Chapter XII

Age determinations based on dendrochronology

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1. INTRODUCTION

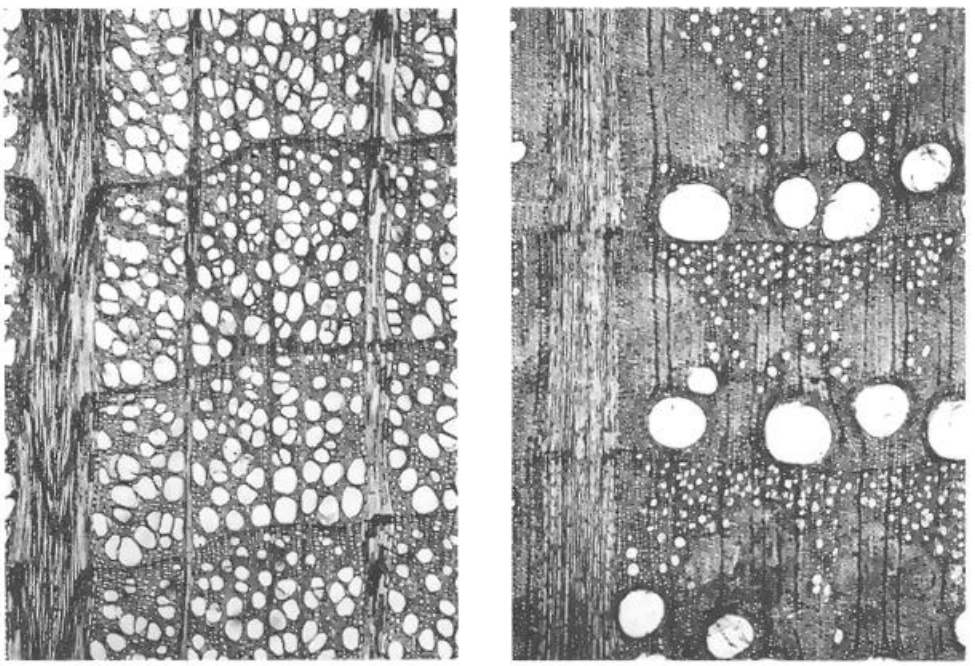
Dendrochronology is a rather recent discipline of biological sciences which, among a number of other objectives, serves the purpose of determining the age of wooden objects. The methods employed and hereafter described were used primarily for dating archaeological and architectural objects[18,19,20], but recently also for solving art historical problems[3,18]. In this context it is the discipline's principle goal to give at least a *terminus post-quem* for the creation of a painting by determining the felling date of the tree which provided the wood for the panel. It is now possible to date the age of wooden panels used for paintings created by Dutch, English, Flemish, French and German artists for the period between 1400 and 1800 D.C.[5,6,13,16,22,24].

In the following, the present state of application of dendrochronology as an aid for solving art historical problems is presented as well as an outlook for further possibilities preceded by a short description of the biological background and the methods employed.

2. BIOLOGICAL BASE OF DENDROCHRONOLOGY

Any imaginary line drawn from the centre of a tree to its periphery crosses a series of consecutive rings. These represent, at least in regions of temperate climate, the annual increments of circumferential growth. The ring width varies widely according to growth conditions — for example temperature, rainfall, soil and geographic location and can be accurately measured on a cross-section of the tree.

The principal precondition for the analysis of the growth rings is the accurate identification of every ring making part of different ring patterns. In softwoods the ring boundaries can be differentiated by the contrast between the light early wood and the dark latewood. The diffuse porous deciduous trees, such as beech (Fig. 1a), lime or poplar possess a more homogeneous cross structure making a clear perception of ring boundaries difficult. In ring porous wood species like oak (Fig. 1b) the boundary can easily be differentiated by the contrast between the large early wood vessels and the small late wood vessels.



a b

Fig. 1. Photomicrographs (cross-section) of a. beechwood and b. oakwood : 25 x.

