Figure 1. The J. Paul Getty Museum's Burgundian Renaissance Cabinet (71.DA.89).

The Practical Application of Dendrochronology to Furniture: The Case of the J. Paul Getty Museum's Renaissance Burgundian Cabinet

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ABSTRACT

This paper is intended to be a primer for furniture conservators and curators interested in applying dendrochronology, or tree-ring dating, to the study of furniture. After reviewing the basic principles of dendrochronological analysis, specific considerations related to furniture are discussed. A case study, focusing on a French Renaissance cabinet at the J. Paul Getty Museum, is used to illustrate the procedures required for analysis and to emphasize the use of minimally-intrusive measurement techniques as well as the advantages of close collaboration between dendrochronologist and conservator.

Introduction

Dendrochronology, or tree-ring dating, is a well established technique that allows the dating of wood based on the careful measurement of tree ring sequences and statistical comparison of the results with standards of known geographic and temporal origin. Since the development of the technique in the late 19th century, dendrochronology has been extensively used for the dating of historic and archaeological woods, particularly in architectural contexts. The technique has also been often applied to works of art; however, to date, this has been largely limited to the study of panel paintings.

Though obvious, the application of dendrochronology to the dating of furniture has been extremely limited, at least in the published literature. To illustrate the point, the Art and Archaeology Technical Abstracts (AATA) online database was queried using several different search terms.[1] A query for *dendrochronology* alone yielded 540 results; a query for *dendrochronology + painting* yielded 45, while a query for *dendrochronology + furniture* yielded 11 articles, of which only six discussed direct application of the technique to furniture, with no published accounts originating in the United States.

This paper is intended to be a primer for furniture conservators and curators, outlining some of the potential advantages and opportunities afforded by the application of dendrochronology to the study of furniture. A case study, focusing on the J. Paul Getty Museum's Renaissance Burgundian cabinet (fig. 1) is used to illustrate the procedures required for analysis and to emphasize the use of minimally intrusive measurement techniques as well as the advantages of close collaboration between dendrochronologist and conservator.

Background

Dendrochronology begins with the examination and quantification of the pattern of wide and narrow growth rings within a given piece of wood. This pattern reflects the unique annual weather conditions in the climatic region or sub-region where the tree grew. Through rigorous statistical analysis of the correla-

