

## Woodbiological Investigations on Panels of Rembrandt Paintings

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**Summary.** Paintings on 150 wooden panels accepted and not accepted as authentic Rembrandts were investigated using wood-anatomical and dendrochronological techniques. Paintings on 131 panels came from oaks in the coastal area of the Netherlands and 1 panel came from an oak in the interior. The wood of the remaining 18 panels was from beech, poplar and walnut, presumably from the Netherlands, and from cedrela, mahogany and jequitiba imported from Central and South America. In several cases wood of different panels was from the same trunk. By determining the felling date of a tree, a “terminus post quem” could be set for the production of the panel and the completion of the painting, respectively. The art-historical dating of most paintings could be dendrochronologically confirmed. In some cases the attribution was corrected by a few years. In one case an older panel was re-used.

### Introduction

New scientific techniques are being used in art-historical research. It is now possible to date by dendrochronology the wooden supports of paintings done between 1400–1800 by Dutch, Flemish, English and German artists. When the technique was first used for art-history (Bauch 1968) the aim was to determine the felling date of the tree which yielded a panel. This date gave the art-historian a “terminus post quem” for the creation of the painting. Extensive analyses of hundreds of panels (Bauch et al. 1972; Eck-

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stein, Bauch 1974; Fletcher 1976; Klein 1981) showed that the greatest amount of information could be obtained by studying the œuvre of one artist (Bauch et al. 1978). This is demonstrated here.

Stimulated by the critical revision of the œuvre of Rembrandt by Gerson (1969) and the cooperation with the Rembrandt-Research-Group in Amsterdam, 150 paintings of Rembrandt and his associates were studied to learn the species of wood used and the origin of the trees as well as the technology for manufacturing panels. Special emphasis was on dendrochronological dating of the panels.

Rembrandt lived from 1606 until 1669 in the Netherlands. In his early period he worked in Leyden and from 1631 onwards in Amsterdam. The complete edition of Rembrandt's paintings by Bredius (1935) is a standard reference, and therefore we refer to his numbering.

### Wood Species Used for Panels

According to Gerson's art-historical revision of the Rembrandt-œuvre (1969), about 577 paintings are regarded as the artist's authentic work. From this number 296 paintings are on wood panels. In Fig. 1 all supports of Rembrandt paintings are differentiated into various wood species and other materials used. In Leyden Rembrandt painted mostly on oak panels. This was true for contemporary artists also working there (Bauch 1978). After Rembrandt's move to Amsterdam, besides oak panels he began to use canvas for his paintings as well. In addition, Rembrandt was the first artist to select other wood species for panels, including tropical timbers. This could be attributed to his individual behaviour but may also be due to the special situation of Amsterdam being a harbour for the import of tropical trees. Of 150 panels studied 18 were of wood other than oak (Table 1). *Juglans regia* L., *Populus nigra* L., and *Fagus sylvatica* L. grew apparently in the Netherlands. But *Lecythidaceae* wood, presumably jequitiba, was brought from South America, most likely as sugar case timber, and *Cedrela odorata* L. as well as *Swietenia mahagoni* Jacq. from Central America. The latter was imported frequently at that time. Mahogany was used by Rembrandt six times at different periods of his life. He never took a panel of a tropical tree species for an ordered painting. In the literature (comp. Marette 1961; Grosser 1974) only oak panels were reported for Dutch and Flemish artists earlier than about 1650.

All 18 paintings are regarded by most of the art-historians as originals. The wood analysis supported this by evidence that within a species some panels came from the same tree (Table 1).

