A Closer Look
Santos from Puerto Rico

Tiburcio de la Espada (1798-1852). *Virgen de Monserrat*,
courtesy of the Vidal Collection, National Museum of American History, Smithsonian Institution.
Photograph by Diane Nordeck.

Santos from the Vidal Collection
National Museum of American History

By Jia-sun Tsang

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Teodoro Vidal, donor of the Vidal Collection, and Jia-sun Tsang, SCMRE paintings conservator, discuss *Virgen de Monserrate* during the "Preservation of *Santos*" workshop at the Smithsonian Institution, on September 23, 1997. (Photograph by Doc Dougherty)

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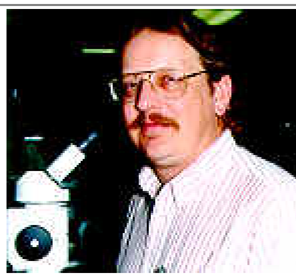
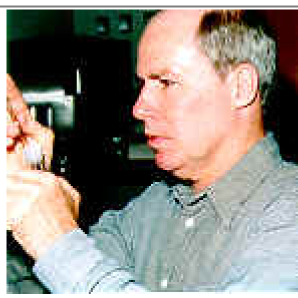
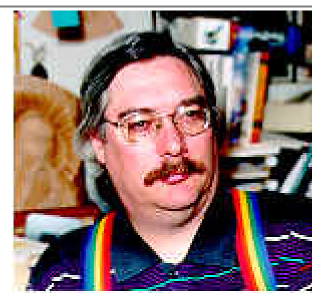
 Harry Alden Microscopist SCMRE	 Diane Nordeck Photographer SIOPS	 Fabian G. Borrega Visiting Scholar SCMRE
 Walter Hopwood Organic Chemist SCMRE	 Camie Thompson Analytical Chemist SCMRE	 Donald Williams Education Coordinator SCMRE

Photographs by Doc Dougherty

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Jia-sun Tsang
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Forward

Objects tell us about ourselves. Looking at an object and analyzing its style, form, and iconography we can learn much about the artist, the society, and culture in which he or she lived and worked, and thus about our own cultural and historic background. When we extend our observations by means of techniques in addition to the naked eye, we also expand the nature of information that we can gain. Resorting to such a "closer look" we become aware of choices in materials and techniques made in the fabrication of the object. This may add to our knowledge of the creative process, the artist, and since such choices are influenced by culture and society, aspects of the latter that enrich our understanding of our background and traditions. We also may discern material evidence of the history of the object between its creation and today, which may tell us about changes of its place in society and thus in society itself.

"A Closer Look: *Santos* from Puerto Rico" is not meant as a scholarly tome written for experts. Rather, it is an introduction to another way of looking at artifacts, intended for the enjoyment of the layman with an interest in the history and tradition of these objects. It introduces the materials culture concept to the study and enjoyment of objects that represent a living cultural tradition. The manufacture of *santos* in Puerto Rico has a history that goes back for centuries, to the early Spanish Colonial era, but continues through this day. Dedicated artists in the Hispanic American communities still create these images, working within an evolving tradition steeped in a rich history but adapting to the cultural and material parameters of modern society. As objects of veneration that play an important role in religious life, *santos* take a place at this very heart of Latino cultural traditions. At a time when we celebrate the variety of our cultural backgrounds, recognizing these as the threads that together weave the rich tapestry of our society, it is especially pleasing to be able to make this modest contribution to enriching the experience of these material manifestations of an essential aspect of Hispanic cultural traditions.

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Introduction

Artifacts are both immediate and timeless. When we encounter them and when we use them, they affect our lives at that moment, just as they affected people before us and those yet to come. For sacred objects incorporated into worship, such as *santos*, this effect can be considered eternal. In the same way, then, artifacts and the ideas they represented can transcend time.

Unfortunately, one of the fundamental and irreversible laws of this universe is commonly called "deterioration." *Ashes to ashes, dust to dust* is not simply a saying, it is a statement of reality. As preservers of cultural and material history, it is our task to slow down this path back to dust that all things must endure.

Whether we are discussing monuments or molecules, the key to preserving physical things is in understanding their creation, use, and deterioration. Only by balancing these factors can actions for their preservation be wisely chosen. Without this information, care, maintenance, and restoration activities are equally likely to damage as to aid the artifacts.

The quest to acquire this information increases our understanding about the artifacts being examined and analyzed. These examination can reveal the processes used to fabricate ancient artifacts whose cultural and historical context is not known, or it can simply verify or call into question scholarship and recorded history.

Such is the case in this instance, where selected *santos* from the Teodoro Vidal Collection underwent exhaustive examination and analysis. By employing modern technologies, we learned a great deal about these *santos*: what materials and techniques were used to make them; how they were decorated; with what; and how often. The technical examinations provided information about the culture and people who made and used the *santos*. While some of the information is not explicitly necessary for the preservation of the artifacts, nor for their use as devotional objects, it contributes to appreciating them more completely.

The purpose of this monograph is not necessarily to provide a historical perspective of these artifacts, although that is certainly one result of the investigations of them. Nor does it attempt to provide cultural meaning regarding the use and function of *santos*. Instead it focuses on and informs the reader on the material nature of them in the hope that is contributes to both understanding and preserving them through more informed use and care.

In order to understand artifacts, we must know as much as possible about their context. To preserve them, we must recognize their physical nature - what they were made from and what condition they are in and the circumstances in which they will exist. The circle is then complete: in accomplishing the latter, we fulfill the former.

Donald C. Williams
Education Coordinator
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1. *Santos*

"*Santo*" is a contemporary generic name in Spanish for *sacred image*. *Santos* are commonly found in Catholic Churches and private homes. In general, *santos* are wood carvings of saints, the Virgin Mary, and other religious and biblical subjects. The sculpted images can then be decorated with paint, metal, and precious stones. Makers of *santos* are called *santeros* (male) or *santeras* (female).

