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WOOD IDENTIFICATION OF THE ALTARPIECE AND A SCULPTURE OF THE CATHEDRAL BASILICA SANTA MARÍA LA ANTIGUA

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Abstract

The Basilica Santa María la Antigua Cathedral in Panama is an architectural jewel in the Republic of Panama. The current building was built in 1792 and consecrated in 1796. This study aims to identify the woody plant species that constitute part of the interior of the Cathedral and of a sculpture that was exhibited for many years on the façade. Five wood samples were anatomically described using transverse, longitudinal tangential and longitudinal radial sections cut with a microtome following standard histological techniques. These sections were examined, described, and compared with photographs and anatomical descriptions available on the Insidewood database. Anatomical features of the wood samples from the rear of the altarpiece coincide with those of the genus Swietenia (Meliaceae) and the sample from the sculpture matches the anatomical features of the genus Handroanthus (Bignoniaceae).

Keywords: Handroanthus, flora, mahogany, Swietenia, wood anatomy

1. Introduction

The Metropolitan Basilica Cathedral Santa María La Antigua is the seat of the Catholic Archdiocese of Panama, located in the San Felipe district of Panama City, known as Casco Antiguo, a UNESCO World Heritage site [E. Tejeira-Davis, *El Casco Antiguo de Panamá*, Biblioteca Digital de Panamá, 2000, http://bdigital.binal.ac.pa/BVIC/menudecontenidos.php]. The current building was finished by 1792 and was consecrated in 1796. In 1943 it was

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declared a national monument by Panama [1]. A recent restoration of this architectural jewel began in 2016 and was completed in 2018 [2]. The Cathedral altarpiece or reredos and the sculptures are made of wood. Currently, there are no records of dates or place of construction nor the carving artist, installation or any detail of the altarpiece and sculptures; the building previously caught fire and any documents were lost [1]. Work was probably completed during the bishopric of Manuel Joaquín González de Acuña Sanz Merino (1798-1813), during which the first paint and 23-karat yellow gold foils were added. The actual altar has undergone several interventions (SL, personal observation.). The first major intervention on the altarpiece was carried out between 1871 and 1875 [3; J. Blanco, personal communication, 2018].

The altarpiece is 21m height and 9m wide; at the rear it is reminiscent of a ship's hull and is held with support beams. At a macroscopic view, the structure of the altar is not homogeneous, artisanal and industrial tables can be recognized, which indicates that it has been modified over time. The rear of the altarpiece was heavily affected by past fires and termites, which was not visible from the outside. It is not known which woody plant species were used on previous restorations. Based on prior determination by artisanal woodworkers, it was tentatively believed that the altarpiece was made of cedar (*Cedrela odorata* L., Meliaceae), cedar wood was used to replace the affected wood. During the Dalmática Consevação e Restauro works, tie rods were added to strengthen the altar structure. The upper part was in better state of conservation than the lower part, so it was repaired according to its needs. *Ochroma pyramidale* (Cav. ex Lam.) and Urb. (Malvaceae) (balsa), was used to consolidate large cracks, while in others, resins or a paste of dust and glue were used. Thick layers of dust, smoke, dirt, and poor-quality re-painting of up to eight layers and glitter were removed from the altarpiece and then painted to give the appearance of marble. The oil painting image at the centre was also restored. The sculptures were worn and affected by saline breeze, rain, humidity and bird faeces. All sculptures were replaced by stone sculptures and the originals are now exhibited in another church in Casco Antiguo. The sculptures appear to have been carved from a single woody plant species. Only Saint Andrew's sculpture could be analysed because it already had splinters; the others could not be macroscopically nor microscopically evaluated. The faithful claim that all sculptures were made with *Handroanthus guayacan* (Seem.) S.O. Grose, known locally as 'guayacan'.