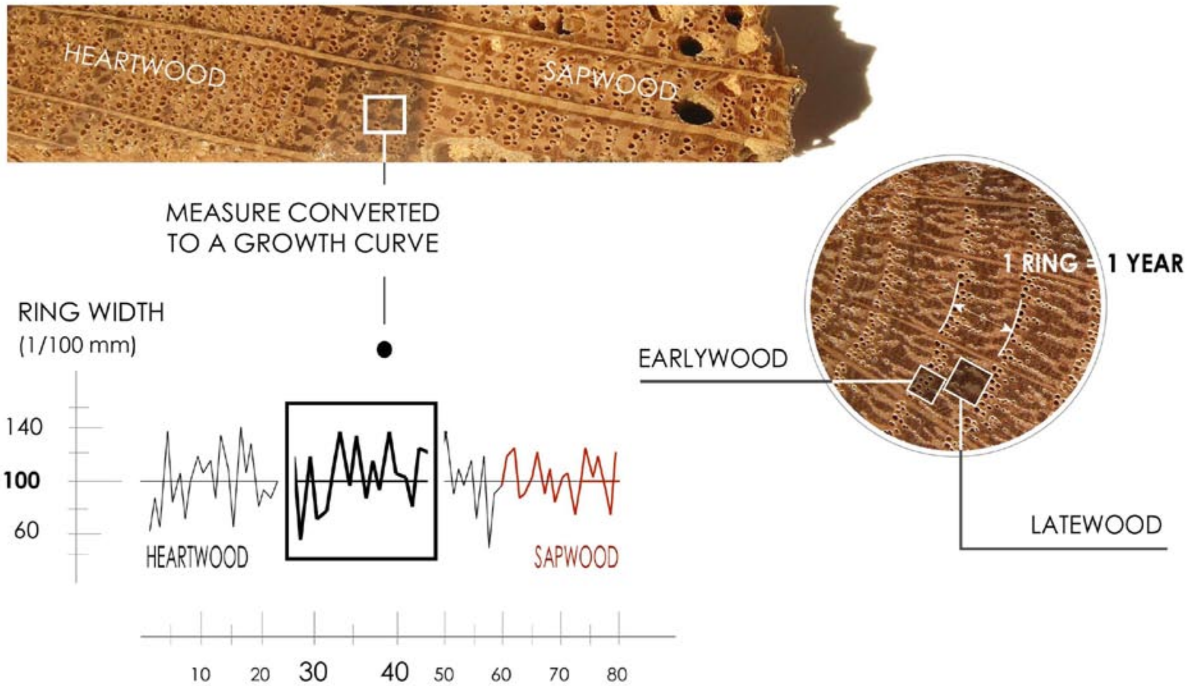

Figure 2. Measurements of individual rings are recorded and used to generate a *growth curve* for each piece of wood studied.

tion between the measured ring pattern and the patterns of known reference materials, the piece of wood can be assigned to a particular place and time of growth. The principles of dendrochronology are thoroughly described in other sources,[2] but several salient points should be emphasized for clarity.

In order for a given species of wood to be dateable by dendrochronology two basic criteria must be met. First, the species of tree must exhibit a reasonably regular and predictable growth habit, without anomalous inter- or intra-individual variability. Woods which can often be dated with success at the current time include oak (*Quercus* spp.), beech (*Fagus sylvatica*), ash (*Fraxinus* spp.), linden (*Tilia* spp.), elm (*Ulmus* spp.), fir (*Abies alba*), spruce (*Picea abies*), larch (*Salix alba*), and pine (*Pinus* spp.). In addition, a sufficient body of regionally appropriate comparative data must exist in the form of master chronologies compiled by competent dendrochronologists.

When a sequence of rings is measured, the resulting data is converted to a growth curve (fig. 2) which can be mathematically manipulated to take into account factors such as the tendency of ring width to decrease as a tree ages. It is important to understand that dendrochronology is based on correlations between the curve of the unknown wood and *master chronologies* generated from provenanced wood in many regions of the world. For a match to be considered significant, with a low statistical risk, it is generally necessary to compare at least 80 consecutive rings, although this number varies based on how distinctive the measured curve is found to be (i.e. how many atypical/exceptional features it manifests).

Another point worthy of special consideration regards the importance of measurement techniques. For dendrochronology to be as effective as possible, it is critical that the rings are measured very precisely (to the nearest 0.01 mm). Several different techniques can be used to measure a sequence of tree rings, depending upon circumstance.[3] In general, the preferred method is to make direct measurements of ring widths by examination of the end grain (or transverse section). While this technique provides the most precise measurements, it can only be applied where the end grain of a piece of wood is accessible. Direct end grain measurement often requires some form of surface preparation in order to make the rings clearly distinct and legible prior to analysis. This preparation is of concern with regard to conservation as it is necessarily destructive to some degree, though modern techniques can minimize the negative impact of this step (see case study below).

In cases where end grain is not accessible for study, it is possible, with some species of wood, to make direct measurements of ring width from the longitudinal surface of a radially cut piece of wood. This method can be used primarily on conifers such as spruce, fir and pine where the ring boundaries are clear and distinct on longitudinal surfaces. Violins and other stringed instruments can often be dated in this way, even though the end grain of the broad panels is typically not visible.[4] With many species of wood however, this measurement technique is not possible or may result in a curve of significantly degraded precision.