Santos illuminate the life of people by and for whom they are made. Images of *santos* reflect the social, cultural, and religious aspects of the lives of Catholic Hispanic people in America. *Santos* are about their spirituality; how they maintain the faith of the Church, how they lead a Christian life. The *santos* were and are central components in the religious lives of Catholic Latinos.

During the colonial period (1490's-1890's), there were three principal European traditions of artisanship: the Flemish, the Italian, and the Spanish. Each contributed to the formation of local expressions and materials that would ultimately become a distinct and independent American style. This blending of native and imported forms resulted in one of the most unusual and compelling elements in American colonial art. Many traditional religious practices through the Latin American world continue to represent a merging of pre-Hispanic and African influences with the occidental notion of the craft workshop. The art of the colonial era constituted a subtle yet strong and open combination of different traditions.

2. *Santos* from Puerto Rico

Santos and the tradition of making *santos* have been with the people of Puerto Rico since the early 1500's. These religious folk images are known as *Santos de Palo* - "saints of wood." The making of *santos* started in rural areas where access to priests and churches were limited. *Santos* were placed in home alters. The oldest surviving *santo* in Puerto Rico, a *Santa Ana* from the Vidal Collection, now at the National Museum of American History, Smithsonian Institution, is dated from the 16th century*.

In the early 20th century, *santos* were brought out of their domestic settings by the Dominican friars of the Dutch Province established at Bayámon. In 1931, *santos* from Puerto Rico were exhibited at the mission-fair in the Netherlands**, where they were praised for their simplicity and aesthetics. By the late 1930's, *santos* were gaining further recognition and they can be found in major museums and private collections today.

In general, *santos* from Puerto Rico are presented in a frontal pose, seated or standing. The *santos* made and used for private homes tend to be smaller and less elaborate than those intended for the Church. In some Puerto Rican houses, *santos* used to be placed in a wooden box with folding doors placed prominently and openly in the living room or bedroom. This box is called a *nicho* or niche. The early *santos* were carved out of one piece of wood. Those of a later date were assembled from a body carved from one piece of wood with "inserts" of the hands and the attributes. One unique material and technique in the making of *santos* was the use of wax for the face or head. Wax was mixed with chalk, molded to the desired contour and fixed to the top of the body or face. These methods of assembly are clues to production aspects of some of the workshops.

In 1997, Puerto Rican philanthropist, businessman, and art patron, Teodoro Vidal, donated 3,264 objects to the Smithsonian Institution from his magnificent collection. There are 622 *santos* in the collection, gathered by Mr. Vidal over four decades. Mr. Vidal strongly believes that *santos* in the collection must be made available for scholarly study. He also felt it important to establish an awareness of and commitment to preserving *santos*. The study of *santos* as material artifacts is critical to understanding them as icons but also is essential to preserving both the *santos* and the continuing tradition of *santos* making.

* attributed by *santos* scholar Arturo v. Dávila.

** Yvonne Lange, "*Santos de Palo*: The Household Saints of Puerto Rico," The Clarion, Vol. 16, No. 4, Winter 1991-1992, New York: The Museum of American Folk Art, pp. 43-65.

3. A Closer Look with Modern Scientific Techniques

When we look at art and artifacts, the knowledge we have collected previously about them leads us to interpret, enhance, sometimes overlook what our senses tell us. Using all our senses, "looking" can be systematic, thorough, and objective. Our eyes inform us one way, our ears another, and our touch yet a third way. In technical studies of artifacts, our goal is to use not only all our senses and knowledge but also techniques and tools that act as extensions of them. With our eyes we can determine general form and appearance: characteristics as color, surface texture, sheen, and so forth. With tools such as microscopes, we can see minute layers of paint and pigments that provide color and decoration. Imaging techniques that use light frequencies our eyes can't see, such as infrared, ultraviolet, or x-ray, reveal that which is otherwise invisible. Other instruments and techniques literally extend our senses of touch, smell and hearing as we examine samples under our scrutiny. Taking "a closer look" through these and other methods - colorimetry, chromatography, and spectrometry - allows us to observe and in many cases identify things like artists' materials and techniques.

Modern scientific tools can provide information used to suggest the age, provenance, materials and function of objects and artifacts of all types. Many museums have conservation laboratories with modern scientific equipment. The conservation laboratory shares a common interest with the forensic laboratory in its goal of examining very small and often irreplaceable samples without context to learn as much as possible. Often, the conservation laboratory faces the more challenging task because sampling of a "treasure" may not be an option. Growing public interest in the interrelation of science and art has promoted a closer look at art and artifacts.

Archives of literature are an important source for the study of *santos*. Another approach, the study of *santos* by iconography and iconology, is also critical. However, when attribution of a *santo* is uncertain or the *santo* has been altered or repainted several times, studying the material structure is necessary to acquire a thorough understanding of the sculpture.

Wooden sculptures like *santos* change over time and may eventually show signs of deterioration. This can be brought about by internal factors, as well as by conditions of usage and the actions of people. A closer look to understand the materials and techniques of a *santo* is indispensable in order to define the best conditions for storage and housing of the *santo* and developing a viable treatment scheme, if needed.

As they examine art works, conservators use many approaches which are separated into "non-destructive" and "destructive" methods. Non-destructive methods involve looking at art and artifacts with x-rays, ultraviolet light, infrared light, and magnifying devices. Destructive methods such as x-ray diffraction or gas chromatography with mass spectrometry require taking small samples from unobtrusive areas of an object. The samples collected can be used to identify pigments, binders, wood types, metals, and other materials in the *santo*. One special interest in *santos* focuses on the study of the paint layers to see how many times the original has been painted over. Discussion among collectors, conservators, *santeros*, and the Church about the ethics of removing the most recent paint layers on *santos* is common. Analytical technology can contribute to this decision making.

