



HAL
open science

Case study of Wood Identification of Japanese Shinto Statues Owned by the Honolulu Museum of Art

Suyako Tazuru, Mechtild Mertz

► **To cite this version:**

Suyako Tazuru, Mechtild Mertz. Case study of Wood Identification of Japanese Shinto Statues Owned by the Honolulu Museum of Art. [Research Report] 19,6, Spring-8 /SACLA Research report. 2021. hal-03353184

HAL Id: hal-03353184

<https://hal.science/hal-03353184>

Submitted on 4 Jan 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Wood identification of Chinese Buddhist statues in the Philadelphia Museum of Art

Suyako TAZURU¹, Mechtild MERTZ², Hiromi KINOSHITA³, Takao ITOH⁴, Junji SUGIYAMA⁵



Keywords : synchrotron X-ray microtomography (放射光X線マイクログラフィ), wood identification (樹種識別), Chinese Buddhist statues (中国の仏像), the Philadelphia Museum of Art (フィラデルフィア美術館)

Abstract

Wood identification based on anatomical features was performed on thirty Chinese Buddhist and deity statues, preserved in the Philadelphia Museum of Art (PMA). While research on Buddhist statues' wood species in Japan has an over 70-year-old history, Buddhist statues in East Asian countries such as China and Korea have not yet been fully investigated scientifically. This research is part of a large project in which the wood species of Chinese Buddhist and deity statues from various Western museums underwent microscopic wood identification and our goal is to construct the database of wood selection for statues.

In order to know the reason for what kind of species of trees were used for sculptures in different countries, the best way would be to examine the species of wood statues made in ancient countries

starting with China. However, it is believed that few wooden statues from before the 10th century have survived in China. Therefore, this survey of the tree species of Chinese wooden statues preserved in the United States was very important to compare that of wooden statues made in Japan.

In this study, aside from conventional optical microscopy, synchrotron X-ray micro tomography for very small samples was performed. The following wood species were identified for the Chinese statues: *Tilia* sp. (11 statues), *Paulownia* sp. (7 statues), *Salix* sp. (6 statues), Lauraceae (2 statues), *Pinus* subgenus Haploxyylon (1 statue), *Cladrastis* sp. (1 statue), *Populus* sp. (1 statue), and *Juniperus* sp. (1 statue).

We hope this research will contribute to discussing the historical context of the statues and to elucidating the criteria of wood selection for Chinese, Korean and Japanese statues.

¹ Research Institute for Sustainable Humanosphere, Kyoto University, Gokasho, Kyoto 611-0011

² East Asian Civilisations Research Centre (CRCAO-CNRS), Collège de France, 52 rue du Cardinal Lemoine, Paris, 75005

³ East Asian Art, Philadelphia Museum of Art, 2600 Benjamin Franklin Pkwy, Philadelphia, PA 19130

⁴ Nara National Research Institute for Cultural Properties, 2-9-1, Nijo-cho, Nara 630-8577

⁵ Graduate School of Agriculture, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502

1. Introduction

Microscopic wood species identification of important wooden cultural heritages provides meaningful information on the criteria of wood selection, a new understanding of the meaning that these wood species held in ancient times.

The choice of wood for Buddhist sculptures seems to have been important to the Buddhist devotee.

The historical Buddha lived in India, 5th to 4th century BC. According to an Indian legend, the first image of the Buddha was made from sandalwood, a material being even or superior to gold. Therefore, sandalwood was considered to be the best wood for carving Buddhist images. Buddhism was introduced to China via the Silk Road devotees and traders from the west, probably in the first century AD.

In the 630s AD the Chinese pilgrim Xuanzang (AD 602-664) brought a sandalwood copy of the supposedly original sculpture back to China, and thereby initiated the East Asian iconography of this type.

Recently, several wood identifications of Buddhist statues have been conducted little by little in East Asia. In Japan, scientific wood identification from the 8th century statues have been conducted jointly by art historians and wood anatomists (Kaneko *et al.*: 1998, 2003, 2010). The selection of *Torreya nucifera* for the 8th century AD statues is referring to an ancient sacred text that mentions the use of the so-called *haku* (Cupressaceous wood in China) as a substitute for *Santalum album* for statues and that this selection might have brought to Japan with the arrival of the monk Jianzhen (Ganjin in Japanese, 688-763) in Japan.

In South Korea, in the Joseon Dynasty (AD 1392-1897) wood identification showed that *Ginkgo biloba*, *Alnus* sp., *Pinus densiflora*, *Pinus koraiensis*, *Salix* sp., and *Tilia* sp. were frequently used (Jeong: 2013). The major species used for Buddhist statues is *Ginkgo bi-*

loba in South Korea, a tree known to have been introduced to Korea from China with Buddhism (Jeong: 2013).