In cases where neither end-grain nor longitudinal direct measurement is possible, tree rings may be measured by using x-radiographic techniques. This method is generally less precise than direct measurement and results vary considerably depending on the species of wood studied. Conifers with a strong late/early wood density gradients are generally considered to be most appropriate for this technique. Oaks work less well, but can still be successfully imaged. Success with x-radiographic measurement of tree rings depends primarily on the ability of the operator to align the x-ray beam perfectly parallel to the rings of the wood. Naturally, this is easiest to achieve with thin, quartersawn panels. In order to ensure the best possible results, the authors have found that certain procedures should be followed. First, the distance between the x-ray tube and the wood should be maximized; this reduces the effective divergence of the beam with the result that the beam angle is more nearly equal from one side of the panel to the other. In addition, a series of films (typically 4 to 5) should be prepared, varying the beam angle by 1 to 1.5 degrees for each exposure. This helps to ensure that for each area of the panel, at least one film will provide an image of optimal sharpness. Once a series of x-radiographs has been prepared, measurements of ring widths can be made directly on the film, or the images can be scanned and the measurements made digitally.

A final note to consider regarding dendrochronological analysis is that a precise felling date for the wood studied is rarely obtainable. This is due to the fact that the outermost rings of a tree (sapwood) are generally cut away when it is converted to workable timber. Since the last sapwood ring corresponds to the felling date, and this ring is usually not in evidence, estimations must be made of the time elapsed between the formation of the last extant ring and the felling date. Dendrochronologists have established valuations of the number of sapwood rings that are present in different types of trees in different regions and this information can be used to help give an estimated felling date, particularly when at least one sapwood ring is present in the wood to be studied. For instance, Baltic oak is known to have an average of 16 sapwood rings with a standard deviation of ±3;[5] therefore, if a piece of Baltic oak timber has five sapwood rings present and the last of these rings has been dated to 1750 by dendrochronology, then the felling date for the tree can be estimated as 1758–1764. Occasionally, wood from an historic artifact will contain a full series of sapwood rings and a felling date can be determined to the precise year or even season (see case study below).

Use in Furniture Conservation

To date, most applications of dendrochronology to art have typically relied on a single measurement of a single board such as a panel painting, with 70 or more rings. Furniture, by its nature, tends to be an assemblage of many pieces of wood of varied dimension. Within a typical piece of furniture, many of the individual elements would normally be considered too small to use for dating (i.e. too few rings present), but in the context of furniture, measurements from many smaller pieces of wood can often be fitted together to form an expanded *composite mean chronology* of sufficient length to allow an analysis to proceed (fig. 3). This not only allows the dating of smaller pieces of wood than would otherwise be possible, but because of the opportunity to replicate measurements of the same ring sequence from multiple elements, the resulting *composite mean chronology* will be of greater statistical significance than any single measurement. In addition, the ability to utilize numerous elements of small dimension increases the likelihood that some or all of the sapwood from the tree in question can be measured.

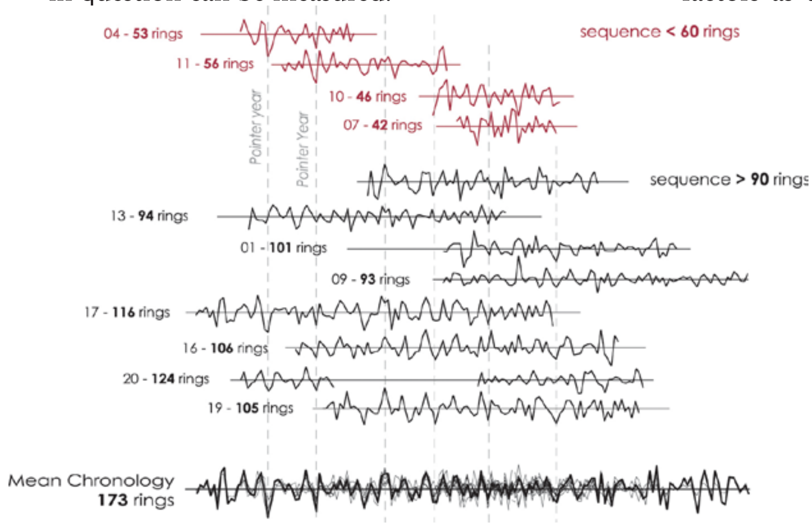

Figure 3. Individual *growth curves* are aligned and assembled to generate a *mean chronology*.