This study includes anatomical description of hardwood to determine their identity using morpho-anatomical features. Morpho-anatomical studies of wood alongside historical and environmental records are valuable to determine the state, dating, conservation and restoration required [4, 5]. In addition, these studies provide information on the artistic technique used, materials, chronological aspects and its great utility in studies of ecological restoration on certain sites, since it can provide clues about the floristic composition of the past [6, 7].

2. Material and methods

On June 2019, wood samples were extracted from three different parts of the altarpiece, sampling wooden panels spanning a period of reconstructions (Figure 1A, E), from a swan-shaped ornament which maintained the original blue background layer and the first layer of gold foil (Figure 1B), and from a splinter of the sculpture representing Saint Andrew the Apostle (Figure 1D). These small samples obtained from the altarpiece were taken from areas allowed by the restoration workers, in order not to alter the artwork.

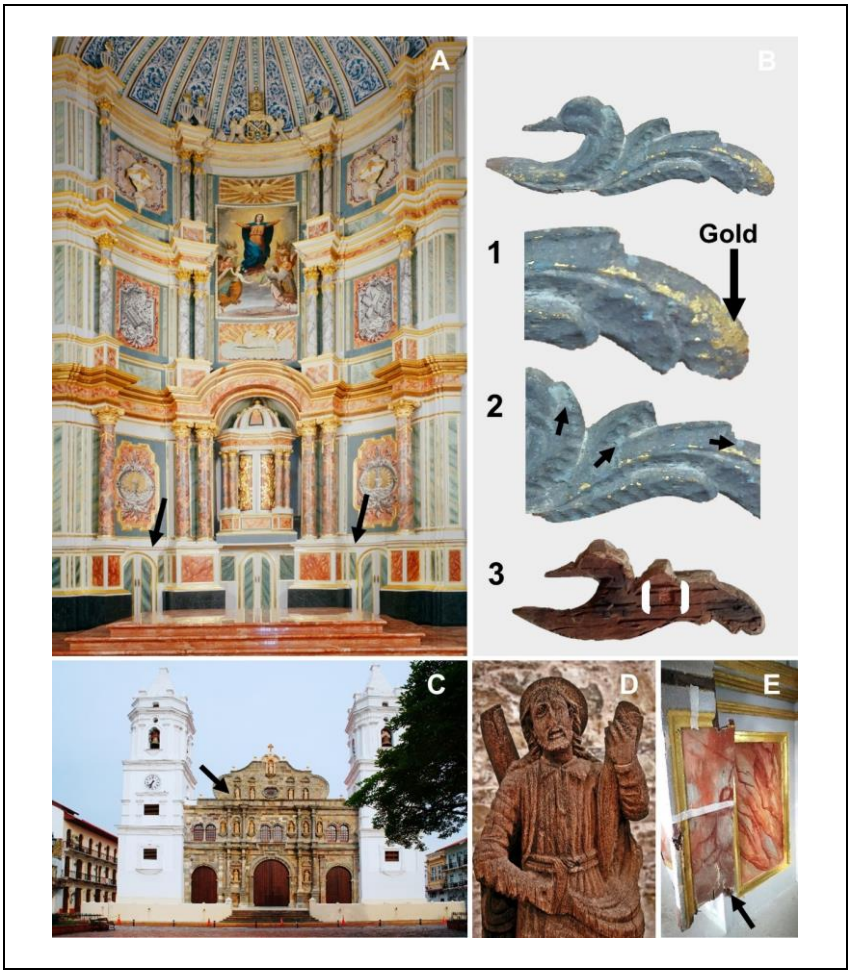

Figure 1. A) the Metropolitan Basilica Cathedral Santa María La Antigua altarpiece. Arrows point to the areas where samples were taken on top of each door (photographed by Daniel E. Sánchez; B) (1) swan-shaped ornament with gold foil layer, (2) blue background layer, (3) rear of the swan-shaped ornament where the wood sample was removed; C-D) Cathedral's façade, where all wood-carved sculptures can be viewed. The arrow points to the Saint Andrew Apostle sculpture (D), (photographed by Daniel E. Sánchez); E) front view of a panel from which another sample was taken.