As for Chinese Buddhist sculptures, *Paulownia* sp., *Salix* sp., *Tilia* sp., and *Populus* sp. (Mertz and Itoh: 2010, Tazuru: 2020 accepted) have been revealed to be used. For instance, the identification of the wood species in the Metropolitan Museum of Art's collection in New York was conducted in 2010 (Mertz and Itoh: 2010), and of the twenty-eight wood sculptures selected for species identification, nine were found to be made of *Salix* sp., eight of *Paulownia* sp., five of *Tilia* sp., three of *Santalum album*, two of *Juniperus* sp. and one of *Populus* sp.

Compared to the large number of wood identification for Japanese Buddhist statuary, that for Chinese and Korean Buddhist statues are much less. Therefore, our approach is to focus on wood species identification of mainly Chinese Buddhist wooden statues in Western Museums, where a great number of religious sculptures are preserved. By comparing the wood species used for Buddhist sculptures in various East Asian countries, we aim to elucidate the relationship and historical background of the spread of Buddhist sculptures, and to gain new insights for art historical research.

This study investigates the wood species of Chinese Buddhist and deity statues preserved in the Philadelphia Museum of Art (PMA, <https://www.philamuseum.org/collections/search.html>). The museum has a large collection of Chinese wood sculptures that are rarely found in Japanese museums and galleries.

In this research, we applied the conventional preparation method and the synchrotron X-ray microtomography (SRX-ray μ CT) method (Tazuru-Mizuno and Sugiyama : 2019, Hwang *et al.* : 2020, Mizuno *et al.* : 2020) for the wood identification of the wooden statues.

2. Materials and methods

In this study, wood identification was performed on 42 samples from thirty Chinese sculptures, preserved in the Philadelphia Museum of Art (PMA). Especially for some statues, which present joined wood block construction, two or three samples from different parts were taken. The statues were all assumed to be made from the 7th to the 17th centuries AD (Table 1).

The methods used are conventional microscopy, and SRX-ray μ CT. In cooperation with the curator and conservators, wood samples were collected in the Philadelphia Museum of Art. Small samples were taken by a scalpel from the underside of the sculpture, from cracks and from a hollowing without harming the integrity of the sculptures.

The samples were prepared for wood identification at the Research Institute for Sustainable Humanosphere, Kyoto University, Japan.

First, the samples were soaked in water for softening. For the following preparation of the microscopic slides, thin slices were taken from the samples by using single razor blades in cross, radial and tangential directions (15 μ m to 30 μ m thick). The slices were heated on a hotplate in glycerin : ethanol (= 1:1) to remove the internal air bubbles, and enclosed with Gum-chloral. The slides were studied under the optical microscope (Olympus BX51, Japan), and photos were taken by a digital camera (Olympus DP70, Japan).

Five samples, marked by two stars** in Table 1, namely (1929-8-6**), (1990-75-3-B**), (1929-8-7-A**), (1929-8-10-B**) and (1929-8-2**) were too small and fragile for optical microscopic preparation, therefore, SRx-ray μ CT was undertaken at BeamLine20XU (BL20XU) in SPring-8, a large synchrotron radiation facility in Hyogo Prefecture, Japan. As reported in the past (Tazuru-Mizuno and Sugiyama: 2019, Hwang

et al.: 2020, Mizuno *et al.*: 2020), we have made it possible to identify wood species using SRX-ray μ CT. Tiny and fragile samples with a size of 1 mm \times 1 mm \times 2 mm was fixed on a designed stage of the SRX-ray μ CT equipment. Transmitted images obtained thorough the beamline 20XU were recorded by a Hamamatsu High Resolution camera (resolution is 0.472 μ m/pixel). Reconstituted images were further analyzed with the “VGStudio” and “ImageJ” software. The thickness of wood sections should be around 10-20 μ m for wood identification, based on microscopy. Each original reconstituted slice made by the SRX-ray μ CT was under 0.5 μ m thick, therefore it was necessary to increase the depth information, in order not to lose the anatomical information. For this purpose, about 24 slices were integrated, and approximately 12 μ m thick pseudo-micrographs prepared. The anatomical characteristics were referenced from previous publications (Wheeler *et al.*: 1989, Richter *et al.*: 2004). For identification, we also referred to the Wood Diversity HSDB network (<http://database.rish.kyoto-u.ac.jp/cgi-bin/bmi/en/namazuru.cgi>) in Japan.

Table 1 Details of statues and wood identification results.

Five samples, marked by two stars**, namely (1929-8-6**), (1990-75-3-B**), (1929-8-7-A**), (1929-8-10-B**) and (1929-8-2**) were too small in size (around 1 mm × 1 mm × 2 mm) and fragile for optical microscopic preparation, therefore, SRx-ray μ CT was applied.