### Manufacturing of Oak Panels

The following considerations were related to those 132 panels made of oak wood (*Quercus robur* L., *Quercus petraea* L.). The size of the panels varies from about

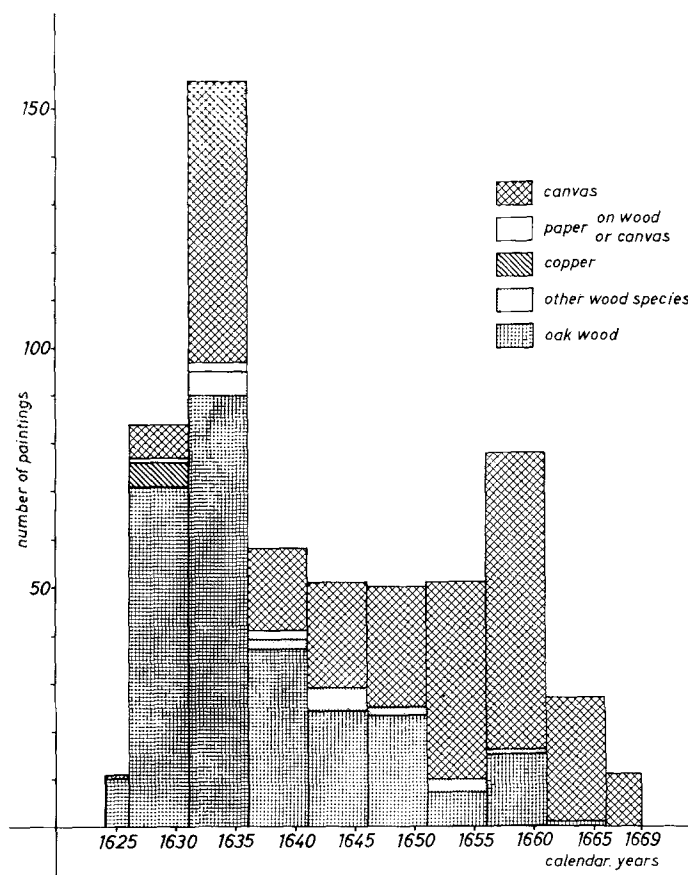


Fig. 1. Portions of various supports of Rembrandt paintings in relation to time. Rembrandt was born in 1606 in Leyden and worked there up to late in 1631 when he moved to Amsterdam, where he died in 1669

15.5 cm x 12.5 cm (Fig. 2) to 123 cm x 103 cm. The small-sized supports of the paintings consisted of one board whilst large-sized ones were made usually by two or three boards (comp. Fig. 3). The boards were in most cases 7–11 mm thick. They were probably dried only after cutting from the oak stem. Thus it was possible to use the panels very soon (comp. Fig. 6). This assumption contradicts a widespread old opinion that decades for drying were necessary.

Van de Wetering (1979) and Bruyn (1979) showed from the art-historical point of view that the size and quality of a panel for Rembrandt's period depended on the carpenter's custom and experience. The cut of high quality panels was made parallel to the rays, which guaranteed an optimum dimensional stability. Care was taken in removing the less durable sapwood as well as the juvenile wood near the pith. However, several Rembrandt panels did not show these qualities. Figure 4 shows the possibilities of selecting boards for panels from a trunk. In no case did a board contain all sapwood.

**Table 1.** Wood species – besides oak – used for panels of Rembrandt paintings

No.	Bredius number	Size of the panel height x width (cm x cm)	Art historical dating (year)	Wood species	Possible origin	Remarks
1	163	90 x 67.5	attr. 1632	<i>Juglandaceae:</i> <i>Juglans regia</i> L. (Walnut)	Netherlands	Panels 1 and 2 identified as being made of the same tree
2	332	90 x 67.5	attr. 1632	<i>Juglans regia</i> L. (Walnut)	Netherlands	
3	49	49 x 41	attr. 1657	<i>Juglans regia</i> L. (Walnut)	Netherlands	
4	96	60.5 x 49	attr. 1633	<i>Salicaceae:</i> <i>Populus nigra</i> L. (Poplar)	Netherlands	—
5	356	107 x 82	sign. 1639	<i>Populus nigra</i> L. (Poplar)	Netherlands	Some indication that the panels 5 and 6 are from one tree
6	358	96 x 80	sign. 1641	<i>Populus nigra</i> L. (Poplar)	Netherlands	
7	457	95.5 x 69	sign. 16. . attr. 1655	<i>Fagaceae:</i> <i>Fagus sylvatica</i> L. (Redbeech)	Netherlands	The only Dutch panel in that period made of beech
8	550	93 x 68	attr. 1633	<i>Meliaceae:</i> <i>Cedrela odorata</i> L. (Cedrela)	Central America	—
9	221	81 x 67	sign. 164.	<i>Cedrela odorata</i> L. (Cedrela)	Central America	—
10	568	60 x 77	attr. 1644	<i>Cedrela odorata</i> L. (Cedrela)	Central America	—
11	514	20 x 27	sign. 1645	<i>Lecythidaceae:</i> <i>Cariniana legalis</i> (Mart.) Kuntze	South America	Panels 11 and 12 are from the same tree
12	569	20 x 27	sign. 1645	or <i>C. estrellensis</i> (Raddi) Kuntze (Jequitiba)	South America	