The samples were taken from accessible, not previously replaced, or restored areas in an effort to identify the original woody plant species from which the altar was built. Due to their condition, the swan-shaped ornament and part of the decorative panel of the altarpiece were discarded by the restorers, who considered them appropriate for analysis because they were part of homogeneous areas of the altar. Wood blocks of 2 cm^3 were extracted with razor blades, chisels, spatulas, and prospector picks for sectioning. The studied material was extracted from the rear of each area. Radial chips were removed from each block of wood for maceration.

2.1. Sample preparation and analysis

The samples were soaked in mineral oil, softened in boiling water, cut into thin sections (18-30 µm) with a Leica CM 1860 cryostat and stained with 1% aqueous solution of safranin and aniline blue in alcohol as contrast stain according to Tardiff & Conciatori [8]. Wood was macerated using the Jeffrey technique [9]. Woods were measured and described using the IAWA List of Features for Hardwood Identification [10, 11]. After macro- and microscopically identifying four samples as the same species, the following measurements and counts were made from the material prepared from two blocks: percentage of solitary from the altarpiece and sculpture samples, so all visible vessels in ten different fields were counted using the magnifications of 4x and 10x, respectively. Tangential diameter of 25 vessels, length, lumen, and wall thickening of 25 fibres, rays per millimetre (ten counts) and height of 25 rays and horizontal diameter of 25 pits. Measurements were made with Image J 1.46r. Woods were compared with available descriptions and images by Richter & Dallwitz [H.G Richter, M.J. Dallwitz, *Commercial timbers: descriptions, illustrations, identification, and information retrieval*, 2000, 25.06.2009, http://delta-intkey.com, accessed on 25.05.2019] and the InsideWood Database [12; InsideWood, 2004 onwards, http://insidewood.lib.ncsu.edu/search, accessed on 9.07.2019]. General characteristics of colour, odour, flavour, grain, texture, and hardness were determined according to the criteria of COPANT [13]. Wood colour classification was determined using Munsell's colour table [14]. Images of macroscopic features were captured with a Leica EZ4D stereo microscope. Microscopic features were captured with a Nikon DS-Ri1 camera mounted on a Nikon Eclipse E 600 microscope, and a Zeiss Evo 40 scanning electron microscope (SEM) on uncoated samples.

3. Results

The samples from the rear of the altarpiece and the swan-shaped ornament match the anatomical characteristics of the genus *Swietenia* Jacq. (mahogany), Meliaceae (Figure 2). The wood from the sculpture of the apostle Saint Andrew matches the anatomical characters of the genus *Handroanthus* Mattos, Bignoniaceae (Figure 2).