表1 木彫像詳細と樹種識別結果

を付与した5 サンプル、つまり 1929-8-6, 1990-75-3-B**, 1929-8-7-A**, 1929-8-10-B**, 1929-8-2** の試料片はプレパラート作成が困難なほど非常に小さかったため (1 mm × 1 mm × 2 mm 以下)、放射光 X 線マイクログラフィーによる識別に供した。

Serial number	Sub division of samples	Accession Number	Title of statues/objects	Dynasty	Medium	Location of collected wood samples	Identified wood species
1	A	1929-20-1	Attendant Bodhisattva	Jin Dynasty (1115-1234)	Wood with painted decoration	Back of base	<i>Paulownia</i> sp.
1	B	1929-20-1	Attendant Bodhisattva	Jin Dynasty (1115-1234)	Wood with painted decoration	Back of lower torso	<i>Paulownia</i> sp.
1	C	1929-20-1	Attendant Bodhisattva	Jin Dynasty (1115-1234)	Wood with painted decoration	Back of upper torso	<i>Paulownia</i> sp.
2	A	1929-8-11	Seated Bodhisattva	Northern Song (960-1127) or Jin Dynasty (1115-1234)	Wood with traces of painted decoration	Upper thigh	<i>Paulownia</i> sp.
2	B	1929-8-11	Seated Bodhisattva	Northern Song (960-1127) or Jin Dynasty (1115-1234)	Wood with traces of painted decoration	Thigh, detached sample	<i>Pinus</i> sp. Haploxyton
2	C	1929-8-11	Seated Bodhisattva	Northern Song (960-1127) or Jin Dynasty (1115-1234)	Wood with traces of painted decoration	Upper thigh, detached sample found underneath	<i>Paulownia</i> sp.
3	A	1929-20-2	Attendant Bodhisattva	Jin Dynasty (1115-1234)	Wood with painted decoration	Back of the base	<i>Paulownia</i> sp.
3	B	1929-20-2	Attendant Bodhisattva	Jin Dynasty (1115-1234)	Wood with painted decoration	Back of lower torso	<i>Paulownia</i> sp.
3	C	1929-20-2	Attendant Bodhisattva	Jin Dynasty (1115-1234)	Wood with painted decoration	Back of upper torso	<i>Paulownia</i> sp.
4		1925-53-11	Bodhisattva of Compassion (Guanyin)	Yuan Dynasty (1271-1368)	Wood (linden) with traces of painted and gilt decoration	Back of base	<i>Cladrastis</i> sp.
5	A	2013-74-1	Seated Luohan	Ming Dynasty (1368-1644)	Wood (basswood/linden/lime figure and honoki base) with painted and gilt decoration	Proper right side, bottom of garment, area of loss	<i>Tilia</i> sp.
5	B	2013-74-1	Seated Luohan	Ming Dynasty (1368-1644)	Wood (basswood/linden/lime figure and honoki base) with painted and gilt decoration	Base, front, proper right side, sample taken from opening in crack/split	<i>Magnolia</i> sp.
6		1925-53-10	Bodhisattva	Northern Song Dynasty (960-1127) or Liao Dynasty (907-1125)	Wood with traces of painted decoration	Inside of lower torso hollow at back	<i>Salix</i> sp.
7		1923-21-470	Bodhisattva of Compassion (Guanyin)	Northern Song Dynasty (960-1127)	Wood with traces of painted decoration	Proper left side, waist, under arm	<i>Paulownia</i> sp.
8		1925-53-14	Bodhisattva of Compassion (Guanyin)	Ming Dynasty (1368-1644)	Wood with traces of painted and gilt decoration; glass eyes	Proper right side, top of base (loose piece in area of loss)	<i>Salix</i> sp.
9	A	1925-53-12	Figure of Guanyin	Ming Dynasty (1368-1644)	Wood with traces of paint and gilt decoration	Proper right side, base, at back	<i>Salix</i> sp.
9	B	1925-53-12	Figure of Guanyin	Ming Dynasty (1368-1644)	Wood with traces of paint and gilt decoration	Proper left side, base, detached fragment	<i>Salix</i> sp.
10		1925-53-13	Figure of a Bodhisattva	Ming Dynasty (1368-1644)	Wood with traces of paint and gilt decoration	Front of base, center	<i>Salix</i> sp.
11		1976-72-1	Standing Buddha	Nambokuchō Period (1333-1392)	Cypress wood (hinoki)	From hollow in back, near the top on the proper left	<i>Torreya</i> sp.
12		1990-75-4	Head of a Military Official	Ming Dynasty (1368-1644)	Wood with traces of painted decoration	Proper left tenon	Lauraceae
13	A	1990-75-3	Head of a Civil Official	Ming Dynasty (1368-1644)	Wood with traces of painted decoration	Proper left side, in back, neck	Lauraceae
13	B	1990-75-3 **	Head of a Civil Official	Ming Dynasty (1368-1644)	Wood with traces of painted decoration	Detached fragments on blanket	Lauraceae
14		1925-99-1	Bodhisattva Avalokiteshvara	Jin Dynasty (1115-1234) - Yuan Dynasty (1271-1368)	Wood	Interior of base, proper left side	<i>Tilia</i> sp.
15		1929-8-4	Figure of Bodhisattva	Jin Dynasty (1115-1234)	Wood	From bottom of base near front edge, along crack	<i>Tilia</i> sp.
16	A	1929-8-7 **	Head of Official	Ming Dynasty (1368-1644)	Wood	Proper left side, along edge and loss	<i>Tilia</i> sp.
16	B	1929-8-7	Head of Official	Ming Dynasty (1368-1644)	Wood	Detached fragment from top of head, next to pith	<i>Tilia</i> sp.
17		1929-11-1	Figure Group	Ming Dynasty (1368-1644) or later	Wood	From underside of base, along crack on proper left	<i>Paulownia</i> sp.
18		1929-8-8	Bust of Guardian	Yuan Dynasty (1271-1368)	Wood	Inside proper left shoulder	<i>Tilia</i> sp.