Table 1. (continued)

No.	Bredius number	Size of the panel height x width (cm x cm)	Art historical dating (year)	Wood species	Possible origin	Remarks
13	22	80.5 x 66	sign. 1634	<i>Meliaceae:</i> <i>Swietenia mahagoni</i> Jacq. (Mahogany)	Central America	—
14	109	75.2 x 60	sign. 1643	<i>Swietenia mahagoni</i> Jacq. (Mahogany)	Central America	—
15	516	76.6 x 92.7	sign. 1647	<i>Swietenia mahagoni</i> Jacq. (Mahogany)	Central America	—
16	578	67.8 x 65	sign. 1648	<i>Swietenia mahagoni</i> Jacq. (Mahogany)	Central America	—
17	387	40 x 33	sign. 165(4)	<i>Swietenia mahagoni</i> Jacq. (Mahogany)	Central America	—
18	272	102 x 78	sign. 1654	<i>Swietenia mahagoni</i> Jacq. (Mahogany)	Central America	—

attr. = attribution; sign. = signature

About 30% of all boards showed at least a few sapwood rings (case 1). However, the carpenter tried to cut along the sapwood-heartwood boundary (case 2). To use valuable timber efficiently they took smaller sized boards from inner heartwood (case 3). Six large sized boards extended across the pith (“Herzbohle”). They came from two oak trees, three of each side by side (case 4). Occasionally the boards were oriented tangentially within the trunk, which included the risk for warping (case 5).

Growth-ring measurements showed that small sized stems of about 30 cm in diameter as well as old trees with more than 340 growth rings and large diameters of about 120 cm were selected for panels (Table 2).



Fig. 2. Rembrandt: Selfportrait (Br. 2) sign. 1629; one board of 15.5 cm x 12.5 cm (Permission: Alte Pinakothek, München)

### Dendrochronological Dating of Oak Wood Used for Panels

The dendrochronological method as modified for dating panels is described in detail elsewhere (Bauch et al. 1974). The aim is to date the youngest annual ring of a panel by the characteristic growth pattern of the entire ring series of the wood (comp. Fig. 3 and 5). The panel in Fig. 3 contained only heartwood, which was built in board 1 between 1371 and 1619, and in board 2 between 1430 and 1614. Figure 5 shows that