4. Scientific Tools at a Glance

Some analytical tools, such as optical microscopes, are easy to imagine. Anyone who has used a magnifying glass has at least a conceptual understanding of what the microscope does. At the same time, microscopic cross-sections are equally understandable if thought of as looking at the edge of a stack of materials, whether paper, rock formations, or paint and varnish layers.

The function and purpose of other scientific techniques, however, are not readily comprehensible without at least a brief description of them.

XRF - Energy dispersive X-ray fluorescence

What is it?
XRF is a non-destructive tool for determining the chemical make up of an object. It is especially useful for identifying **inorganic compounds** such as metal alloys, glass, ceramics and pigments.

How does it work?
An x-ray beam is aimed at a spot on the surface of an object, causing the chemical elements in the material to emit characteristic "fluorescent" radiation. Measuring this fluorescent radiation provides identification and determination of the elements present.

FTIR - Fourier transform infrared spectroscopy

What is it?
FTIR is an analytical tool that produces a "fingerprint" spectrum of the different chemical compounds that make up an object. FTIR is useful for characterizing **organic materials** such as coatings, adhesives, and paint binders. When attached to a microscope, the sample size is drastically reduced.

How does is work?
A sample is radiated in the infrared region of the electromagnetic spectrum. The manner in which it absorbs infrared radiation is characteristic of the sample's **molecular structure**. Identification can be achieved by comparing the wavelength spectrum of the absorbed IR light with spectra of known compounds.

XRD - X-ray diffraction

What is it?
XRD is an analytical tool that permits "definitive" identification of **crystalline** inorganic pigments, using very small samples.

How does it work?
X-rays are diffracted (bent) or reflected in a manner determined by a material's crystalline structure. The angles and intensity of the diffractions and reflections are recorded and interpreted by comparison with references.

SEM-EDS - Scanning electron microscopy-energy dispersive x-ray spectroscopy

What is it?
SEM is a tool that allows image magnification up to 100,000 times. Through an analytical attachment that functions similarly to the already described XRF, it can provide the elemental analysis of a **sample's surface**. It can, for example, be used to identify pigments in cross-sectional paint layers.

How does it work?
A sample is exposed to a beam of electrons in a vacuum system. Recording the interactions of electrons with the sample create an image that allows the observer to see extremely small surface features. The XRF-like attachment allows for the simultaneous analysis of the elemental composition.

Ultraviolet/visible (UV-VIS) spectrometry

What is it?
UV/VIS spectrometry is a tool that measures the wavelength-dependant absorption of light in the visible or ultraviolet region. It is very useful for identifying a variety of materials, for example **dyestuffs**.

How does it work?
A sample in solution is irradiated in the UV-Visible range. Certain wavelengths are selectively absorbed by the sample producing a characteristic pattern which can help identify the **dissolved** material.

GC-MS - Gas chromatography with mass spectrometry

What is it?
GC-MS gives "definitive" identification of organic materials such as **paint binders**.

How does it work?
GC-MS first separates dissolved samples or derivatives (chemically modified samples), into fractions according to their volatility (and polarity). Each fraction is then ionized so that electrically charged fragments are formed. These ions are separated according to mass and counted. Interpretation of the resulting "mass separation" provides the identification and chemical makeup of the sample.

X-ray Radiography

What is it?
X-radiography is used for the structural examination of art and artifacts, as it is used by doctors in hospitals. For art works, it helps to reveal losses, replacements, and methods of construction that may not be visible to the naked eye.

How does it work?
X-rays are a form of high energy electromagnetic radiation that travel like ordinary light but can penetrate through most objects. The amount of x-ray intensity absorbed by the object depends on the density and thickness of the material. Thus, exposing an x-ray sensitive film to the transmitted x-rays provides a recorded image of the interior of the object. Since denser areas absorb more x-rays, the film receives less exposure and the corresponding areas appear lighter.

Xeroradiography

What is it?
Xeroradiography is an alternative method of **recording X-ray images**.

How does it work?
Instead of using a photographic film to record the image, x-rays travel through objects and are received on an x-ray sensitive metal plate. The plate is then processed through a unique photocopying-type machine. The recorded image of the interior of the object is then transferred onto plastic-coated paper. The denser elements appear darker by xeroradiography. Xeroradiography is more sensitive than film-based x-ray imaging, and for painted wood, it helps to reveal attachments, insect damage, and construction. The final image is a mirror image of the object (different from X-ray film images), so it is important to avoid any confusion in interpretation.

The scientific tools listed above were used in the study of the santos of the Vidal Collection. Two methods of investigation, xeroradiography and paint cross-section study through optical and scanning electron microscopy, are highlighted in this monograph for visual presentation.

4. Un vistazo a las herramientas científicas

Algunas herramientas analíticas, tal como los microscopios ópticos, son muy fáciles de imaginar. Cualquier persona que haya utilizado un lente de aumento comprende, por lo menos conceptualmente, la función de un microscopio. De la misma manera, se puede entender el concepto de microscopia de secciones transversales, si se piensa que lo que se está observando es el borde de una variedad de materiales, ya sea papel, formaciones rocosas o capas de pientura y barniz.

Sin embargo, la función y el propósito de otras técnicas científicas no se puede comprender tan fácilmente sin llevar a cabo una breve descripción de las mismas.

XRF - Dispersión de energía fluorescente por rayos X

¿Qué es?
Es una herramienta analítica no intrusiva que se usa para determinar la composición de los elementos químicos de un objeto. Resulta especialments útil para el análisis de **compuestos inorgánicos**, como aleaciones de metales, vidrio, cerámica y pigmentos.

