of a tree felling date. The possibility of a secondary use or weathering of wood is to be evaluated when counting the manufacture date.

If a wooden artefact meets the requirements, dendrochronological dating is the most precise dating method. Thus far it has been mainly applied to archaeological wood in Lithuania. On the basis of the analysis of the waterlogged constructions excavated in the Vilnius Castles site and other historic buildings, a millennium-long pine tree-ring standard chronology was constructed. This chronology has been used to date several wooden constructions from the site under conservation at present. An 8.6 meter-long water collector made of pine and oak boards conserved with sucrose was dated back to 1539. A bridge pier treated with PEG was dated back to 1584. A well made of 1.5-meter-long radial split oak boards conserved with sucrose was dated against the oak chronology back to 1484-1490.

The modern digital photography technique enables us to have non-destructive images of the tree rings and thus facilitates a dendrochronological analysis of the artefacts that cannot be analysed directly. With the help of digital images the date of the winding stairs in Vilnius Cathedral-Basilica was established to be between 1662 and 1692.

KEYWORDS

Historic wood, tree-ring analysis, pine chronology, oak chronology, millennium, the Vilnius Lower Castle, the Palace of the Grand Dukes of Lithuania

INTRODUCTION

The dendrochronological method is based on a laminar wood structure consisting of layers of annual tree rings. Annual resolution of the material makes it datable within the accuracy to one year. Also, the dendrochronological method of dating wooden objects has one important difference from other dating methods used in historical sciences. The accuracy of many physical dating methods decreases with the time span separating the present from the past moment under study increasing, whereas dendrochronological dating gives the same resolution (in an optimal case up to one year) regardless of the historical period. Due to this precision it becomes analogous to chronological information contained in written sources and therefore wood is sometimes called "the natural archive".

Precision of dating is important because it helps separate events to be synchronised. The more precise dates of the artefacts and events we have the more complete picture of social processes in human history and their causalities we are able to reconstruct.

DENDROCHRONOLOGICAL METHOD

Synchronisation of annual ring series of different trees forms the basis for dendrochronological dating. A change in widths of tree rings of the same species growing in the similar environment has many common features. This common rhythm enables rings of the same year to be identified in different trees. Measured series of ring widths are synchronised according to statistical indicators of resemblance and visual resemblance of graphics in each position of two overlapping series. When dating, it is necessary to follow the principle of replication in synchronising several series; the established synchronous position in couples and a group must coincide and confirm the exactness of the date. Usually at least 5 (the classical number of samples is 10) samples of wood elements from a simultaneous construction are needed to make reliable dendrochronological dating. Synchronisation work is time consuming because hundreds of thousands of overlapping positions have to be verified. Therefore application of dendrochronological dating has become widespread during the past decades after computers and software capable of handling and analysing large data arrays appeared and became perfected.

REQUIREMENTS FOR APPLYING THE DENDROCHRONOLOGICAL METHOD

It is not every wooden object that can be dated by the dendrochronological method. What requirements should be fulfilled so that having examined annual rings of a wooden sculpture or the board of a painting we could expect to receive a good result?

First and foremost, the species of a tree is of great importance. When dating, the series of widths of the annual rings of the object under investigation must be synchronised with the reference chronology of the same species of a tree because trees of different species have a different rhythm of rings. The pine and the oak are the species that have been studied best; chronologies of their rings have been constructed for the majority of European regions. In Lithuania we have a thousand-year-long chronology of the pine and a chronology going back for several hundred years of the oak. The principle of

constructing a chronology is represented in ill. 1. Information about the rings of each dated object supplements or prolongs the chronology. The "anchor" of the chronology on the timescale is rings of live trees because the concrete year of the formation of the last ring is known. Most probably in the future, provided that attempts are made and special attention is devoted to this matter, chronologies will also be constructed for such species of trees as lime and birch, which are much more difficult to investigate.