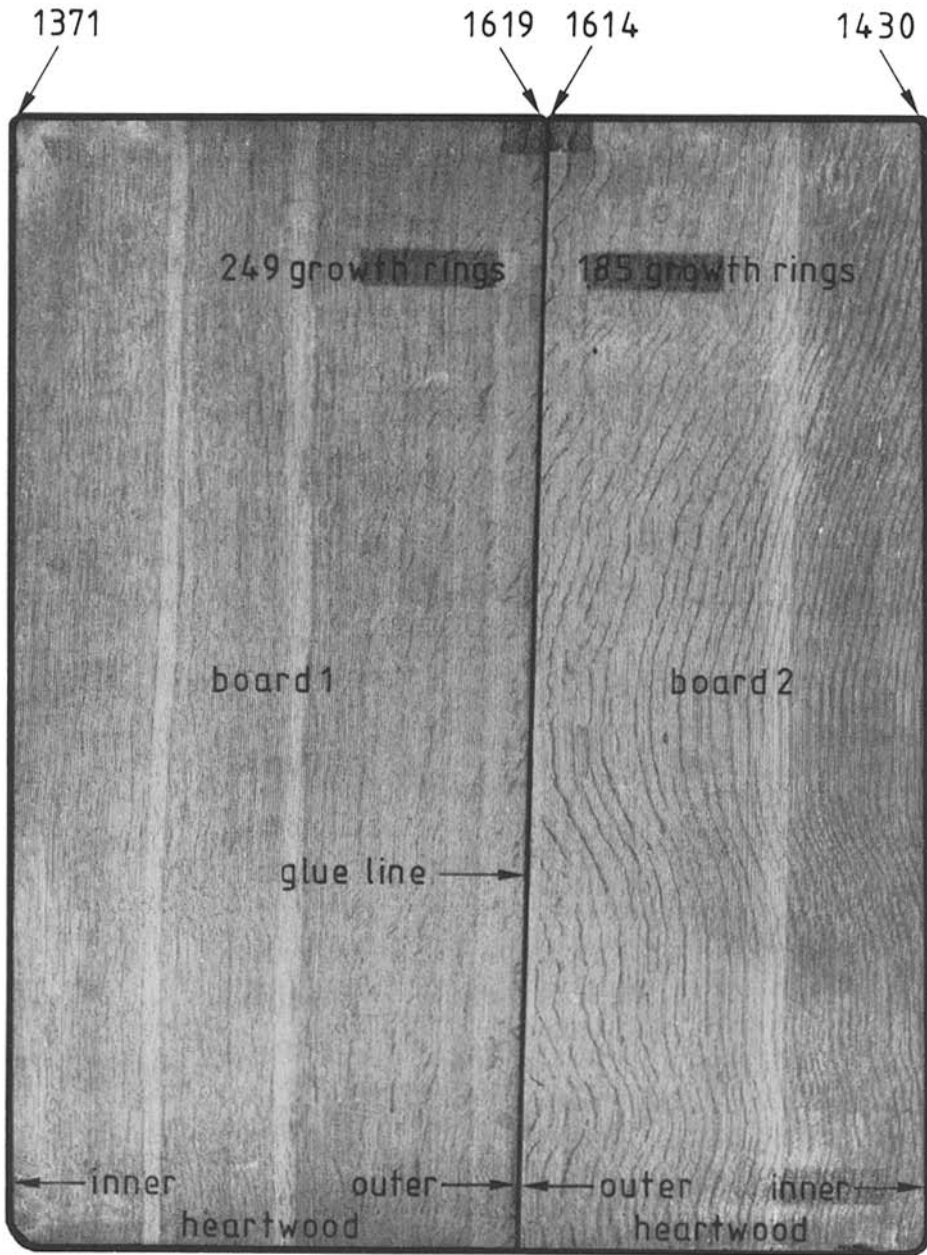


Fig. 3. A 17th century oak panel of two boards; size 62.2 cm x 50 cm, thickness 1 cm

only the earliest felling date can be calculated for the tree. As the average number of growth-rings for the withdrawn sapwood for oak amounts  $20 \pm 5$ , it leads to a felling date earliest possible of 1634. In the case of missing sapwood it cannot be determined whether outer heartwood rings were also cut off. Taking into account the period