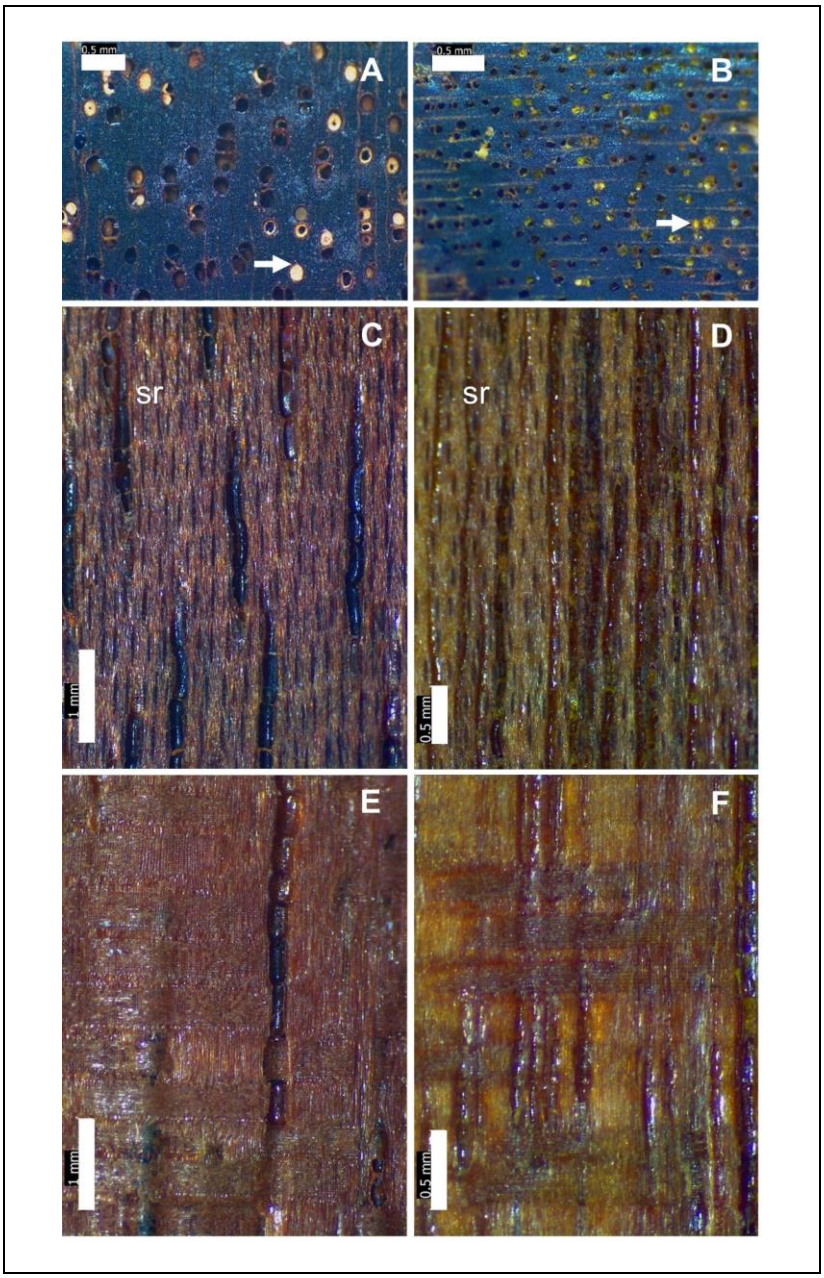

Figure 2. Macroscopic features of the altarpiece sample (A, C, E) and the sculpture sample (B, D, F): A) transverse sections (TS), vessel arrangement of *Swietenia* sp. and the white deposit covering some vessels; B) TS, lapachol deposits in *Handroanthus* sp.; C, D) tangential longitudinal section (TLS), storied rays (sr); E, F) radial longitudinal section (RLS). Scale bar A, B, D, F = 0.5 mm; C, E = 1 mm.

3.1. General features of the altarpiece and sculpture wood samples

Swietenia sp. wood has distinct growth ring boundaries. In dry condition, heartwood is dark reddish brown (5YR 3/4). Odour and taste are indistinct or absent. Golden luster, straight to interlocked grain and medium texture present. Wood is moderately heavy and hard. *Handroanthus* sp. wood has growth ring boundaries distinct, indistinct or absent. In dry condition heartwood is brown (7.5 YR 5/6). Odour and taste are indistinct or absent. Medium luster, straight to interlocked grain and fine texture present. Wood is heavy and hard.

3.2. Macroscopic features of the altarpiece and sculpture wood samples

Swietenia sp. has distinct growth rings, defined by marginal parenchyma. Wood diffuse-porous present. Vessels are solitary and multiple short radials. Vessels and rays are visible to the unaided eye. Other deposits in heartwood vessels present (white covers) (Figure 2A, C). *Handroanthus* sp. has growth ring indistinct or absent. Wood is diffuse-porous with solitary vessels and short radial multiples. Vessels and rays are visible to the unaided eye. There are deposits in heartwood vessels (copious amount of a yellow compound) (Figure 2B, D).