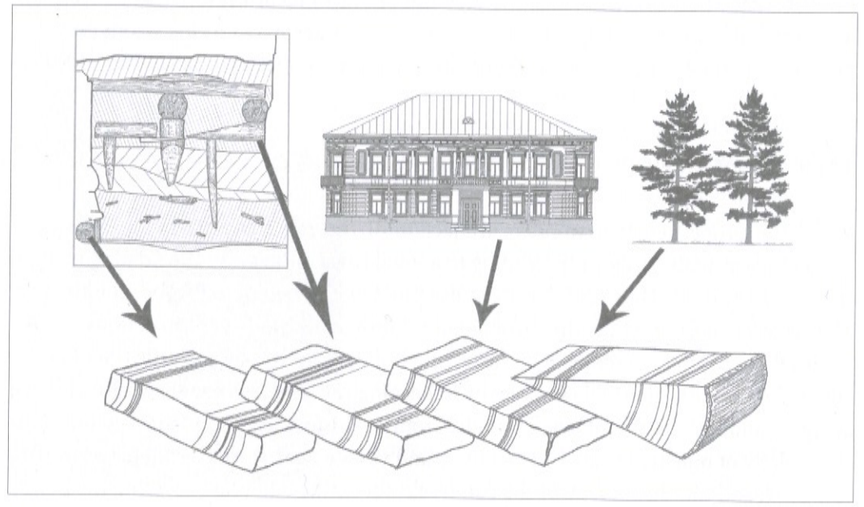
The chronologies constructed are suitable for dating the objects that come from the same region only because similarity of the rhythm in the tree rings decreases with distances increasing (Baillie, 1995). On the one hand, this limits the application of the method but at the same time it raises new possibilities. With the network of regional chronologies of the same species of trees expanding, the possibility arises not only to date the object but also to establish the place of its origin.

Since the dendrochronological method is based on a statistical evaluation of the resemblance between the time series, a wooden object being dated is to have the number of rings sufficient for the investigation. It is considered that a series of at least 50 rings is necessary for reliable dating. With the number of rings being smaller than 50, dating is possible only if additional information confirming simultaneity of the objects is available.

INTERPRETATION OF DENDROCHRONOLOGICAL DATES

The result of cross dating of a wooden object according to the reference chronology is recording of each ring, beginning with the first ring and ending with the last one, on the calendar timescale. The aim of an investigator of a wooden artefact is to establish the time of manufacture as exactly as possible. The date of the last ring is of profound significance to him/her. However, to establish the date of manufacture of the object according to the date of the last ring in the artefact, it is necessary to take several circumstances into consideration.

The most exact date is established if the bark edge has survived in the artefact. The bark edge shows the last year of the growth of a tree prior to its felling. Usually trees



ill. 1. The principle of constructing a chronology by the overlaping of crossdated tree ring sequences (compiled by Mantvidas Mieliauskas)

ill. 1

are felled after the vegetation season has come to an end, in September of the year of the growth of a ring – in April of the following year. In case a tree is felled during the vegetation season, this can be established having examined the bark edge ring – usually it is not completely grown. In this case even the month of felling can be approximately established.

If the outside layers of wood have not survived in the artefact, only an approximate date of felling a tree is established by adding the number of the established years to the date of the last ring. It is known that some species of heartwood trees such as the oak, and partly the pine, have a certain number of sapwood rings depending on the age of the tree, the speed of growth and the geographical region. If there are at least several surviving sapwood rings in the artefact, their missing quantity is established according to the regularities characteristic of this species.

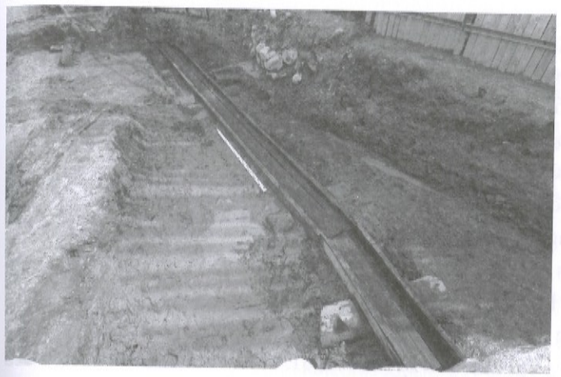
The least exact date is obtained when only the heartwood part has survived in the artefact. In this case it is impossible to establish the number of the rings lost therefore the tree felling date is established as "*terminus post quem*" (Baillie, 1982).

Seeking to interpret the time of manufacture of an object it is necessary to assess the time period that has passed between felling of a tree and its use. It is considered that wood for building was used without being dried, right after felling a tree. Wood was not used in the same year, and sometimes it was used in the following year or even in another year for large-scale construction work or when floating it over long distances (Hillam, 1998). In this case trees felled in different years are found in the constructions, and the date of the construction is established according to the latest one. Whereas wood used for works of art, for making furniture or other special articles was often kept for some or even several years before being used. Therefore to establish the exact time of manufacture of these objects on the basis of the time of felling it is necessary to have additional information.

Another circumstance that is to be taken into consideration when applying dendrochronological dating of objects is a secondary use of wood. Though things that were no longer useful were used as fuel, wood that was more valuable or large in size was applied for other purposes too. Casks that had no use were often used for wells, beams of the dismantled buildings were used to build other structures or for flooring. When investigating wood constructions it is very important to record features of a secondary use so that dendrochronological dates should not be interpreted in the wrong way. For the same reason it is necessary to investigate as large a number of samples as possible.