Besides the differences in structure the two species' groups are distinct physiologically : in ring porous wood the latest growth ring fullfills the major task of water conduction and, consequently, a new ring must be formed every year. In diffuse-porous woods all growth rings participate in the water conduction. Hence, under adverse climatic conditions the trees do not need to form a growth ring every year and may be characterized by totally or partially missing rings. On the other hand, even two growth increments may be formed in one year. These occurrences make the determination of growth rings and dendrochronological work with diffuse porous species more difficult than with ring porous ones such as oak.

The biological regularity of the ring series in trees of temperate zones allow the dating of wood by comparing the sequences of undated wood with

those of wood of known age and position in time. In order to establish comprehensive continuous growth ring curves for periods longer than a tree's life it is necessary to use an overlapping system of individual curves. Such standard curves exist, among others, for Southern and Western Germany, for several regions of Northern Germany and, in part, for several areas in the Netherlands and also for the Baltic area, from which the wood for most Flemish and Dutch paintings was obtained[2,14,15].

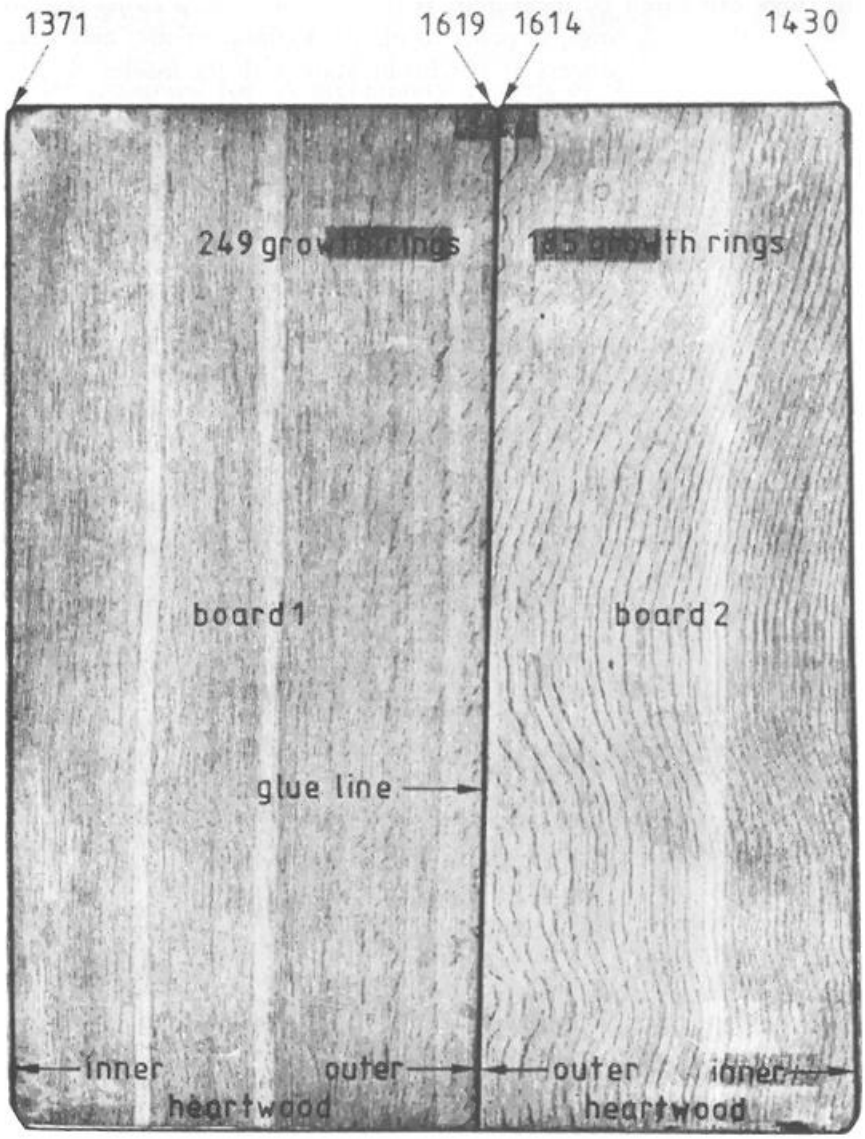


Fig. 2. A 17th century oak panel joined from two boards ; size 62,2 cm x 50 cm, thickness 1 cm (7).