19		1925-99-2	Head of Temple Guardian	Ming Dynasty (1368-1644)	Wood	Proper right bottom of head cavity	<i>Populus</i> sp.
20	A	1930-38-1	Chinese Temple of Wisdom	Ming Dynasty (1368-1644)	Wood with lacquer and gilded decoration	Fragments in bag labeled "ceiling panel"	<i>Pinus</i> sp. Diploxyton
20	B	1930-38-1	Chinese Temple of Wisdom	Ming Dynasty (1368-1644)	Wood with lacquer and gilded decoration	Underside of lotus pedestal	<i>Tilia</i> sp.
20	C	1930-38-1	Chinese Temple of Wisdom	Ming Dynasty (1368-1644)	Wood with lacquer and gilded decoration	Fragment from a roof ridge	<i>Tilia</i> sp.
21		1965-25-1a,b	Shinto Deity	Heian Period (794-1185)	Wood	Proper right underside of robe	<i>Magnolia</i> sp.
22	A	1929-8-10	Figure of a Bodhisattva	Ming Dynasty (1368-1644)	Wood with traces of pigment	Underside of sculpture, inside rectangular cavity	<i>Tilia</i> sp.
22	B	1929-8-10 **	Figure of a Bodhisattva	Ming Dynasty (1368-1644)	Wood with traces of pigment	Detached fragment from cavity	<i>Tilia</i> sp.
23	A	1929-8-9	Torso of Bodhisattva	Tang Dynasty (618-907)	Wood	Underside of base, back edge (end grain)	<i>Salix</i> sp.
23	B	1929-8-9	Torso of Bodhisattva	Tang Dynasty (618-907)	Wood	Detached, two pieces that fell off	<i>Salix</i> sp.
24		21-1938-1	Bodhisattva	Song Dynasty (960-1279)	Wood with traces of painted decoration	Proper left shoulder blade, along large crack, from behind, above cavity	<i>Paulownia</i> sp.
25		1949-90-1	Bodhisattva of Compassion (Guanyin)	Song Dynasty (960-1279) to Ming Dynasty (1368-1644)	Wood with traces of painted decoration	Inside crack on proper right side of base	<i>Paulownia</i> sp.
26		1929-8-5	Bodhisattva	Jin Dynasty (1115-1234) or Yuan Dynasty (1271-1368)	Wood with traces of painted decoration	Center of hole under base	<i>Tilia</i> sp.
27		1929-8-6 **	Bodhisattva	Jin Dynasty (1115-1234) or Yuan Dynasty (1271-1368)	Wood with traces of painted decoration	Proper left side, lotus petal at back, along area of loss	<i>Tilia</i> sp.
28		1929-8-1	Guardian Figure	Tang Dynasty (618-907)	Wood with traces of painted and gilt decoration	Center of underside of base	<i>Tilia</i> sp.
29		1929-8-3	Daoist Deity	Song Dynasty (960-1279)	Wood with traces of painted decoration	Underside of base, proper right, below right heel	<i>Salix</i> sp.
30		1929-88-39	Head of a Bodhisattva	Ming Dynasty (1368-1644)	Wood with traces of painted and gilt decoration	Proper right side of cavity at back of head	<i>Tilia</i> sp.
31		1929-8-2 **	Guardian Figure	Tang Dynasty (618-907)	Wood with traces of painted and gilt decoration	Along crack below head, bottom right of crack	<i>Tilia</i> sp.
32		1929-18-1	Female and Child	Ming Dynasty (1368-1644) or Qing Dynasty (1644-1911)	Stucco with pigments, wood	At bottom of wooden armature, along proper left side	<i>Pinus</i> sp. Diploxyton
33		1929-12-1	Bodhisattva or Female Deity	Ming Dynasty (1368-1644) or Qing Dynasty (1644-1911)	Stucco with pigments, wood	Bottom of wooden armature	<i>Juniperus</i> sp.

Five samples, marked by two stars ** in Accession Number, were identified by SRX-ray μ CT.

3. Results

Wood identification was performed on the thirty Chinese wood sculptures. As a result, the following wood species were identified: *Tilia* sp. (11 statues), *Paulownia* sp. (7 statues), *Salix* sp. (6 statues), Lauraceae (2 statues), *Pinus* subgenus Haploxyton (1 statue), *Cladrastis* sp. (1 statue), *Populus* sp. (1 statue), and *Juniperus* sp. (1 statue). Four important Buddhist statues from China are shown in Fig. 1. Details are described below.