SAMPLES OF DENDROCHRONOLOGICAL DATING OF CULTURAL OBJECTS

If the properties of a wooden artefact fulfil the requirements set to a dendrochronological analysis, dating according to annual rings is the most exact dating method at the present time. Thus far it has been used to date archaeological wood in Lithuania. The richest collection of dendrochronological samples of wooden constructions – about 3000 items – has been assembled in the territory of the Vilnius Lower Castle (Pukienė, R., 2009). On the basis of the 500 samples of archaeological collection that have already been analysed and the analysis of wood samples from the historical Vilnius constructions, the chronology of pine tree rings dating a thousand years covering the period between 1010 and 2009, and the chronology of the oak tree rings dating 329 years covering the period between 1202 and 1530, have been constructed.



ill. 2

ill. 3

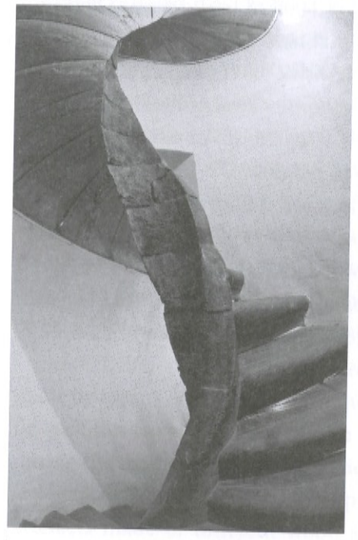
With the help of these chronologies several wooden constructions of the Vilnius Lower Castle, which at the present time are under conservation at the restoration workshops of the National Museum of the Palace of Grand Dukes of Lithuania and are being prepared for display, have been dated.

One of the most impressive artefacts under conservation is a wooden 8.6-meter-long collector constructed from pine boards fastened in the base of pine logs and covered with lids made of pine and oak planks (ill. 2). Oak lids are dated according to the oak chronology, the last surviving ring grew in 1530, however, several outside rings have been rotten away. Meantime, the pine logs of the base and several boards have survived up to the bark edge. The series of their rings are synchronised with the pine chronology and the last ring is dated back to 1539. Elements of the collector have been conserved with sucrose and currently are being dried.

1.5-meter-long boards of the curb of the well made of oak boards of radial split are also conserved with sucrose. The outside layers of wood are decayed in the boards but there are quite a number of sapwood rings. The last sapwood ring is dated back to 1484. On the basis of the number of surviving sapwood rings the date of oak felling has been established to be between 1484 and 1490.

The last ring of the pine bridge pier of the Pilies (Castle) Gate being conserved with polyethylene glycol (ill. 3) is dated back to 1584. The beams have the surviving bark edge; hence this date shows the year of feeling the tree.

The dendrochronological method is easier adapted to investigating archaeological wood because usually it is not the entire construction found in the archaeological layer that is being conserved, a part thereof can be used for samples (for cross-sections). To investigate the annual rings it is necessary to have a segment of the cross-section of the trunk with the prepared surface. When examining art objects or wood of standing structures, access to the cross-section surface and its preparation are often quite problematic. In that case the advancing digital photography technique



ill. 4

ill. 2. Sewage collector dated to 1539. (photo by M. Kaminskas)

ill. 3. Remnants of the Castle Gate bridge pier dated to 1584 (photo by M. Kaminskas)

ill. 4. Winding stairs of the St. Casimir chapel of Vilnius Cathedral-Basilica dated back to 1662-1692 (photo by V. Abramauskas)

enabling images of cross-section of a tree of large resolving power to be recorded extends the possibilities of investigating the rings. Later the enlarged digital photographs of the rings can be studied by means of standard dendrochronological methods additionally using programmes of the analysis of digital images. A non-destructive dendrochronological investigation into the winding stairs of the St. Casimir Chapel of Vilnius Cathedral-Basilica with the help of digital photography technique can serve as an example (ill. 4) (Pukienė, R., 2008). Having analysed the annual rings recorded by means of the digital Nikon D200 camera in the pictures of cross-sections of the stairs, the last surviving ring was dated back to 1662. Having assessed the possibly lost rings, the stairs were dated back to 1662-1692. Thus the stairs were installed following the reconstruction of the interior of St. Casimir Chapel that was carried out after the war with Moscow in 1655-1661.

CONCLUSIONS

Synchronisation of annual ring series of different trees forms the basis for dendrochronological dating. Dating according to annual rings is the most exact dating method at the present time but the properties of a wooden artefact have to fulfil the requirements set to a dendrochronological analysis.

Thus far the dendrochronological method has been principally used to date archaeological wood in Lithuania. Application of the method can be extended and art-historical objects or wood of standing structures can be investigated using digital photography for a non-destructive tree ring image recording.

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