¿Cómo funciona?
Se apunta una columna de rayos X sobre un sitio en la "superficie" de un objeto, causando que los elemento químicos que componen el material emitan radiaciones "fluorescentes" características. La medición de esta radiación fluorescente permite la identificación y determinación de los elementos presentes en el objeto.

FTIR - Transformación espectroscópica de radiación infrarroja Fourier

¿Qué es?
Es una herramienta analítica que produce un espectro de la "huella dactilar" de los diferentes componentes químicos presentes en un objeto. Resulta muy útil para el análisis de **materiales orgánicos** tales comobarnices, adhesivos y aglutinantes. Cuando se ensambla un microscopio, el tamaño de la muestra se reduce drásticamente.

¿Cómo funciona?
Al exponer una muestra a la región infrarroja del espectro electromagnético, la manera en que ésta absorbe dicha radiación indica la **estructura molecular** de la muestra. La indentificación se logra por comparación del espectro de las longitudes de ondas con los espectros de luz infrarroja absorbidos por otros elementos conocidos.

XRD - Difracción de los Rayos X

¿Qué es?
Es una herramienta analítica que permite la identificación "inequívoca" de pigmentos inorgánicos en forma cristalina en muestras muy pequeñas.

¿Cómo funciona?
Los rayos X son difractados (curvados) o reflectados de una manera determinada según la estructura cristalina del material. Los ángulos y la intensidad de las difracciones y reflexiones se registran e interpretan por comparación con datos de referencia.

SEM-EDS - Visualización por microscopia electrónica - espectroscopica por dispersión de energía fluorescente de rayos-X

¿Qué es?
Es una herramienta analítica que permite aumentar una imagen hasta 100.000 veces y también, a través de un accesorio analítico que funciona como el XRF descripto anteriormente, realizar el análisis elemental de la superficie de una muestra. Puede usarse, por ejemplo, para la identificación de pigmentos en secciones transversales de capas de pintura.

¿Cómo funciona?
Se expone una muestra a una columna de electrones en un sistema al vacío. El registro de las interacciones de los electrones con las muestra crean una imagen que permite visualizar en la superficie rasgos extremadamente pequeños. Con el accesorio similar al XRF se puede, a la vez, analizar la composición elemental de la muestra.

UV-Vis - Espectrometría visible por ultravioleta

¿Qué es?
Es una herramienta analítica que mide la absorción de la luz, dependiente de las longitudes de onda, en la región visible o ultravioleta. Es muy útil para la caracterización de una variedad de materiales, como por ejemplo las anilinas.

¿Cómo funciona?
Una muestra en solución es irradiada en el campo visible por ultravioleta. Ciertas longitudes de onda son selectivamente absorbidas por la musetra produciendo un patrón espectral característico, el cual puede ayudar a identificar el material disuelto.

GC-MS - Cromatografía gaseosa con Espectro de Masa

¿Qué es?
Es una herramienta analítica que permite la identificación "inequívoca" de materiales orgánicos tales como los aglutinantes de pintura.

¿Cómo funciona?
El GC-MS separa primero muestras disueltas o derivadas (muestras modificadas químicamente) en fracciones, de acuerdo a su volatilidad (y polaridad). Luego se ioniza cada fracción de manera que se forman fragmentos con cargas eléctricas, los cuales se agrupan de acuerdo a la masa y se cuentan. La interpretación de la "separación de masas" obtenida permite la identificación y determinación de la composición química de la muestra.

Radiografía por rayos-X

¿Qué es?
La radiografía por rayos-X que utiliza para examinar arte y artefactos es la misma que emplean los doctores en los hospitales. Su utilización para el análisis de objetos de arte constituye una ayuda para revelar pérdidas, reemplazos y métodos de construcción que de otra manera no serían visibles.

¿Cómo funciona?
Los rayos-X son radiación electromagnética de alta energía que viaja como la luz común, pero que tiene la capacidad de atravesar la mayoría de los objetos. La cantidad e densidad y del espesor del material. De manera que, al exponer una película sensible a los rayos-X a una transmisión de rayos-X, se obtiene una imagen del interior del objeto. Las áreas más densas absorben una mayor cantidad de rayos-X, por lo tanto, dichas áreas donde la película resulta menos expuesta se ven más claras.

Xerorradiografía

¿Qué es?
Es un método alternativo alternativo para registrar imágenes por rayos-X. Los rayos-X viajan a través de objetos que se colocan cuidadosamente sobre una placa de metal sensible a rayos-X.

¿Cómo funciona?
En vez de usar una película fotográfica para registrar la imagen, los rayos-X transmitidos se reciben en una placa de metal sensitiva a los rayos-X. A continuación, la placa se procesa en una máquina tipo fotocopiadora muy especial. Luego, la imagen registrada del interior del objeto se transfiere sobre un papel plastificado. En la xerorradiografía, los elementos más oscuros. La xerorradiografía es más sensible que la las radiografías basadas en película, y su utilización en madera pintada ayuda a revelar agregados, daños causados por insectos y tipos de construcción. La imagen final es una imagen espejada del ibjeto (diferente de las imágenes de las radiografías sobre película), por lo cual es muy importante evitar confusiones en las interpretación.

Las herramientas científicas enumeradas más arriba se utilizaron para el estudio de lossantos de la Colección Vidal. En esta monografía de resaltan dos métodos de investigación para realizar presentaciones visuales: la xerorradiografía y el estudio de secciones transversales de pinturas a través de visualización por microscopia electrónica.

5. Materials and Techniques of *Santos*

The *santos* in this study were mostly used and made for private devotion. In general, they are smaller in size and not as elaborate as *santos* commissioned for the Church. However, the materials and techniques used by the artists were the same for *santos* regardless of their intended audience.