3. Dating procedure

The aim of the examination on the unframed painting is to obtain a complete sequence of the successive widths of the annual growth rings of the board of a panel (Fig. 2). This is done by measurements with a magnifying lense along an edge at which the grain appears. For mounting the panels generally only quarter-sawn boards were used in order to prevent excessive warping and distortion. Thus over a radial length of 10 cm more than 100 growth rings can often be measured. It is necessary that a panel contains at least 50 to 100 growth rings, in order to obtain a characteristic, and therefore useful, pattern for the process of synchronization with the master-chronology of the respective geographical area.

The key information to be determined for the dating of panels is the felling year of the tree. In the case of oak with its light coloured and perishable sapwood various possibilities must be distinguished in function of the sawing technique employed (Fig. 3).

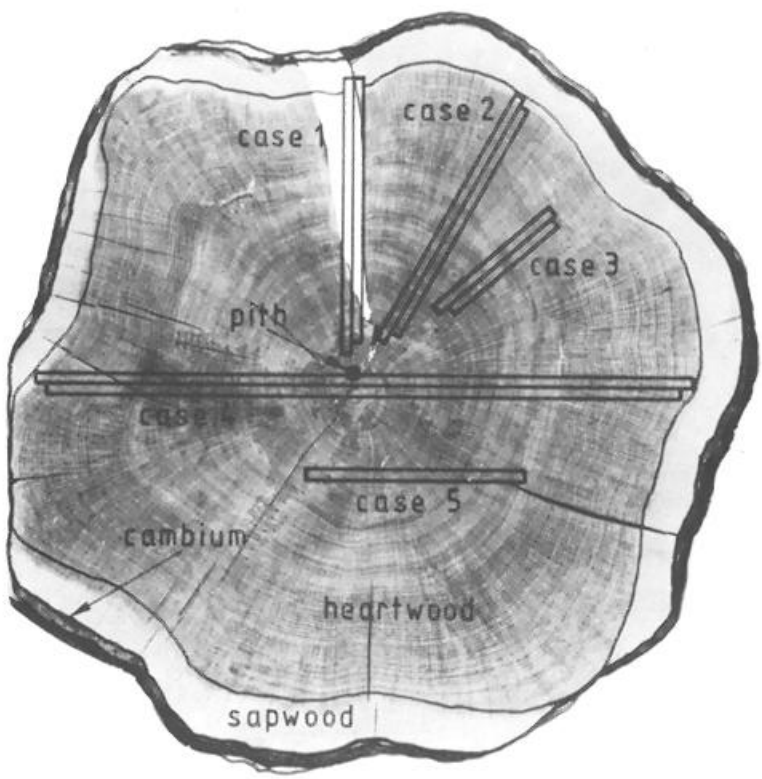


Fig. 3. Various modes for the extraction of boards from the tree (7).

For the determination of the felling date in each case a number of sapwood rings must be added to the latest measured ring on the panel. Only the latest measured growth ring can be determined to the exact year. On the other hand the statements regarding the number of sapwood rings to be added are derived from statistical evaluation and must be considered in each particular case. In addition to the dependence of the number of sapwood rings from the tree's age — the provenance of the oakwood is significant. In Europe the number of sapwood rings varies from west between 19-50[21] ; 16-50[1] ; 14-43[18] ; 15-25[12] and east 9-36[15]. With the elaboration of the new data (eastern provenance) for oak panels new evidence for the sapwood allowance has to be accounted for. A preliminary analysis of the numbers of sapwood rings from 100 oaks from North Poland resulted in a median value of 15 with 50 % of all values lying between 13 and 19[15]. For wood originating from Germany or the Netherlands a median value of 17 with 50 % of all values lying between 13 and 22 was determined. Panels originating from the eastern region containing a few sapwood rings allow a determination of the felling date within the range of $+4$ and -2 years.