Accession No: 1929-8-6

Title: Bodhisattva

Artist: Artist/maker unknown, Chinese

Collection

URL:<https://www.philamuseum.org/collection/object/162822>

Credit Line: Philadelphia Museum of Art: Gift of Joseph Wasserman, 1929, 1929-8-6

Accession No: 1929-20-1

Title: Attendant Bodhisattva

Artist: Artist/maker unknown, Chinese

Collection

URL:<https://www.philamuseum.org/collection/object/115250>

Credit Line: Philadelphia Museum of Art: Gift of Joseph Wasserman, 1929, 1929-20-1

Accession No: 1925-53-10

Title: Bodhisattva

Artist: Artist/maker unknown, Chinese

Collection

URL:<https://www.philamuseum.org/collection/object/41534>

Credit Line: Philadelphia Museum of Art: Gift of Charles H. Ludington from the George Crofts Collection, 1925, 1925-53-10

Accession No: 1925-53-11

Title: Guanyin Seated in Royal Ease

Artist: Artist/maker unknown, Chinese

Collection

URL:<https://www.philamuseum.org/collection/object/41538>

Credit Line: Philadelphia Museum of Art: Gift of Charles H. Ludington from the George Crofts Collection, 1925, 1925-53-11

The optical micrographs and pseudo-sections constructed from the SRX-ray μ CT dataset of these images are shown in Fig 2. One sculpture and its pedestal (2013-74-1) are made of two different species: *Tilia* sp. and *Magnolia* sp., respectively. In statue 1929-8-11, two samples were identified: *Paulownia* sp. was used for the proper left, upper thigh, and *Pinus* sp. Haploxyton was used in a detached sample from the proper right thigh. As *Paulownia* sp. was used for upper left thigh, the sample made of *Pinus* sp. Haploxyton could have been from an alternative material for repair, maybe. Although it is difficult to determine whether the detached sample made of *Pinus* sp. Haploxyton is original wood or a wood used for repair by naked eyes, the fact that different species were used is an important finding for future research. In all the other seven cases (acc. Nos. 1929-20-1, 1929-20-2, 1925-53-12, 1990-75-3, 1929-8-7, 1929-8-10, and 1929-8-9), two or three samples were collected from different parts with the same species identified for all parts (Table. 1).

Fig. 2.1 shows the pseudo-optical micrographs of wood sample 1929-8-6**, reconstructed from the synchrotron μ CT dataset. From the pseudo-optical micrographs, the following features can be observed.

Growth ring boundary distinct (Fig. 2.1.a). The wood is diffuse-porous to semi-ring-porous (Fig. 2.1.a). Solitary vessel outline is angular (Fig. 2.1.a). Axial parenchyma is in marginal or in seemingly marginal bands. Helical thickenings are observed on inner vessel walls (Fig. 2.1.b). Intervessel pitting is alternate, and all ray cells are procumbent (Fig. 2.1.c). From the above-described features, the wood is identified as *Tilia* sp.

Fig. 2.2 shows the micrographs of wood sample 1929-20-1. The growth ring boundary is distinct and it shows ring-porous wood (Fig. 2.2.a). Tyloses is observed (Fig. 2.2.a). Vessel pores are arranged in multiples of 2 and round in outline (Fig. 2.2.a). The perforation plate is simple, and rays are homogeneous (Fig. 2.2.b, c). From the above-described features, the wood is identified as *Paulownia* sp.

Fig. 2.3 shows the micrographs of wood sample 1925-53-10. Growth ring boundaries are not observed; diffuse-porous wood is observed (Fig. 2.3.a). Intervessel pitting is alternate, and rays are exclusively uniseriate and heterogeneous (Fig. 2.3.b). Body ray cells are procumbent with one row of upright and / or square marginal cells. Perforation plate is simple (Fig. 2.3.c). From the above-described features, the wood is identified as *Salix* sp.

Fig. 2.4 shows the micrographs of wood sample 1925-53-11. The growth ring boundary is distinct and it shows ring-porous wood (Fig. 2.4.a). Axial parenchyma is confluent. Intervessel pitting is alternate and the shape of the alternate pits is polygonal. The perforation plate is simple and helical thickenings are observed in vessel elements (Fig. 2.4.b.c). Vessel-ray pits are with distinct borders. From the above-described features, the wood is identified as *Cladrastis* sp.

Table 2 Summary of the identified wood species and their corresponding period as indicated at PMA.

表2 フィラデルフィア美術館における中国木彫像に使用された樹種と製作年代（推定）との関係

Century AD	Wood species used for Chinese sculptures								
	<i>Tilia</i> sp.	<i>Paulownia</i> sp.	<i>Salix</i> sp.	Lauraceae	<i>Pinus</i> sp.	<i>Populus</i> sp.	<i>Cladrastis</i> sp.	<i>Juniperus</i> sp.	<i>Magnolia</i> sp.
7th-10th	2		2						
10th-13th	4	11	2		1				
13th-17th	7	1	4	3		1	1		1
17th-18th					1			1	
Total	13	12	8	3	2	1	1	1	1