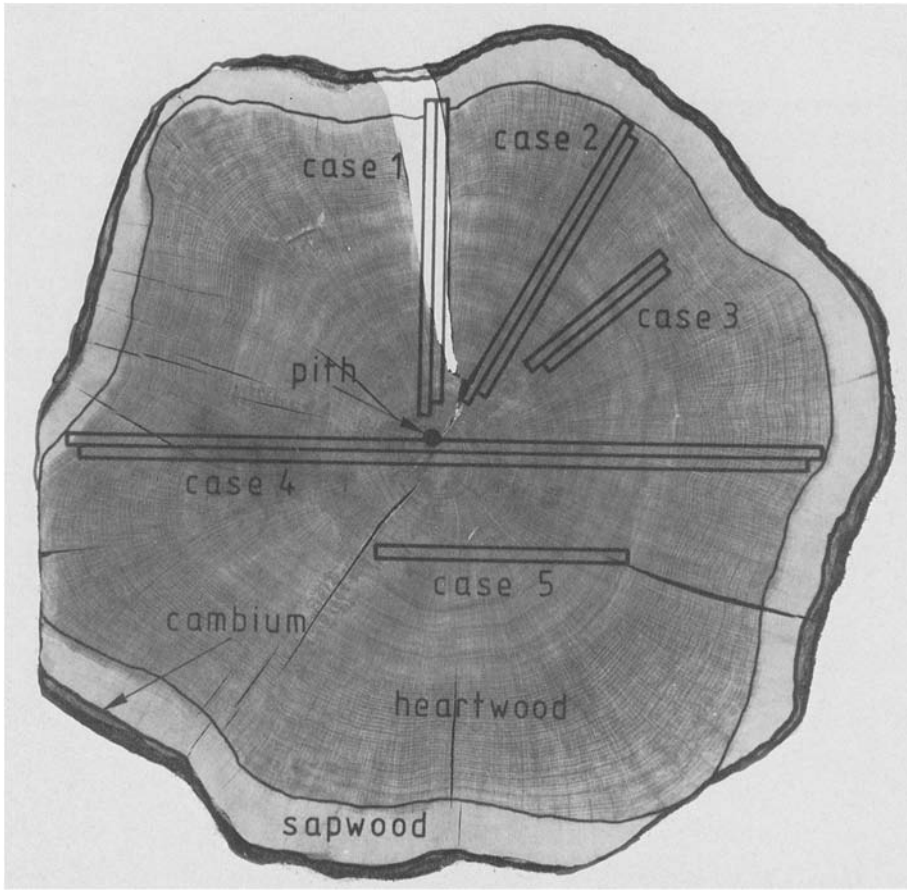


Fig. 4. Various modes for the formation of boards out of an oak trunk as supports for Rembrandt paintings

between felling and the creation of the painting – in most cases an average interval of  $5 \pm 3$  years – the painting could not be created before 1636 ( $1619 + 15 + 2$ ) which can be interpreted as “terminus post quem” by the art-historian.

Table 2. Three examples for the size of oak panels consisting of one board and for the reconstruction of the minimal dimension of the original trees

Br. Nr.	Size of the panel (height x width in cm) cross-section is underlined	Number of the growth-rings present	Estimated total ring-number of the tree	Approximate diameter of the tree, cm
2	15.5 x <u>12.5</u>	132	≥ 150	≥ 30
206	72 x <u>54.5</u>	308	≥ 340	≥ 120
604	58 x <u>46</u>	322	≥ 340	≥ 100



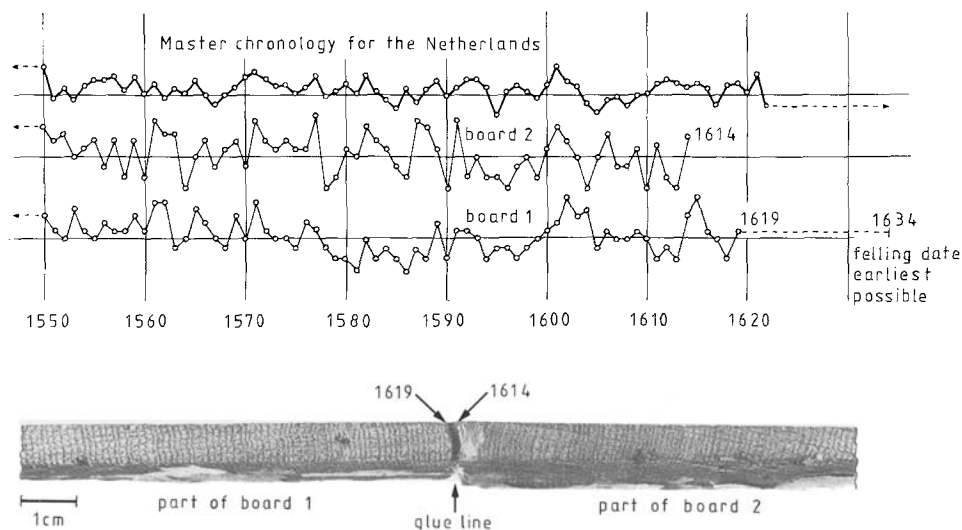


Fig. 5. Example for the dendrochronological dating of the oak wood of a 17th century panel (comp. Fig. 3)

Many panels of Rembrandt paintings contain a few sapwood rings (comp. Fig. 4, case 1), that enable the determination of the felling date with an accuracy of  $\pm 5$  years. In the case of totally missing sapwood this range will be  $\pm \frac{x}{5}$  years.