In the case of missing sapwood the felling date can only be approximated ; this is illustrated by the mathematical term $15\pm\frac{x}{2}$. In this expression the '15-2' accounts for the sapwood rings possibly involved while the 'x' stands for an unknown number of removed heartwood rings.

For beech, however, an all-sapwood species, the last growth ring available for measurement in many cases corresponds to the one last formed in the living tree and thus to the felling year. Usually, when making the panels merely the bark was removed and the entire tree utilized[24].

The determination of the felling date also gives some information as to the time the wood was stored before use in paintings. For oak panels of the 16th and 17th century in most cases the interval between felling of the tree and creation of the painting has been determined as approximately 5 ± 3 years[7,9]. The few investigations carried out with signed and dated Flemish panels of the 15th century do not yet permit such a close estimate. Instead, present studies regarding this period[23] indicate a storage time of 10 to 15 years, which corresponds to the result of analyses obtained from 15th century panels of the School of Cologne[11]. Similar investigations with 16th century beech wood resulted in an estimated storage time of 2-7 years. This corresponds very well to what holds true for oak wood from the same period[24].

4. Dendrochronological dating of oak panels

Master-chronologies were established for the dating of Dutch and Flemish paintings of the 16th and 17th century by Bauch *et al.*[8]. The analyses of panels from P.P. Rubens[10] showed that the greatest amount of informa-

tion could be obtained by studying the whole œuvre of one artist or of a group of closely related painters rather than single paintings. Such conclusions were corroborated by the investigations of Tudor Portraits[17], of Rogier van der Weyden[22] and of Rembrandt paintings[7].

From this latter investigation a few selected examples of dendrochronology analyses shall be demonstrated here. In Fig. 4, the growth ring series of several panels are symbolized by horizontal bars ; further, the felling date of the oaks used for panels and the art-historical data are marked.

Three paintings are illustrated in detail : the panels used for the paintings Br. 486 (*Tobias and Anna*, Rijksmuseum Amsterdam) and Br. 2 (*Self portrait*, Alte Pinakothek München) contain sapwood rings and the determination of the felling date as 1623 $\pm \frac{4}{2}$ and 1631 $\pm \frac{4}{2}$ respectively confirms the signatures, dated 1626 and 1629.