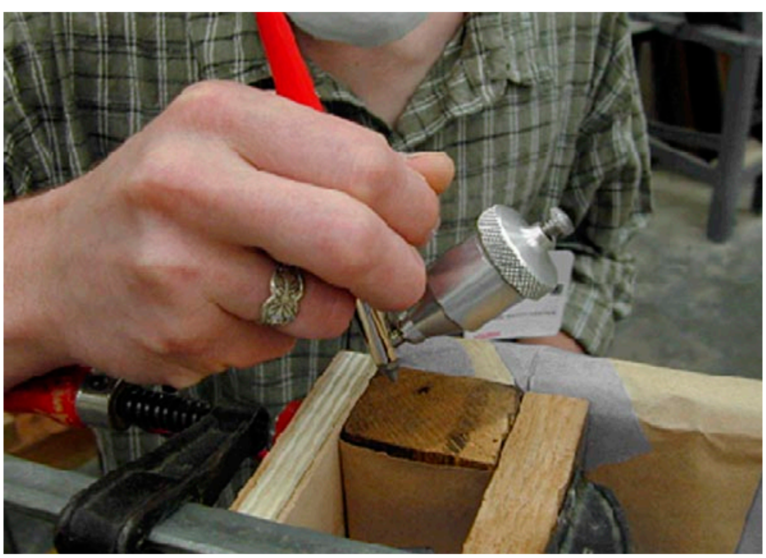

Figure 4. The apparatus for micro-abrasive blasting is similar to an airbrush, offering precise control and portability.

The inclusion of sapwood in a chronology is of great value in determining the felling date for the tree. This advantage will be clearly illustrated in the case of The Getty Museum's Burgundian cabinet below.

Close collaboration between dendrochronologist and conservator is very desirable in the study of furniture. Working together, optimal decisions can be made regarding which pieces of wood are to be selected for study. These decisions must take into account the conservator's judgement of such factors as the presence of prior restorations, and the possibilities for non-destructive partial disassembly of the furniture in question. The conservator may also take on the responsibility of insuring that the genus and, if possible, the species of the wood to be analyzed have been securely determined.

Once the elements to be measured have been selected and made accessible, the procedures for direct measurement can begin. The first step is the preparation of end grain. In practice, the end grain of a piece of wood will not normally be suitable for dendrochronological measurement without some initial surface preparation; distorted fibers and accretions of dirt or other particulates often obscure the grain, making high-precision measurement difficult. To date, dendrochronologists have often prepared the end grain of art objects and furniture with razor blades or carving knives, with obvious irreversible damage.[6] Perhaps surprisingly, such practices are still fairly common; however, more recently, less destructive methods of surface preparation have been developed in close collaboration with conservators. The adaptation of micro abrasive-blasting (fig. 4) using 40µm aluminium oxide particles is now commonly used in France and is generally approved by conservators and curators.[7] This method provides a very high-quality cleaning of transverse sections by removing built-up patina and opening the large early wood pores of ring-porous woods, revealing tree-rings boundaries without significantly affecting features of the wood surface such as tool marks or evidence of use (fig. 5). While laser cleaning has also been suggested for end grain preparation,[8] the micro-abrasive technique offers several distinct advantages; in particular, the clarity of the tree rings is generally superior after treatment, and secondly, the apparatus required is remarkably portable and can be used *in situ* without supporting equipment, lengthy training, or stringent safety controls. Once the end-grain surfaces have been prepared, tree-ring widths and anatomical features can be recorded by taking macro-photographs, or even by direct digital scanning of detached elements. Image-based documentation of sample sites is advantageous to the dendrochronologist, constituting an invaluable record of a wide range of diagnostic wood information which allows further detailed analysis in the laboratory.[9] It also allows for future confirmation or reanalysis of the raw data without the need for direct intervention on the object.