Grounds and Paint

Santos are produced in the European tradition of polychrome (painted wooden) sculpture. Typically, the polychrome sculpture is made from local wood carved and sanded to achieve the desired contour and expression. Then follows the application of size (animal glue) and gesso (chalk in animal glue) or gesso-soaked cloth to the prepared surface. The gesso can be further sanded to achieve a smoother surface for the application of paint. Gesso provides an ideal ground to receive paint. Without the gesso layer, the paint will sink into the wood and result in lessening of color. Gesso is used to even out tool marks left by the carving. Sometimes, colored bole (fine clay and glue) is applied on top of gesso as special preparation for gold leaf. Gesso is also used to build three dimensional designs under gold leaf or paint for the surface decoration of more elaborate polychromes. Paint on top of gold leaf can be selectively scratched away to create the illusion of richly embroidered cloth.

Oil paint or egg tempera (pigments in egg yolk) are traditional paints for polychromes. The pigments are mostly hand ground and the particles are larger and less uniform than modern commercial machine ground pigments. The types of pigments and the size of their particles are useful for the dating of polychromes, especially when there is no other information available.

All the artists' materials and techniques of this European tradition are found in the making of *santos* from Puerto Rico.

The oldest *santo* in the study, a *Santa Ana*, has ultramarine in the blue paints. In medieval times, ultramarine was a costly material. Like gold, ultramarine was used as a symbol of luxury and it was frequently specified by rich patrons in contracts and commissions. Other traditional pigments like lead white, ground chalk, vermillion, and red lake, are found in *Santa Ana*.

In studying the paint layers through visual examination and optical and scanning electron microscopy, it is apparent that most of these *santos* were painted several times. Modern commercial pigments are used on top of original traditional pigments. This information is useful in interpreting and deciding on how to care for and preserve the *santos*.

From the analysis of paint binders with a scientific tool such as GC-MS, FTIR or with simple microchemical tests, it is evident that drying oil is the predominant binder used in this group of santos. When water soluble binder was found, it turned out to be primarily not original.

Molded Wax

One unique material and technique in this group of *santos* is the use of wax for the faces or heads of saints. Wax mixed with rosin and chalk was molded to the desired contour and fixed to the body or face. In *Santa Ana*, the faces of the two saints are missing, and it is possible that wax was used. We closely examined the faces of the two seated saints. There appears to be a deliberate roughing of the flat wooden surface which may have been intended to help the wax stick to the wood. This way of making *santos*' heads or faces has not been found in the modern pieces of the collection.

Structure

From studying the construction of the *Santa Ana* by xeroradiography, it is obvious that the seat or stand is carved as an integral part of the sculpture. In the production of later *santos*, stands are nailed to the carved polychromes. Sometimes, multiple nails were used to secure the stand to the figures after they had left the workshop. It is safe to assume that some of the stands are not original.

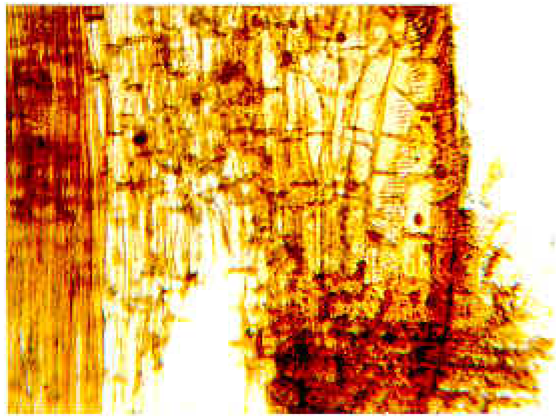
Wood

Historically, the most popular wood used for *santos* was *cedro hembra* or Spanish cedar (*Cedrela odorata* L.), in the family *Meliaceae*. Other members of this family, also used, include the true mahoganies, *caoba dominicana* or Cuban mahogany (*Swietenia mahogani* Jacu.) and *caoba hondureña* or Honduras mahogany (*Swietenia macrophylla* King) as well as *guaraguao* or American muskwood (*Guarea trichilioides* L.). These woods possessed durability, a perceived resistance to insect attack, and the desirable characteristics for carving (fine texture, straight grain and relative softness). Other "soft" woods that exhibit these characteristics include *aguacate* or avocado (*Persea americana* Mill.) and *almácigo* or gumbo-limbo (*Bursear simaruba* L.). Harder woods were occasionally used. These included *úcar* or oxhorn bucida (*Bucida buceras* L.), *capá* (*Cordia alliodora* Ruiz & Pav.), *ausubo* or butterwood (*Manilkara bidentata* A.DC.) and *guayacán* or lignum-vitae (*Guaiacum officinale* L.).

Wood Analysis

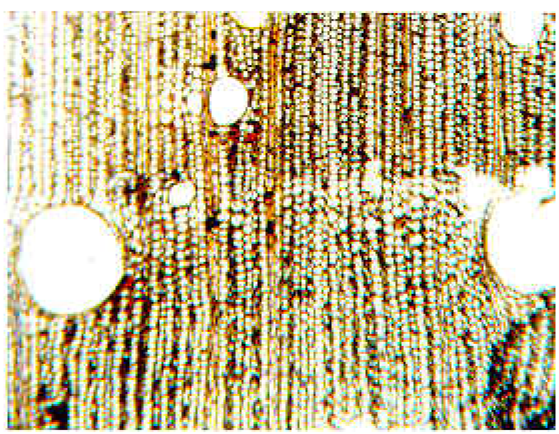
Wood samples were taken from three figures (*Santa Ana* [Figure A], *Santa Rosalia* [Figure B] and *Virgen de Monserrate*). These were selected because they had wood previously exposed by a buyer/recipient who would ascertain that traditional wood had been used for the carving.