On the other hand the panel of Br. 440 (*Landscape with a stone bridge*,

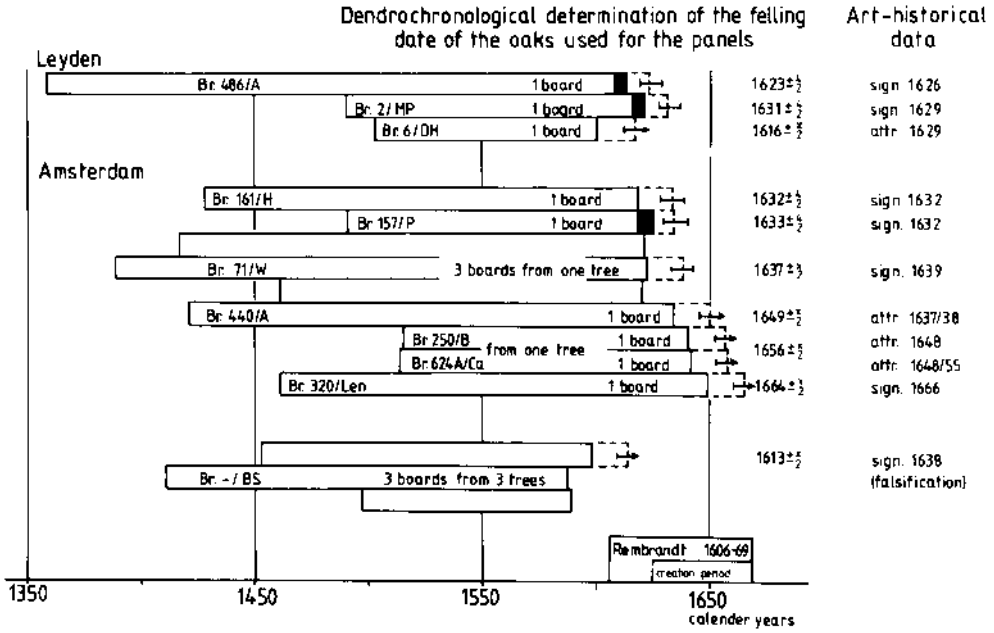


Fig. 4. Some examples for the dendrochronological dating of oak panels attributed to Rembrandt and his circle.
□ - heartwood. ■ - sapwood ; provenance of the wood :
Baltic area ; estimated sapwood range with a median value of 15 with 50 % of all values lying between 13 and 19 years.
A — Rijksmuseum Amsterdam ; B — Gemäldegalerie Berlin-Dahlem, BS Herzog Anton Ulrich Museum, Braunschweig ; Ca — Fogg Art Museum, Cambridge ; DH — Mauritshuis, The Hague ; H — Kunsthalle Hamburg ; Len-Hermitage Leningrad ; MP — Alte Pinakothek München ; P — Paris, priv. coll. ; W — Kunsthistorisches Museum Wien (7).

Rijksmuseum Amsterdam) consists of only one board which does not contain sapwood. In this case the determination of the felling date was 1649 ± $\frac{5}{2}$. Considering that this panel contains more than 200 heartwood rings and thus was cut from an old oak tree, it may be assumed that the tree had 19 rather than 13 sapwood rings. The analysis showed that the art historian's attribution is about 10 years too early.

Another illustration is provided by the analysis of 15th century Flemish panels[22] mainly referring to the œuvre of Rogier van der Weyden (1399/1400-1463). This analysis is of special interest, because the paintings are neither signed nor dated.

The interpretation of the dendrochronological analyses of 5 altars (Fig. 5) originally assigned to Rogier van der Weyden resulted in ideas with regard to proper attribution. For example the *Frankfurter Johannesaltar* (Städelsches Museum, Inv. Nr. 878) obviously must be a copy painted more than 50 years after the death of Rogier van der Weyden.

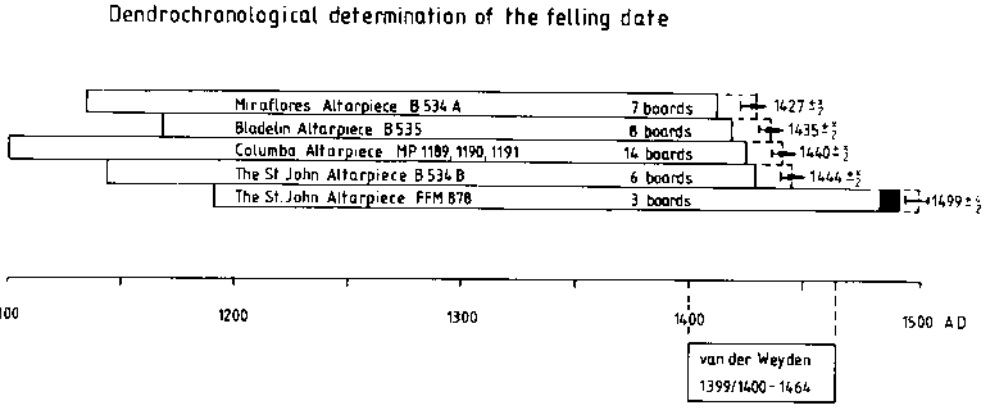


Fig. 5. Dendrochronological dating of oak panels from altar pieces originally attributed to Rogier van der Weyden
[ ] - heartwood, - sapwood ; provenance of the wood : Baltic area ; estimated sapwood range with a median value of 15 with 50 % of all values lying between 13 and 19 years.
B — Gemäldegalerie Berlin-Dahlem ; FFM — Städelsches Kunstinstitut Frankfurt ; MP — Alte Pinakothek München (22).