4. Discussion

In our research at the Philadelphia Museum of Art, the main wood species identified in the wood sculptures were *Tilia* sp., *Paulownia* sp., and *Salix* sp. The wood identification data at the PMA were compared with the analysis of Chinese sculptures in the Metropolitan Museum of Art's collections (Mertz and Itoh: 2010). Table 2 summarizes the wood species and their period in the PMA. Although the total number of sculptures was limited, *Tilia* sp. was used constantly from the 7th to 17th century AD. Interestingly, the usage of *Paulownia* sp. was concentrated in the 10th to 13th century AD. Our recent research in the Museum of Fine Arts, Boston, one sculpture (made from the 10th to 13th century AD) was also made of *Paulownia* sp. (unpublished). The use of *Paulownia* sp. might be a key factor to estimate the date of sculptures in China. In our research, no sculpture made of the sacred sandalwood was identified in the PMA so far. Nevertheless, wood identification results on thirty Buddhist statues gave very useful information to expand our database on wood species used for Chinese statues, and to consider Chinese historical wood selection for statues. In order to know whether the reason for the use of *T. nucifera* in Japanese wood carvings originated from the choice of wood in ancient China, wood identification of Chinese and Korean wood

statues would bring the important hint. However, it is believed that few wooden statues from before the 10th century have survived in China and Korea. Therefore, this survey of tree species of Chinese wooden statues in the United States is very important to understand the history of Japanese wood statues and an aspect of wood selection in Japan.

We hope that this research will contribute to discussing the historical origins of statues and to elucidating the historical background of wood selection for Chinese, Korean and Japanese statues. We also hope that our research will contribute to a better understanding of the interaction of different cultural heritages.

5. Conclusion

Microscopic wood identification was performed on thirty Chinese Buddhist and deity statues, preserved in the Philadelphia Museum of Art (PMA). By using both, conventional optical microscopy and synchrotron X-ray micro tomography, the following wood species were identified for the Chinese statues: *Tilia* sp. (11 statues), *Paulownia* sp. (7 statues), *Salix* sp. (6 statues), Lauraceae (2 statues), *Pinus* subgenus *Haploxyton* (1 statue), *Cladrastis* sp. (1 statue), *Populus* sp. (1 statue), and *Juniperus* sp. (1 statue). Our study

was conducted by wood anatomists in collaboration with art historians, curators and conservators. We believe that it is indispensable to cooperate, publish and share the results of all fields to deepen the interdisciplinary research. Our results showed a possibility of revealing differences in the wood selection between Chinese and Japanese Buddhist

statues in ancient period. This is only an initial step that opens the way for further investigations of East Asian statues. Further investigation, identification and dating of many East Asian statues preserved in Western Museums would have potential to deepen the study of Buddhist images in East Asia.



Figure1

1 Bodhisattva (Acc.No.: 1929-8-6**), 12th - 13th century, size: 27.2 × 11.4 cm, *Tilia* sp.; 2 Attendant Bodhisattva (Acc.No.: 1929-20-1), Jin Dynasty (1115-1234), h.: 224 cm, *Paulownia* sp.; 3 Bodhisattva (Acc.No.: 1925-53-10), 11th cent., size: 152.4 × 41 × 26 cm, *Salix* sp.; 4 Bodhisattva of Compassion/Watermoon Guanyin (Acc.No.: 1925-53-11), Yuan Dynasty (1271-1368), size: 124.5 × 81.3 × 50.8 cm, *Cladastris* sp.;

图 1

1 Bodhisattva (1929-8-6**), 12 . 13 世纪 , 27.2 × 11.4 cm, *Tilia* sp.; 2 Attendant Bodhisattva (1929-20-1), 晋朝 (1115-1234), 高 224 cm, *Paulownia* sp.; 3 Bodhisattva (1925-53-10), 11 世纪 , 152.4 × 41 × 26 cm, *Salix* sp.; 4 Bodhisattva of Compassion/Watermoon Guanyin (1925-53-11), 元朝 (1271-1368), 124.5 × 81.3 × 50.8 cm, *Cladastris* sp.