3.3. Microscopic features of the altarpiece and sculpture wood samples

GROWTH RINGS: *Swietenia* sp. has diffuse-porous and growth ring boundaries marked by marginal parenchyma bands. *Handroanthus* sp. a diffuse-porous wood with distinct, or indistinct or absent growth rings boundaries (Figure 3). VESSELS: vessels of *Swietenia* sp. and *Handroanthus* sp. are irregularly arranged in short multiples, commonly (2 to 4 vessels) radial rows. *Swietenia* sp. and *Handroanthus* sp. vessels have rounded outlines and both species present simple perforation plates. Mean tangential diameter of *Swietenia* sp. and *Handroanthus* sp. vessels lumina 100-200 µm (large) and 50-100 µm (medium), respectively (Figure 3, Table 1). Vessels per square millimetre range for both species is 5-20 mm^2 (Figure 4A, B; Table 1).

Both species have short mean vessel element lengths. Gums were found in both species (Figure 3); also, other deposits in heartwood vessels, a white substance covering *Swietenia* sp. vessels and a yellow compound known as ‘lapachol’ in *Handroanthus* sp. vessels (Figure 2A). *Swietenia* sp. vessel elements were storied. INTERVESSEL PITS: Both species has alternate and polygonal intervessel pits. Mean diameters of *Swietenia* sp. intervessel pits are small and *Handroanthus* sp. intervessel pits are medium (Table 1). Their vessel-ray pits have distinct borders and are similar to intervessel pits in size and shape. FIBERS: *Swietenia* sp. and *Handroanthus* sp. fibres have simple to minutely bordered pits. *Swietenia* sp. fibres are septate (Figure 4C), those of *Handroanthus* sp. are non-septate.

Table 1. Quantitative characteristics of the wood from the altarpiece and sculpture. Means are given with Standard deviations and range. Note: Freq. = frequency, Diam. = diameter, Len. = length, Wt. = wall thickness

Features	**Variables/ Species**	**Altarpiece**	**Sculpture**
		Swietenia sp. Jacq.	*Handroanthus* sp. Mattos
Vessels	Freq. (v/mm^2)	(21.17 ± 1.83; 18-23)	(17.2 ± 2.05; 15-19)
	Diam. (µm)	(138. 37 ± 31.25; 81.43-193.13)	(78.74 ± 10.42; 58.74-96.72)
Pits	Diam. (µm)	(2. 19 ± 0.30; 1.69-2.67)	(10.75 ± 0.79; 8.74-12.46)
Ray	Height (mm)	(0.48 ± 0.10; 0.29-0.67)	(0.35 ± 0.043; 0.24-0.41)
	Freq. (r/mm)	(5.1 ± 0.99; 3-6)	(6.5 ± 1.35; 5-9)
Fibbers	Lumen (µm)	(14.23 ± 4.35; 7.91-24.58)	(2.46 ± 1.16; 0.94-5.21)
	Wt. (µm)	(2.13 ± 0.85; 0.86-4.09)	(5.40 ± 1.52; 2.18-7.99)
	Len. (µm)	(1,381.02 ± 193.57; 928.88-1,765.1)	(975.35 ± 91.57; 809.92-1,161.39)