Thin sections were removed from the exposed wood surface with a modified razor blade, bent into a carving tool to prevent damage to the edges of the painted surfaces. All three samples were a species of *Cedrela*, most likely *cedro hembra* (*Cedrela odorata* L.). Because the samples were very small, only a tentative identification could be made, based on a few macroscopic and microscopic characteristics. These include color, weight, and the size of the vessels (Figure C) and the intervascular pits (Figure D), presence or absence of crystals in rays or axial parenchyma and storied rays (Figure D).



(Figure A) Radial section from *Santa Ana* showing inter-vessel pits and nonstoried, multiseriate rays.

(Figure B) Tangential section from *Santa Rosalia* showing inter-vessel pits.



(Figure C) Spanish cedar cross-section showing vessels and marginal parenchyma.

(Figure D) Spanish cedar tangential section showing multiseriate rays and inter-vessel pits.

Study of a Wax Mold: *Virgen del Carmen*

Maker: Tiburcio de la Espada (1798-1852)

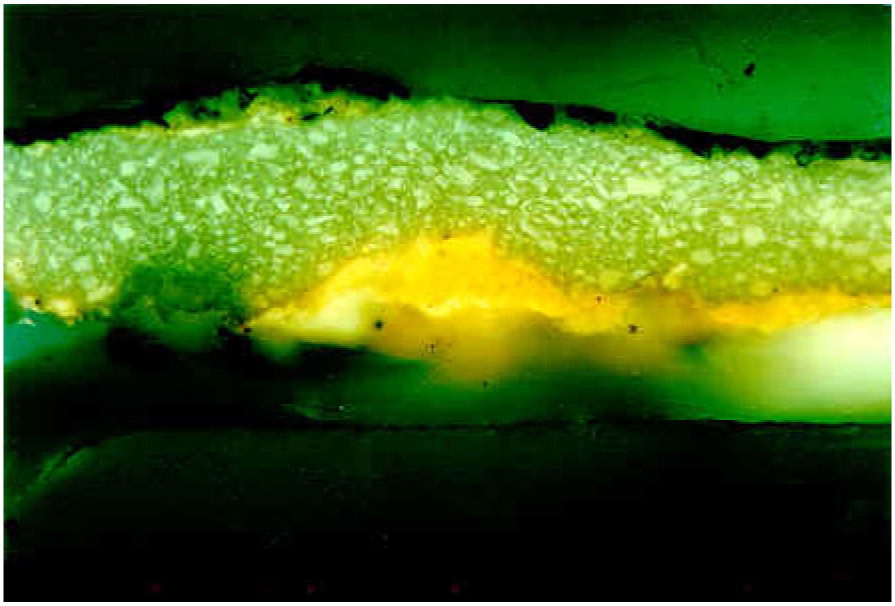
Description: *Virgen del Carmen* (*Virgin of Mt. Carmel*) is holding a child and a book in her left arm, while her right arm reaches outward. She is wearing a blue-green robe with a white cape, and a crown is not present (Figure E).

The *Virgen*'s face and the child's face are made of wax. The wax, mixed with chalk, is dense, not porous like wood and appears dark in the xeroradiograph (Figure F). The presence of wax was confirmed by SEM-EDS and the optical microscope with UV-VIS light (Figure G). The paint cross-section taken from flesh near the neck of the *Virgen* indicated that underneath the white paint is wax mixed with calcium sulfate.

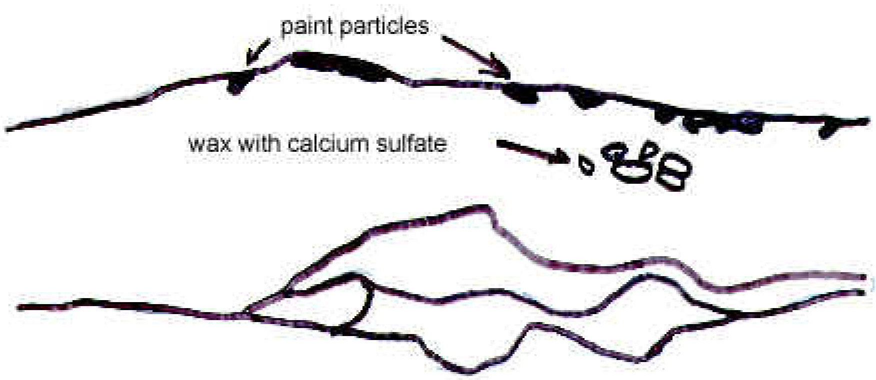
The chemical analysis of this wax layer by GC-MS indicates that the major component is a waxy substance with a minor component of rosin.

(Figure E) *Virgen del Carmen*

(Figure F) Xeroradiograph of *Virgen del Carmen*. The *Virgen*'s face and the child are made of wax and appear dark. The xeroradiograph reveals how the stand is attached to the statue with nails.



(Figure G) Optical microscopy cross-section of wax component from *Virgen del Carmen*, ultra-violet illumination at 200x.



Xeroradiography: *Virgen de Monserrate*

Xeroradiography, one method of recording X-ray images described above, was used in the examination of the *Virgen de Monserrate*. The denser elements appear darker in this xeroradiograph (Figure H). For example, lead white, a pigment on the *Virgen*'s face, is a dense substance and appears dark in ghe xeroradiograph. Lead white has been used in paintings sincce antiquity, but is not used by artists today. The *Virgen*'s face and child are made of wax, which also appear dark in this xeroradiograph. Other dense elements are the metal nails that were used to attach the base to the statue. They are visible and appear dark in the xeroradiography. The final print is exact in size (1:1 ratio) yet a mirror image of the object.

X-rays are useful in revealing structural information, losses, repairs and other changes that may not be visible to the naked eye.