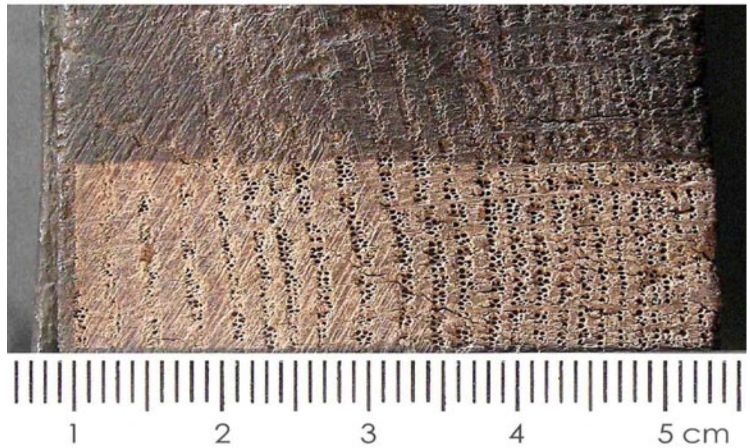

Figure 5. A view of oak end-grain; the lower half has been prepared for measurement by micro-abrasive blasting. Note that the diagonal tool marks are still clearly visible after sample preparation.

Precision and the thoroughness during the sampling phase are extremely important if optimal results are to be obtained. Short cuts or time-saving measures such as the use of plasticine imprints or the "real time" recording of ring widths using a hand lens should be avoided as they are not sufficiently accurate to yield defined measurements and detailed observations.[10]

The Case of the Getty Cabinet

Background

The J. Paul Getty Museum's collections include a large oak and walnut cabinet with an inscribed date of 1581 (fig. 1). The elaborately carved cabinet was long considered to be a nineteenth century fake or, at best, a pastiche of old and new parts. Since its acquisition in 1971, the cabinet had spent most of its time in storage and had never been displayed at the museum.

Assumptions about the authenticity of the cabinet were challenged in 2002 as a result of an exhibit about the French cabinetmaker and polymath Hugues Sambin at the Museum of the Renaissance in Ecouen, France. In publications related to the exhibition it was clearly suggested that the Getty cabinet was an authentic object and was likely to have been made by Sambin's workshop.[11] This naturally prompted a renewed interest in the cabinet among curators and conservators at the museum.

The exhibition publications also presented the work of one of this paper's authors on the dendrochronological study of a second cabinet, also thought to be by Sambin, in the collection of the Musée du Temps in Beançon, France. This cabinet, referred to as the Cabinet of Gauthiot d'Ancier, shares many details of ornamentation and construction technique with the Getty cabinet and was shown to be constructed of oak originating at the end of the 16th century in the region of Burgundy.

As part of an overall technical study of the cabinet begun in 2003, a thorough dendrochronological