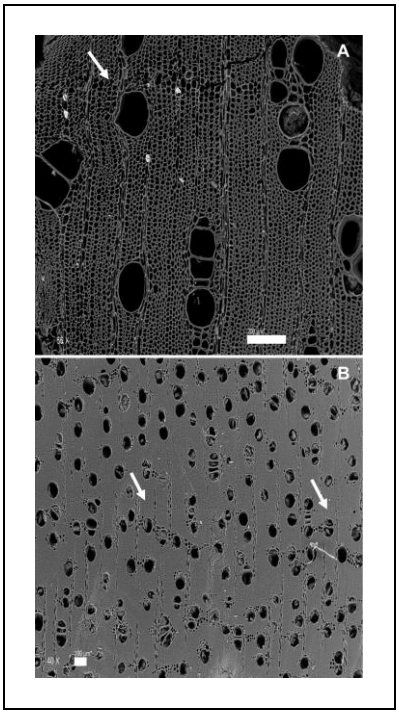

Figure 3. TS of *Swietenia* sp. (altarpiece): A) and *Handroanthus* sp. (sculpture), B) showing vessel arrangement, diffuse- porous xylem, paratracheal axial parenchyma and parenchyma in marginal bands in both wood species. Scale bar A = 200µm, B = 100µm.