The analysis of the *Bladelin-Altar* (Gemäldegalerie Berlin-Dahlem, Fig. 6) showed some interesting details. The boards marked with identical symbols (xx) on the photograph, came from adjacent positions within one and the same tree. One was used in its entire width for manufacturing the left wing.

The other board was sawn up in the centre and one half made part of the left, the other part of the right wing. This became evident when the curves of the two halves were joined and compared with that of the entire board. There was a perfect match except for 2-3 mm missing half way through the joined curve due to the saw cut (Fig. 7).

Fig. 6. Rogier van der Weyden, Bladelin-Altar, *Gemäldegalerie Berlin-Dahlem, Cat. Nr. 534 ; Photography : Gemäldegalerie Berlin-Dahlem (22). Construction of the altar from different boards ; x, xx, xxx-boards from the same tree ; i — towards the pith ; o — towards the bark..*

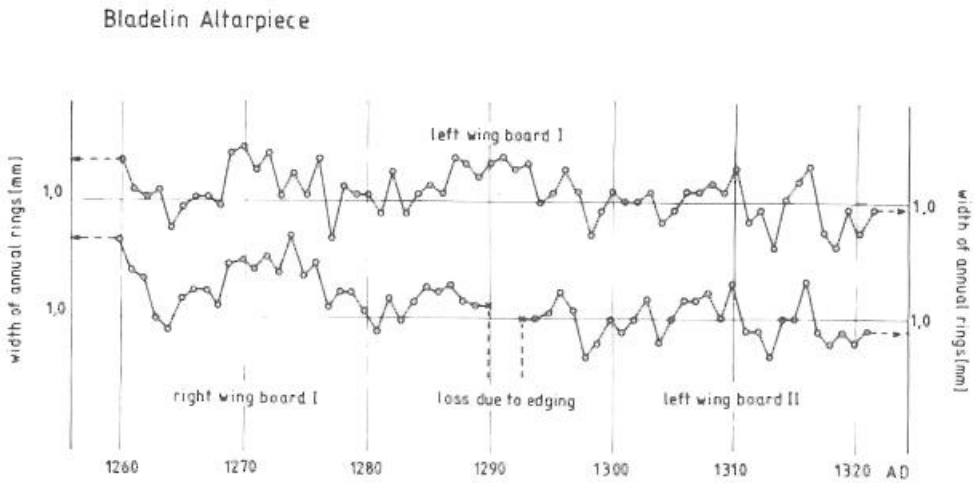


Fig. 7. Bladelin-Altar *; comparison of growth ring curves derived from board I, II (left wing) and board I (right wing) ; (22).*

5. Dendrochronological dating of beech panels

The possibilities and limitations of dendrochronology as described in the foregoing paragraphs were generally derived from the results of the examination of art objects manufactured from the ring-porous oak wood. In Central Europe, however, other woods, such as beech, lime or poplar, and different softwoods were also employed for art objects. Making use of the experience gathered with oak panels in the past three years[24], beech and lime panels of early German painters were also studied and dendrochronological dating is now being successfully exercised with beech panels.

Because in historical times beech was rarely used in construction, it was so far impossible to establish a continuous chronology up to the present time for dating beech panels. However, such dating was achieved in approximation by comparative analysis based on oak chronologies. The positive results did indeed permit the absolute dating of the mean chronological sequence established from the panels used by Lucas Cranach the Elder (1472-1553) and his associates. From the analysis of 15 panels of L. Cranach with time signature (Fig. 8) it becomes quite clear that only a few years had passed by