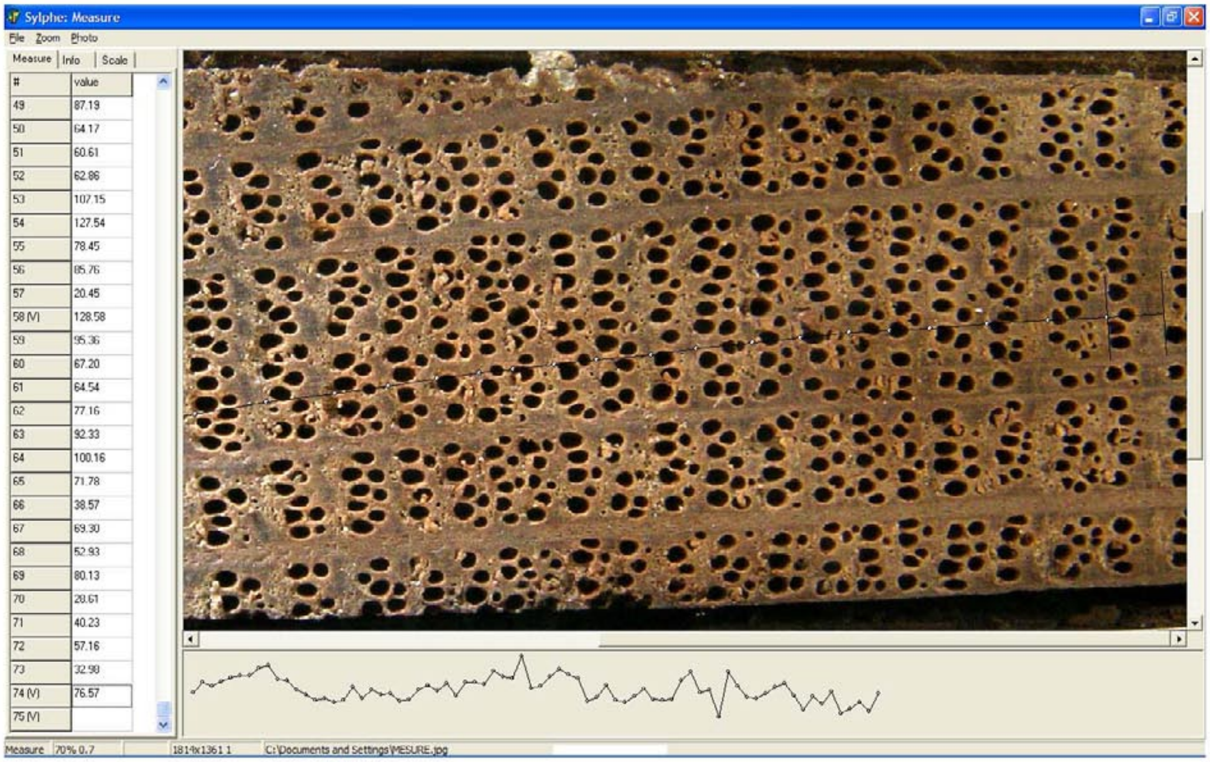

Figure 6. For direct measurement, digitized photomacrographs of prepared end-grain were measured and converted to growth curves using customized Mensor© software created in 2002 by S. Meignier and Didier Pousset.

study of the oak secondary wood of the Getty cabinet was undertaken, the results of which played a major role in confirming the overall authenticity of the cabinet.

Procedure

The Getty cabinet is made of walnut primary wood with oak secondary. Since walnut cannot be studied by dendrochronology, the analysis focused exclusively on the oak secondary structure of the cabinet. In the study, direct measurement of end-grain was used wherever possible (fig. 6). Some sections of the cabinet were partially dismantled where this could be done without damage. In all, twelve oak elements were measured directly; these ranged from 28 to 105 measurable rings per element. These panels contained between 80 and 120 measurable rings. The preparation of end-grain by micro-abrasion and acquisition of photo-micrographs required the work of the authors along with a museum photographer for approximately three days. In addition, five large oak panels which could not be measured directly because of their location