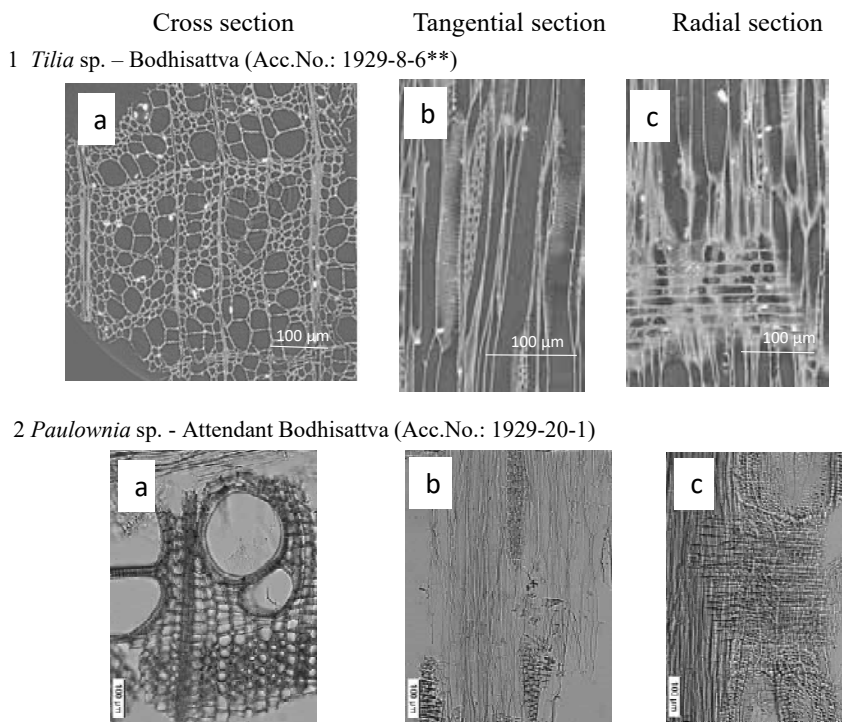


Fig. 2(continued)

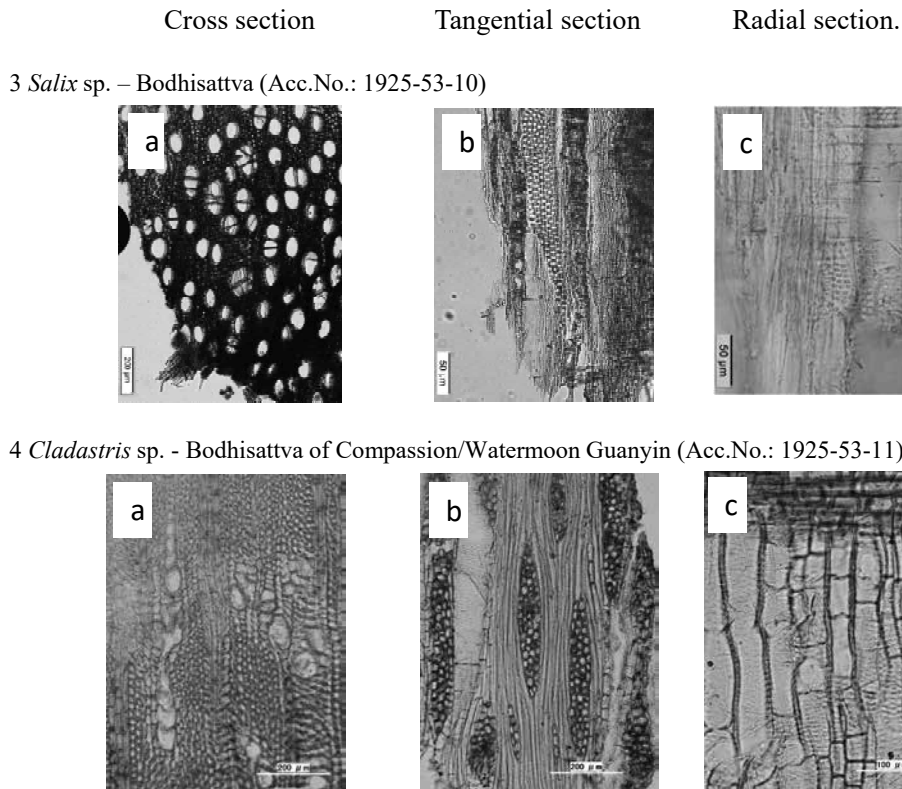


Fig. 2

Micrographs (2 - 4), and pseudo-sections constructed from the SRX-ray μ CT dataset (1):
 1 Bodhisattva (Acc.No.: 1929-8-6**), *Tilia* sp.; 2 Attendant Bodhisattva (Acc.No.: 1929-20-1), *Paulownia* sp.; 3 Bodhisattva (Acc.No.: 1925-53-10), *Salix* sp.; 4 Bodhisattva of Compassion/Watermoon Guanyin (Acc.No.: 1925-53-11), *Cladastris* sp.

図2

光学顕微鏡を用いて撮影した

顕微鏡写真(2-4)と、放射光X線マイクログラフィにより得られた

縦断画像から構築した断層像(1)。それぞれ、a: 木口面、b: 板目面、c: 柁目面である。

1 Bodhisattva (1929-8-6**), *Tilia* sp.; 2 Attendant Bodhisattva (1929-20-1), *Paulownia* sp.; 3 Bodhisattva (1925-53-10), *Salix* sp.; 4 Bodhisattva of Compassion/Watermoon Guanyin (1925-53-11), *Cladastris* sp.

Acknowledgements

Our thanks first go to the PMA's conservators Sally Malenka, Beth Price and Peggy Olley for their kind help with handling the statues and their suggestions. The synchrotron radiation experiments were performed at Beam Line 20XU in SPring-8 (Japan) with the approval of the Japan Synchrotron Radiation Research Institute (JASRI) (Proposal No. 2017B1761). This work was supported by JSPS KAKENHI Grant Number JP26350386, obtained by Takao Itoh, JSPS KAKENHI Grant Number 16K18730, obtained by Suyako Tazuru and RISH, Kyoto University (Mission-

linked Research Funding, #2017-5-4-1, #2018-5-4-1 and #2019-5-4-1).