(Figure H) Xeroradiograph of *Virgen de Monserrate*

Study of Paint Layers by UV-VIS Microscope and SEM-EDS: *Virgen de Monserrate*

Conservation scientists have been able to identify nearly all the pigments used in the history of painting, and we know that different pigments were used at different times. As a result, pigment identification can contribute to determining the date and origin of a particular painting.

A paint cross-section from the *Virgen*'s robe near the base is shown in this photograph (Figure I) taken through a microscope. A tiny sample of paint as small as the period (·) shown in this text was embedded in epoxy and polished to reveal the layers of paint.

In this sample (Figure I), there are at least 7 layers on top of a very thin gold layer. The top three layers are most recent. They contain zinc white, which is regularly found in oil paint after 1850. Puerto Rican *santos* often have various layers of paint, as repainting the figures during usage and worship is part of its history.

In Figure J, the same paint cross-section is examined under the SEM-EDS. The SEM image is always in black and white. Each corresponding paint layer is cross-referenced and double checked with the optical microscope.

(Figure I) UV-VIS Microscope of *Virgen de Monserrate*

(Figure J) SEM image of *Virgen de Monserrate*

6. ***Santa Ana*** **- the Oldest Surviving** ***Santo***

Maker: Unknown
Date: 17th Century

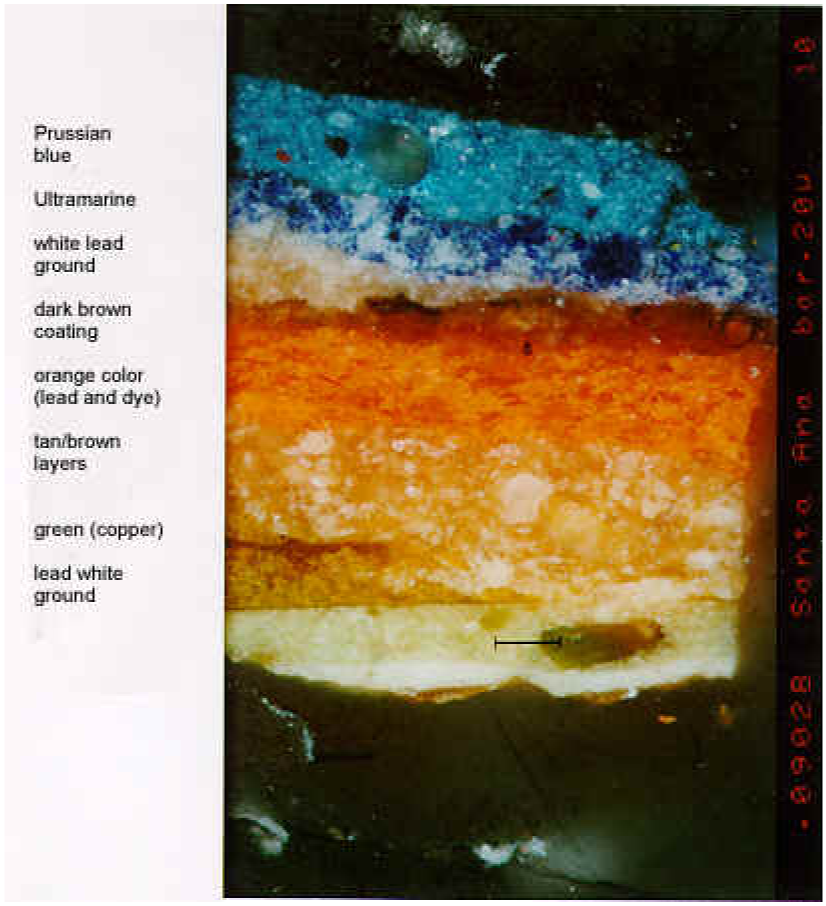
Description: *Santa Ana* is the oldest known surviving *santo* from Puerto Rico. *Santa Ana* is seated holding two small saints on her lap with her proper left arm; her proper right arm rests on the arm of the seat (Figures K and L). The faces of the two smaller saints are missing and there are gouges made with sharp tools on the flat surface - the back of the face (Figure M). The front of the faces of the two saints were not carved from the same piece of wood but were added on. There is no evidence of holes that are commonly seen with insertion of a wooden dowel; it is likely that molded wax, now missing, was used for the fronts of the faces and that the scratches were necessary to ensure that the wax stuck to the flat wooden surface. Dirt and patterns of how the dirt settled in the sculpture indicated that the *santo* was buried in the earth at some point in its life. Underneath these layers of dirt, the paint layers are still in good condition.

A small paint chip was taken from the blue robe near the proper left arm. The cross-section was examined under the microscope with ultraviolet and visible illumination and with SEM-EDS. The paint cross-section (Figure N) indicates the complexity of the paint layer underneath the first layer of blue paint that contains natural ultramarine. Natural ultramarine was a costly material, in a class with gold as a symbol of luxury. On top of the first layer of blue there is a second layer of blue that contains Prussian blue. Prussian blue was commercially produced after 1706.

(Figure K) Unknown artist, *Santa Ana*, overview from the front.

(Figure L) Xeroradiograph of *Santa Ana*, indicating the fabrication from one piece of wood.

(Figure M) Detail from *Santa Ana* showing the missing faces from the two smaller saints. Note the grooves on the surfaces.



(Figure N) Paint cross-section from *Santa Ana*'s blue robe.

7. *Virgen de Monserrate*

Maker: Tiburcio de la Espada (1798-1852)
Date: circa 19th Century

Description: The *Virgen* (molded wax head) is seated holding a globe in her proper right hand (replacement); the proper left hand (replacement) is pointed at the Child; the Child (entirely molded wax) is seated on the lap of the *Virgen*. The *Virgen*'s face was cleaned and repainted in the past, the child is in excellent condition with fine crackles from drying at the juncture of paint and wax. Originally, the border of the white cape and the robe were gilded (Figures O and P). The blue robe's first blue layer contains artificial ultramarine and the modern blue repaints contain zinc white. The red robe is layered with red lake and vermillion.