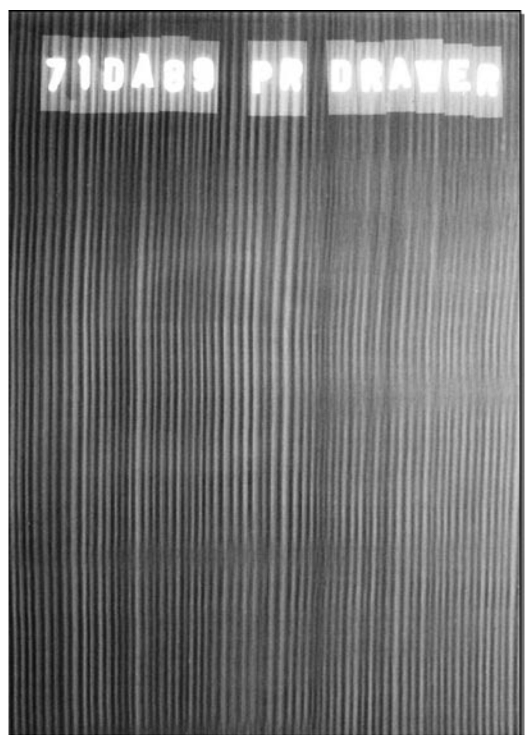

Figure 7. An X-radiograph of a drawer bottom, used to produce a growth curve in a situation where the end-grain of a panel was not accessible.

Figure 8. This small block on the interior of the cabinet contained its entire sapwood sequence, allowing the felling date for the tree to be firmly established.

in the cabinet were measured using x-ray techniques (fig. 7). The acquisition of x-radiographic tree-ring images took approximately two days.

All of the individual tree-ring series (curves) were fitted together to generate an *average growth chronology* for the wood as a group. Had significant restorations involving replacement or addition of new oak elements taken place in the past, these elements could have been detected at this stage since their tree ring series would not have matched those of the original wood. Seven of the measurements made were of pieces of wood containing less than 75 rings. These elements would have been difficult or impossible to date individually, but could be neatly fitted into the larger chronology established by the longer measurements. The inclusion of these measurements not only allowed the individual pieces of wood to be dated, but also contributed to the overall quality of the *average growth chronology* produced for the cabinet.

Fortuitously, the measurements taken from the cabinet included one small block of wood from the interior of the cabinet which contained all of its sapwood out to the cambium layer (fig. 8). The dating of these rings allowed the felling date of the tree to be established. The final results of the dendrochronological analysis determined that the oak secondary wood of the cabinet was taken from a tree which was felled during the autumn or winter of 1574–1575 in the area of Burgundy, France, six years before the inscribed date on the cabinet, and in the region of the workshop of Hugues Sambin. In addition to the dating, the study also brought to light interesting patterns of wood use which can help us better understand traditional shop practices of the period. In reviewing the data, it became clear that the cabinet maker(s) of the Getty cabinet had consistently chosen different qualities of oak for different purposes in the construction. For the wide, split panels, very slow-grown oak was chosen, with very narrow rings. In slow-grown oak, the large-pored early wood (or spring growth) is dominant, with relatively little of the dense late wood. This results in timber that is relatively light weight and easy to split. On the other hand, for the smaller, but thicker structural elements of the cabinet, the cabinet maker(s) chose faster-grown oak which has relatively thick bands of dense late wood. This wood is heavier and stronger than the panels and is sawn to shape rather than split. It is likely that this interesting observation about shop practice in the Renaissance would have gone unnoticed were it not for the dendrochronological study.

In the end, the results of this dendrochronological study proved to be a critical piece of evidence that allowed the Getty's cabinet to be entirely reinterpreted. Prior to the study, the cabinet was widely considered to be a fake or pastiche and had been relegated to deep storage, with no thought that it would ever be displayed again. However, based on the results of the analysis, and supported by additional technical and curatorial study, the cabinet is today considered to be one of the most important and well preserved examples of 16th century Burgundian cabinet-making in the world.[12]

Conclusions

The case study of the Getty's renaissance cabinet provides an instructive example of the practical application of dendrochronology to the study of furniture. Several factors were important to the overall success of this endeavor. In particular, close coordination and collaboration between conservator and dendrochronologist was very important, allowing the maximum number of measurements to be taken from carefully selected elements, all in the safest possible manner. This study also illustrates a significant advantage for the dendrochronologist of working with furniture; the combined analysis of numerous pieces, both large and small, generated an average growth chronology of very high quality which, in turn, allowed both the date and the geographic origin of the wood to be determined with very high confidence. In short, although dendrochronology has so far found limited application in the world of furniture conservation and study, particularly in the United States, there is great potential for this technique to make significant contributions in the future.