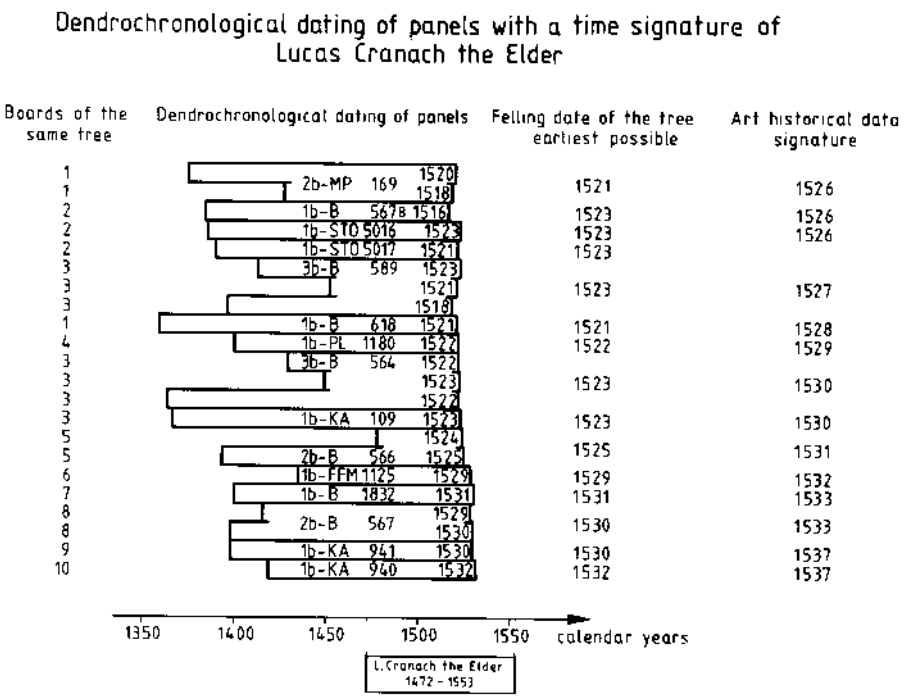


Fig. 8. Dendrochronological dating of beech panels of paintings attributed to L. Cranach the Elder. 1520 — growth ring series with the latest measurable ring ; B — Gemäldegalerie Berlin-Dahlem ; FFM — Städelsches Kunstinstitut Frankfurt ; KA — Staatliche Kunsthalle Karlsruhe ; MP — Alte Pinatothek München, PL-Louvre, Paris ; STO — Nationalgalerie Stockholm (23).