### Examples for the Dendrochronological Determination of the Felling Date of Oaks Used for Rembrandt-Paintings

In total 132 paintings on oak panels accepted as authentic Rembrandts or attributed to his circle were dendrochronologically investigated. The results will be incorporated in the edition of a comprehensive revision of the Rembrandt-œuvre by the Rembrandt Research Group in Amsterdam (in preparation). On the basis of 11 selected examples the findings obtained from dendrochronological analyses can be shown and the importance of the felling dates of the trees used for the panel fabrication can be illustrated. In Fig. 6 the growth-ring series for the panels are symbolized as bars labelling the heartwood, the sapwood and the felling date for the tree.

Three paintings of this selection (Br. 486, 2, 6) consisting each of one board were created by Rembrandt during his time in Leyden. The determination of the felling date is for painting Br. 486 (Tobias and Anna)  $1622 \pm 5$  and for Br. 2 (Self-portrait, comp. Fig. 2)  $1630 \pm 5$  which confirms the signature 1626 and 1629, respectively, very precisely. At the same time it is obvious that between the felling date of the tree and the creation of the painting only a few years passed. The panel of the painting Br. 6 (Self-portrait) does not contain any sapwood and obviously a few outer heartwood rings were cut off when it was manufactured.

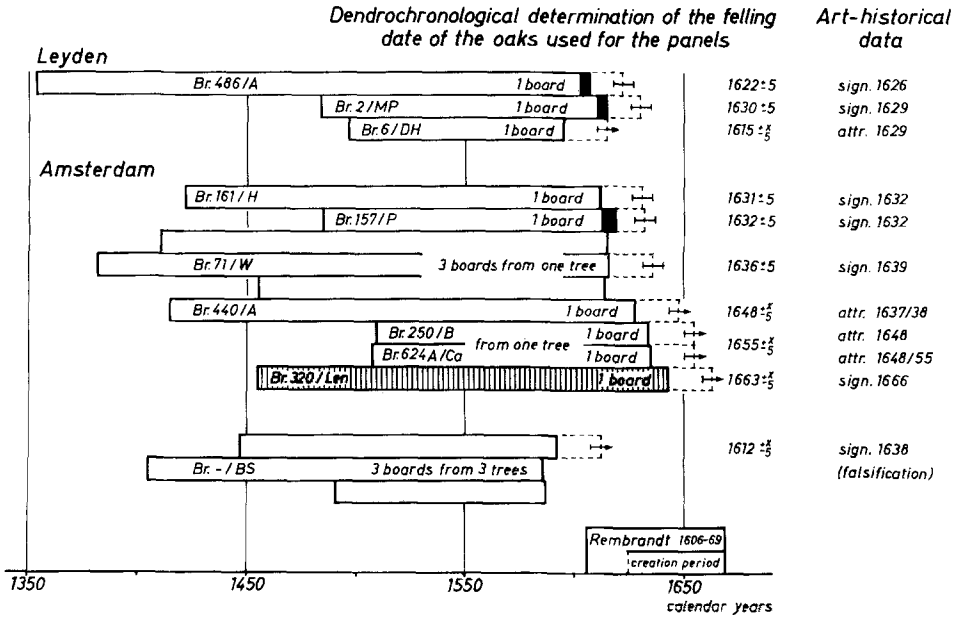


Fig. 6. Some examples for the dendrochronological dating of the wood of oak panels of paintings of Rembrandt and his circle.