About the Authors

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Notes

1. AATA Online (http://aata.getty.edu/NPS/) was queried on October 17, 2006, by entering the terms indicated in the "quick search" field.

2. For an introductory text on the methodology of dendrochronology, see *Dendrochronological Dating*. European Science Foundation, Strasbourg,

1984. and Schweingruber F. H., *Tree Rings, Basics and Applications of Dendrochronology.* Kluwer Academic Publishers, Dordrecht, 1989.

3. It should be noted that architectural and archaeological timbers are frequently analyzed using drilled core samples; however the destructive nature of this process makes it generally unsuitable for the analysis of artworks and so it will not be discussed in this paper.

4. Lavier C., Dendrochronology applied to wooden musical instruments: Methodology and studies. *Actes des 9è Journées d'Etudes de la Section française de l'Institut International de Conservation* "Instruments pour demain, Conservation et restauration des instruments de musique," Limoges, 2000, pp. 99-110.

5. Klein P., Eckstein D., Wazny T., Bauch J., New findings for the dendrochronological dating of panel paintings for the 15th to 17th Century, *ICOM Committee for Conservation,* I, 8th Triennial Meeting, Sydney, 06-12 Sept. 1987, Getty Conservation Institute, ICOM, Los Angeles, 1987, pp. 51-54. Wazny T., Eckstein D., The dendrochronological signal of oak (*Quercus* spp.) in Poland, *Dendrochronologia,* 9, Instituto Italiano di Dendrochronologia, LaboStoriaNat Verona, 1991, pp. 35-48.

6. Klein P., Dating of art-historical objects, *Dendrochronology and Archaeology in Europe,* 141, 28-30 April 1982, eds. D. Eckstein, S. Wrobel, R.W. Aniol, Hambourg, 1983, pp. 209-222.

7. Pousset D., Locatelli C., Etude d'un ensemble mobilier de la fin du Moyen Age. Les atouts de la dendrochronologie, *Les objets d'art : de l'analyse à la conservation,* Coll. TECHNE, 16, Centre de Recherche et de Restauration des Musées de France – CNRS/UMR 171, Paris, 2002, pp. 33-39. See also Lavier C., The use of dendrochronology for the analysis of works of art, *Proceedings, 3rd International Symposium on Wood and Furniture Conservation,* Amsterdam, 11 October 1996, eds. P. van Duin, D. van Loosdrecht, D. Wheeler, 1997, pp. 61-65.

8. Fraiture P., L'apport de la dendrochronologie dans l'expertise des oeuvres d'art en bois : quelques cas concrets, *L'archéométrie au service des monuments et des oeuvres d'art,* Coll. Dossier de la Commission Royale des Monuments, Sites et Fouilles, 10, Liège, 2002, pp. 81-86.

9. Optimum resolution for documentary images yields and image where the size of one pixel is equivalent to approximately 0.01 millimetre.

10. Leuschner B., Leuschner H.H., Plasticine imprints for recording tree rings, *Dendrochronologia,* 14, Instituto Italiano di Dendrochronologia, LaboStoriaNat Verona, 1996, pp. 287-290.

11. Erlande-Brandenburg, A. et al, *Hugues Sambin: Un créateur au XVIe siècle (vers 1520-1601),* Paris, Musée National de la Renaissance, 2001. An eleven-page broadsheet leaflet with comparative photographs of pieces of furniture and drawings that were not exhibited accompanied the exhibition.

12 Hinton, J. and Heginbotham, A. Rediscovering a sixteenth-century Burgundian cabinet at the J. Paul Getty Museum. *The Burlington Magazine*. June, 2006.