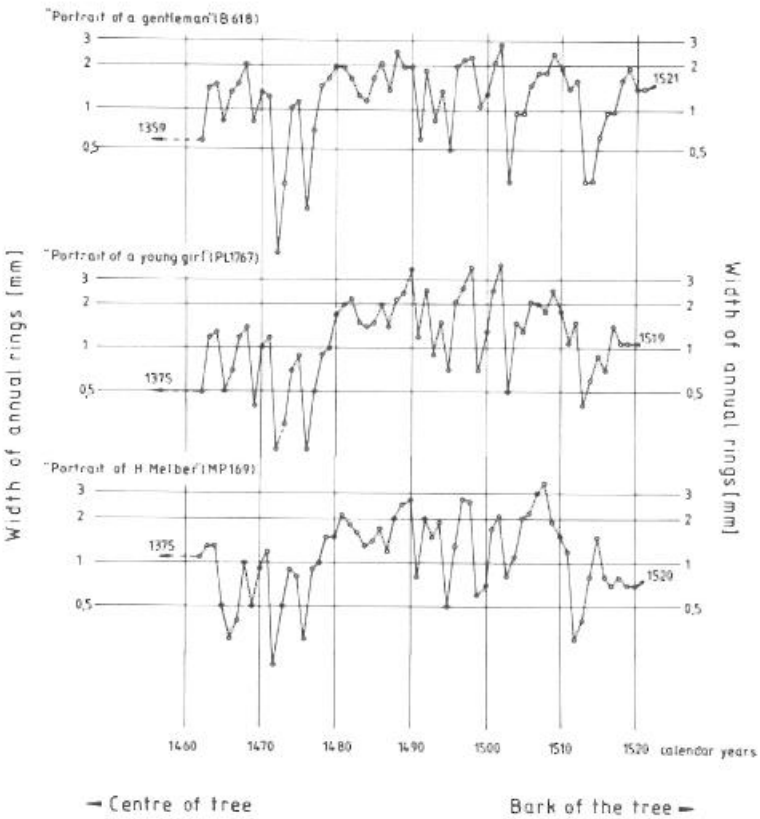


Fig. 9. a. Portrait of a gentleman, *Gemäldegalerie Berlin-Dahlem, sign. 1528 (left)* ; Portrait of a young girl, *Louvre, Paris, attr. 1520 (centre)* ; Portrait of H. Melber, *Alte Pinakothek München, sign. 1526 (right).*

b. Comparison of the growth ring characteristics of the 3 panels of L. Cranach the Elder shown above. (23).

between the youngest annual ring of the respective panel and the time signature. The determination of any given year, however, is limited to the last growth ring available for measurement. Any approximation of the felling date by extrapolating the estimated number of sapwood growth rings, as it is commonly done with oak, is not considered feasible because beech does not develop a visibly differentiated sapwood. Similary to what has been said earlier with regard to oak, it can be shown that boards from the same tree were used for entire panels or as parts for different panels. This may be examplified by the coincidence of the characteristic growth ring sequences (Fig. 9b) taken from the boards joined for the panels of *Portrait of a Gentleman* (Gemäldegalerie, Berlin-Dahlem), sign. 1528, *Portrait of a young girl* (Louvre, Paris), attr. ca. 1520, and *Portrait of H. Melber* (Alte Pinakothek, München), sign. 1526 (Fig. 9a). In this case the youngest growth ring of the panel *Portrait of a Gentleman* could be dated to the year 1521, a date which turned out to be equally valid for the youngest growth ring of the other panels. Taking into consideration the minimum storage time of 2 years the painting *Portrait of a young girl* could have been created at the earliest in 1523 or thereafter. This results in a more accurate attribution then the 'ca. 1520' hitherto achieved.

6. Final remarks

With regard to the analysis of oak used for panels and carvings quite a large number of chronologies exist for several regions and time periods. On the other hand it is evident that the overall climatic conditions are often shrouded by local or regional influences thus impeding the use of such general chronologies for dating particular objects.

Only the establishment of a new regional chronology allows the determination of felling dates, as is the case with the Flemish panels of the 15th century.

The successful dating of beechwood widens the scope of tree-ring dating in its application to wooden art objects and, at the same time, demonstrates the possibilities of dendrochronology to be extended to other diffuse porous wood also used for panels and carvings. In current investigations poplar and lime wood are analyzed. With poplar absolute dating is not yet possible[25] ; in a few cases, however, at least a correlation between different boards originating from the œuvre of one artist could be established. On the other hand early analyses with limewood show promising results making dendrochronological statements a future possibility.

The biological investigations on panels and woodcarvings can be very helpful to the art historian, but they should always been interpreted together with results obtained by other methods. With regard to new results the

existing master chronologies must be completed. Furthermore, additional dendrochronological analyses with several kinds of wood from different centuries and regions must be accomplished.

7. NOTES

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8. RÉSUMÉ

Depuis plusieurs années, la dendrochronologie a été une aide très utile pour l'historien d'art. La question du *terminus post quem* peut souvent être résolue par l'analyse des cernes du bois des panneaux.

Outre la date, le problème de la provenance du bois et du temps écoulé entre la date d'abattage de l'arbre et celle de la réalisation du tableau peut être discuté.

Un certain nombre d'exemples montre à évidence que la datation par la dendrochronologie donne de bons résultats dans le cas de support de hêtre et de chêne. La datation du peuplier n'est pas possible. Dans certains cas il n'est possible que d'établir une corrélation entre diverses planches provenant du même arbre.