References

- Hwang S.W., Tazuru S., Sugiyama J. 2020. "Wood Identification of a Historical Architecture in Korea by Synchrotron X ray Microtomography based Three Dimensional Microstructural Imaging" *Journal of the Korean Wood Science and Technology*, 48, 3, pp.283-290
- Jeong H. M 2013 "Species of Wooden Buddhist Statues in the Late Joseon Dynasty of Korea" Conference book of the 8th Pacific Regional Wood Anatomy Conference, https://www.researchgate.net/publication/280314751_Species_of_Wooden_Buddhist_Statues_in_the_Late_Joseon_Dynasty_of_Korea
- Kaneko H., Iwasa M., Noshiro S., Fujii T. 1998 "Wood types and material selection for Japanese wooden statues of the ancient period (particularly of the 7th-8th centuries)" *MUSEUM. Bimonthly Mag Tokyo Natl Mus*, 555, pp.3-54 (in Japanese with English summary)
- Kaneko H., Iwasa M., Noshiro S., Fujii T. 2003 "Wood types and material selection for Japanese wooden statues of the ancient period (particularly of the 7th-8th centuries)". *MUSEUM. Bimonthly Mag Tokyo Natl Mus*, 583, pp.5-44 (in Japanese with English summary)
- Kaneko H., Iwasa M., Noshiro S., Fujii T. 2010 "Wood types and material selection for Japanese wooden statues of the ancient period, III: further thoughts on 8th and 9th centuries sculptures". *MUSEUM. Mag Tokyo Natl Mus*, 625, pp.61-78 (in Japanese with English summary)
- Mertz M., Itoh T. 2010 "Analysis of Wood Species in the Collection, Wisdom Embodied - Chinese Buddhist and Daoist Sculpture in The Metropolitan Museum of Art" Yale University Press, pp. 216-225
- Mizuno S., Torizu R., Sugiyama J. 2010 "Wood identification of a wooden mask using synchrotron X-ray micro-tomography" *Journal of Archaeological Science*, 37, pp. 2842-2845
- Richter H. G., Grosser D., Heinz I. and Gasson P. E. 2004 IAWA list of microscopic features for softwood identification. *IAWA J*, 25, 1, pp.1-70
- Tazuru-Mizuno S., 2020 "Wood selection for Chinese wood statues preserved in the several museums in the USA" *Seizonken kenkyu (Bull of Sustainable Humanosphere)* accepted
- Tazuru-Mizuno S., Sugiyama J. 2019 "Wood identification of Japanese Shinto deity statues in Matsunoo-taisha Shrine in Kyoto by synchrotron X-ray microtomography and conventional microscopy methods" *Journal of Wood Science*, 65, 60, doi: org/10.1186/s10086-019-1840-2
- Wheeler E. A., Baas P. and Gasson P. E. 1989 IAWA list of microscopic features for hardwood identification *IAWA Bull. n. s. 10*, 3, pp. 219-332

(2021年5月24日受付, 2021年6月22日受理)

フィラデルフィア美術館における中国の仏像の樹種調査

田鶴寿弥子¹, メヒティル・メルツ², ヒロミ・キノシタ³, 伊東隆夫⁴, 杉山淳司⁵

¹ 京都大学生存圏研究所

² 東アジア文明研究センター (フランス)

³ フィラデルフィア美術館 (アメリカ合衆国)

⁴ 奈良文化財研究所

⁵ 京都大学農学研究科

米国フィラデルフィア美術館 (PMA) に保存されている中国の仏像・神像 30 軀を対象に、解剖学的特徴に基づいた木材の樹種識別を行った。日本における仏像の樹種研究は 70 年以上の歴史があるが、中国や韓国などの東アジア諸国の木彫像の樹種については未だ十分に科学的に調査されていない。本研究では、欧米の様々な博物館に所蔵されている中国の木彫像における樹種を解明する大規模なプロジェクトの一環であり、用材選択にまつわるデータベースを構築することを目的としている。

東アジア各国の木彫像にどのような樹種が使われていたのか、その理由を知るためには、中国をはじめとして古代に作られた木彫像の樹種を調べることが唯一にして最良の方法であろう。しかし、中国では 10 世紀以前の木彫像はほとんど残っていないと考えられている。したがって、米国で保存されている中国の木彫像の樹種を調査することは、日本の木彫像の源流を理解する上でも非常に重要である。

今回の調査では、従来の光学顕微鏡の他に、極小サンプルを対象としてシンクロトロン X 線マイクロトモグラフィーを行った。その結果、中国の木彫像では、*Tilia* sp. (11 体)、*Paulownia* sp. (7 体)、*Salix* sp. (6 体)、Lauraceae (2 体)、*Pinus* subgenus Haploxyton (1 体)、*Cladrastis* sp. (1 体)、*Populus* sp. (1 体)、*Juniperus* sp. (1 体) の樹種が確認された。本研究が、木彫像の歴史的起源の議論や、中国、韓国、日本の造像における木材選択の歴史的背景の解明に貢献することを期待したい。