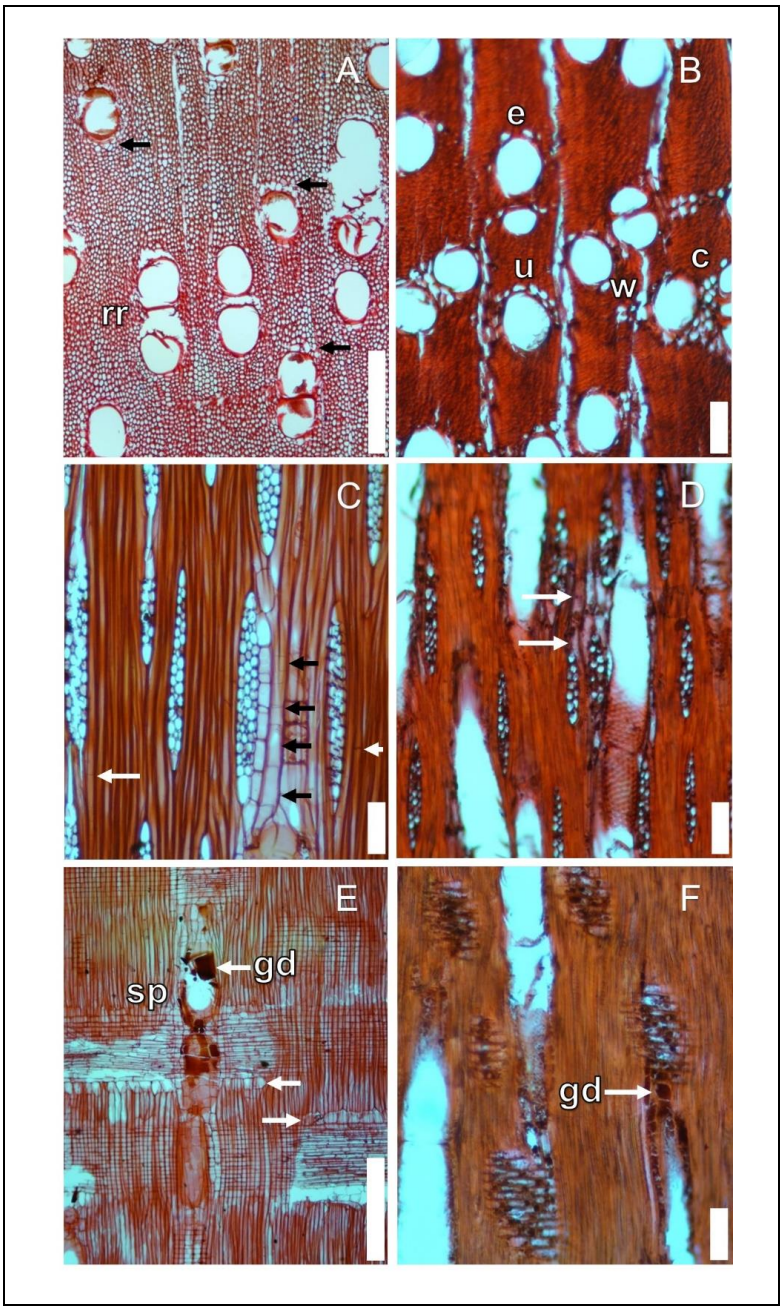

Figure 4. TS, TLS and RLS of the altarpiece (A, C, E) and sculpture (B, D, F): A) solitary vessels and short radial row (rr), axial parenchyma scanty paratracheal; B) vessel arrangement, axial parenchyma: scanty paratracheal (e), confluent (c), unilateral (u) and winged (w); C) rays storied, axial parenchyma cell/strand-length 6 (-8) and septate fibres; D) rays storied, axial parenchyma cell/strand-length (2-3); E) Heterocellular ray's composition, vessel simple perforation plate (sp) and gum deposits; F) Homocellular rays and gum deposits (gd) in vessels. Scale bar A, E = 500 µm; B, C, D, F = 100 µm.

Swietenia sp. fibres are thin-to thick-walled and *Handroanthus* sp. fibres are very thick-walled. Mean fibre lengths of both species range between 900-1,600 µm (Table 1). AXIAL PARENCHYMA: *Swietenia* sp. and *Handroanthus* sp. wood presents diffuse parenchyma (Figure 4A). *Swietenia* sp. has scanty, vasicentric and marginal bands of axial parenchyma up to three cells wide (Figures 3 and 4A). *Handroanthus* sp., wood presents scanty, confluent, unilateral, winged-aliform, and marginal bands of axial parenchyma of two cells (Figures 3 and 4B). *Swietenia* sp. axial parenchyma cells are composed with 5 to 8 cells (Figure 4C); *Handroanthus* sp. presents 2 to 3 cells (Figure 4D). RAYS: *Swietenia* sp. and *Handroanthus* sp. rays are multiseriate, 1 to 3 cells wide (Figure 4C, D). *Swietenia* sp. rays can be uniseriate and others 4(-5) cells wide (Figure 4C, D). Mean frequency of *Swietenia* sp. and *Handroanthus* sp. rays/mm 4-12 (Table 1); both classified as small (Table 1). Rays are storied in both species (Figure 4C, D). *Swietenia* sp. rays are heterocellular, mostly with one row of square or upright cells or 2 to 4 marginal rows of square or upright cells (Figure 4E). *Handroanthus* sp. rays are homocelular, all procumbent (Figure 4F). MINERAL INCLUSIONS: *Swietenia* sp. has few prismatic crystals, located in axial parenchyma cells and upright or square ray cells.

4. Discussion

The woods from the altarpiece and the swan-shaped ornament match the anatomical wood features of the genus *Swietenia* spp. (mahogany) Meliaceae [15-17]. If the timbers used to build the altarpiece was extracted from Panamanian forests these samples could belong to *Swietenia macrophylla* King or *S. mahagoni* (L.) Jacq., an introduce and cultivated species [18]. Both timber species have been internationally used for decades and the wood of these species are unable to discriminated by wood anatomy [15, 19, 20]. Intra and inter-species variation between these species are not enough to separate them either [20]. The studied features coincide with several descriptions and Araya & Moya key [15, 16, 17, 21-25] and [R.H.M.J. Lemmens, *Swietenia macrophylla* King. Record from Protabase, in PROTA (Plant Resources of Tropical Africa*)*, 2005, http://www.prota4u.org/search.asp, accessed on 21.10.20].