□ heartwood; ■ sapwood; □ origin in the coastal area of the Netherlands;  
 ▨ origin from the interior of the Netherlands; —|— felling date earliest possible;  
 —|—|— felling date within a range of ± 5 years accuracy. sign. = signature; attr. = attribution;  
 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

From the oeuvre during Rembrandt's Amsterdam period another seven paintings serve as illustration. The panel of Br. 161 (Maurits Huygens) contains one sapwood ring, which guarantees the felling date with 1631 ± 5 and thus also confirms the signature 1632 on the painting. From this analysis as well as from others we concluded that the customs of the panel-makers in Amsterdam correspond to those in Leyden.

The dendrochronological analysis of the painting Br. 157 (Portrait of a young man) showed the correctness of the signature 1632 on the "Self-portrait". This result is very important, because Gerson (1969) did not accept this painting as a work of Rembrandt.

The panel of Br. 71 (Rembrandt's mother) consists of three boards from one tree. Although no sapwood is present it can be concluded from the almost identical youngest rings 1614, 1615, and 1616 that only — as frequently identified — the sapwood is missing. Consequently the felling date is 1636 ± 5 which confirms the signature 1639 on the painting.

For the painting Br. 440 (Landscape with a stone bridge) analysis showed that the art-historians' attribution 1637/38 is about 10 years too early. The felling date of the tree was 1648 ± 5. Considering that the panel contains 214 heartwood rings and thus



Fig. 7. "A warrior", sign. 1638. Falsification. A re-used panel with a female portrait underneath (82 cm x 67.5 cm). (Permission: Herzog-Anton-Ulrich Museum, Braunschweig)

was cut from an old oak, it can be assumed that the tree's sapwood had 25 rather than 15 rings. Rembrandt's paintings of landscapes, like Br. 440, are very difficult to date by style-criticism alone. For such paintings the dendrochronological dating supplies the art-historian with objective results (comp. Bauch et al. 1972).

The paintings Br. 250 (Portrait of a young jew) and Br. 624 A (Christ) proved that their panels came from one tree, cut out side by side. The felling date for the tree was  $1655 \pm \frac{x}{5}$ . This does not confirm the art-historical opinion for both panels. Both paintings were assumed to be earlier than actually possible. The attribution of Br. 624 A in the late 1640s was done by Gerson (1969). The dendrochronological analysis, however, supports the version of K. Bauch (1966), who dated the painting Br. 624 A around 1655.

The painting Br. 320 (The poet Jeremias de Decker) was created in 1666, a period in which Rembrandt and other contemporary Dutch and Flemish artists preferred canvas instead of panels (comp. Fig. 1). The felling date for Br. 320 could be determined as  $1663 \pm \frac{x}{5}$ , which supports the truth of the signature. The dendrochronological analysis revealed that the wood did not come from the same provenance as the other panels. Eckstein et al. (1975) demonstrated that from about 1640 onwards wood from the interior of the Netherlands was used. For the panels of Rembrandt investigated only one board could be identified from this origin. Wouwerman (1619–1668), who worked exclusively in Amsterdam used, up to about 1640, oak wood of the coastal origin as did Rembrandt, and later he used almost only wood from the interior area. It is known that oak wood became rare and very expensive at that time, which may have contributed to the use of canvas.

The 11th panel (A warrior) which includes three boards (Fig. 6) represents a falsification with a signature of 1638. This panel bears underneath the surface-painting a female portrait, that was detected by x-ray analysis (Fig. 7). The dendrochronological determination of the felling date was  $1612 \pm \frac{x}{5}$ . All three boards from different trees were cut at the sapwood-heartwood boundary. In this case the dendrochronological date for the “terminus post quem” had to be related to the female portrait only. The difference between the felling date  $1612 \pm \frac{x}{5}$  and the signature 1638 of the second painting “A warrior” is indeed considerable and indicates the probability for a re-used panel. This example shows that it is very important to restrict the dendrochronological answer primarily to the “terminus post quem” for the panel without any further interpretations, which should be reserved to the art-historian.

The biological investigations of wooden supports of paintings can be very helpful to the art-historian, but they should always be interpreted together with the results obtained by other methods, such as x-ray analysis, infrared and electron emission techniques, pigment analyses, and others (comp. Asperen de Boer 1969; Nicolaus 1973; Kühn 1974, 1976; von Sonnenburg 1974, 1976).

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