These *Swietenia* spp. species are listed in CITES, *S. macrophylla* a high-value timber species that is threatened in nature, nationally (critically endangered) and internationally (vulnerable) [MiAmbiente, Resolución N° DM-0657-2016, 2016, https://www.gacetaoficial.gob.pa/pdf Temp/28187_A/Gaceta No_28187a_20161229.pdf, accessed on 21.05.2020; IUCN 2020, *Swietenia macrophylla*, The IUCN Red List of Threatened Species, https://www. iucnredlist.org/species/32293/9688025, 2020, accessed on 20.02.2020] and *S. mahagoni*, internationally (near threatened) [IUCN 2020, *Swietenia mahagoni*, The IUCN Red List of Threatened Species, https://dx.doi.org/10.2305/IUCN. UK.2020-1.RLTS.T32519A68104916.en, accessed on 21.10.2020]. During an earlier restoration of the altarpiece, artisanal workers used wood from a local cedar, *Cedrela odorata* L. (Meliaceae) (SL, personal observation). The wood of

C. odorata is easily distinguished from mahogany, as it is light and soft, and reddish brown to yellowish red when dry (5YR 6/6); it has no golden lustre; it is aromatic and has a bitter taste; and many distinctive microscopic traits as well [16, 22, 23, 26, 27].

The wood from the sculpture of Saint Andrew the Apostle on the façade of the Cathedral match anatomical features of the Bignoniaceae family [28-30]. The sculpture of Saint Andrew was the only one with splinters that we could sample, so we do not know if the sculptures of the other Apostles were carved from the same wood. There are no historical records on the production of these artworks. More precise identification of the source of the wood requires broader comparative studies of related taxa of trees. The wood anatomy of the family *Bignoniaceae* has been extensively studied, since several species are of great commercial value, such as 'roble' (*Tabebuia* spp.) and *Handroanthus* spp. [31, 32]. The tropical tree genus *Handroanthus* is related to *Roseodendron* Miranda and *Tabebuia* Gomes ex DC., based on molecular, anatomical, and chemical features [31-35]. Based on microscopic features of wood anatomy the genus *Handroanthus* is distinguished by its dense, dark coloured, hard, and heavy wood, with a yellow substance called 'lapachol' (naphthoquinone) obstructing the vessels of the heartwood and other features [31-39].

Since there are no records about the sculptures, we are assuming that the timber used to carve the San Andrew sculpture was extracted from Panamanian forests. Species of *Handroanthus* reported in the flora of Panama are *H. chrysanthus* (Jacq.) S.O. Grose, *H. guayacan* (Seem.) S.O. Grose, *H. impetiginosus* (Mart. ex DC.) Mattos, *H. ochraceus* (Cham.) Mattos and the introduced and cultivated species *H. heterophylla* (DC.) Britton [18, 40]. Wood anatomies of *H. chrysanthus*, *H. impetiginosus* and *H. ochraceus* are overall similar [36], but differ in some qualitative and quantitative traits [23, 37, 41], including colour, growth rings and cell size [23, 27, 33, 36, 37, 38, 41-46]. The analysed wood sample shares features of one species but not all of them, and so we cannot determine the species identification with accuracy. The wood is similar to *H. guayacan* wood in its reddish yellow or olive-brown colour and the density, shape and distribution of parenchyma cells, except the parenchyma bands are not more than three cells width [27, 46]. Wood traits vary among individuals, and in different climatic and bio-geographical regions [41, 43].

5. Conclusions

Wood samples collected from the rear of the original altarpiece and the swan-shaped ornament correspond to the anatomical wood features of the genus *Swietenia*. The wood sample extracted from the sculpture of Saint Andrew the Apostle matches the anatomical wood features of the Bignoniaceae family, specifically those of the genus *Handroanthus*, as it is a dense, hard, dark-coloured wood and abundant lapachol (naphthoquinone) compound into the vessels. A specific taxonomic identification is indeterminate because the wood anatomical features of *Handroanthus* and *Swietenia* species are very similar

between their species, and there is no information on the origin of these woods. This research contributes to our scientific knowledge of the Cathedral and shows the importance of this knowledge in maintaining our cultural heritage. Woods differ in their physical and mechanical properties. Knowledge of which species are used in constructing our architectural gems have implications for understanding the effect of weather on them, and any maintenance or repairs of wooden pieces that will be needed in the future. This long-term necessity calls attention to the need for us to be better custodians of our natural and managed resources.

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