Binder analysis by GC-MS indicates the presence of drying oil.

(Figure O) *Virgen de Monserrate* overall picture, before treatment.

(Figure P) *Virgen de Monserrate* overall picture, after treatment
(See Preservation and Restoration: An Example)

8. Two Images of *San Jose* - The Same Maker but Different Histories

San Jose (1)

Maker: Felipe de la Espada (1754-1818)
Date: late 18th Century

Description: This *San Jose* has fewer repaintings; carving marks are still visible especially in the face (Figure Q); the attribute - a cane with painted flowers - is made of silver. The *santo* is nailed to the stand (Figure R). This *santo* is almost identical in size, in pose, and especially in the angle of the slightly tilted head (Figure S) to the other one by the same artist (Figure T).

(Figures Q and R) Overall photograph and detail of *San Jose* #1.

(Figure S) Xeroradiograph of *San Jose* #1.

(Figure T) Xeroradiograph of *San Jose* #2.

(Figures U and V) Overall photograph and detail of *San Jose* #2.

***San Jose* (2)**

Maker: Felipe de la Espada (1754-1818)
Date: circa 18th Century

Description: This *santo* has been repainted multiple times (Figure U). In comparison with the other San Jose listed above, the repaints on the face make this San Jose look very different (Figure V), even though they were made by the same artist and appear almost identical in the xeroradiographs (Figures S and T).

9. *Santa Rosalia* - A *Santo* of Distinction

Maker: Unknown
Date: unknown

Description: This *santo* is larger than most *santos* in the Vidal Collection (Figure W). From the construction, it is possible that this *santo* could be further decorated and used in the processions on the feast days (Figure X). The dress is thinly painted. The garland, a more noticeable part of the *santo* is covered with much thicker repaints. Upon closer examination of the paint samples, there is evidence that the garland has been gilded once in the past. The wood is *Cedrela*, a Spanish cedar, the most popular wood for *santos* of Puerto Rico.

(Figure W) *Santa Rosalia* overall photograph.

(Figure X) Xeroradiograpy of *Santa Rosalia*.

10. *San Blas* - A Modern *Santo*

Maker: Roberto Rivera (great-great grandson of Genero Rivera)
Date: 1985

Description: This *santo* was made in Coroza, Puerto Rico. The *santo* is about 5" in height (Figure Y), and has no repaint. This can be seen in the paint cross section taken from the undercut of the red cape (Figure Z). A white ground was used as gesso on the wood and the paint was applied over the gesso. The carving and chisel marks are easily visible.

(Figure Y) Overall photograph of *San Blas*.

(Figure Z) Cross-section from the undercut of the red cape.

11. Care and Preservation of *Santos*

All finished art works are vulnerable to gradual decay, even those made skillfully and properly using high quality materials. Recognizing the causes and consequences of deterioration for the materials used in the creation of *santos* allows us to follow an informed strategy of care and preservation.

Wood

The climate in Puerto Rico lends itself to special concerns for insect damage. Wood is the food source for insects such as termites that can bore tunnels through the wood. The tunnels can be seen in xeroradiographs. If insect infestation is not remedied eventually the *santo* will be damaged and ultimately destroyed. Since insect infestation can spread throughout an entire collection, close initial inspection and constant vigilance are important. Display and storage areas should be kept clean and free of dust. Fresh wood powder, called frass, coming out of the exit holes is a good indication that there is an active infestation. The first thing to do is to isolate the object. Consult a professional conservator for advice or a professional fumigation service if the damage is extensive and ongoing.

Repaint

As part of religious practice, it is common to have a *santo* "repainted" on the evening before the feast day. *Santos* are also repainted as thanksgiving for good fortune. Layers of repaint were found on most of the *santos* that we have studied. There is a trend to have the repaint removed to reveal the "original" layers. This practice of "chipping away" the repaint has caused concern and started vigorous debates among collectors, restorers, cultural institutions, and religious institutions. From our technical study, it is apparent that layers of repaint are not always evenly applied throughout the whole sculpture. For example, on a typical *santo* the face tends to get "cleaned" or "repainted" more often than areas such as the back of the sculpture or the feet. Cloaks will be painted entirely different colors and sometimes paint will cover the gilding. Various materials were used for the repaint. There is evidence of casein, water soluble matte paint, and sometimes oil paint used in the repainting. It is difficult to remove the repaint evenly without inflicting some damage to the original. In addition, it would take a large amount of "personal interpretation" or "personal opinion" and many subjective judgments on the part of the restorer in removing repaint. It also raises the issue of "who is the most qualified to decide which layer of the history of the *santo* should be removed?"

Cleaning

Cleaning is a delicate, irreversible procedure using abrasives, water and detergents, organic solvents and other chemicals to remove unwanted accretions such as grime or discolored varnish, etc. from the surface. Chemicals, such as acids or bases, often used by restorers can destroy the color of the paint. Ultramarine can be decomposed by dilute acid, even with a weak acid such as acetic acid (vinegar). This will cause the loss of blue color. This sensitivity to acid is the source of the so called "ultramarine sickness." Azurite, another common traditional blue pigment, is soluble in acid and van be blackened by heat and warm bases. Traditional red lake is sensitive to solvents such as alcohol. Generally, the risk of cleaning is higher when information on the materials and techniques of the *santo* is not available.

Temperature and Relative Humidity

The rule of thumb is that the speed of a chemical reaction will double when the temperature increases about 20°F (11.2°C). In great part, deterioration is a chemical process.

Humidity refers to the water vapor content in the air and relative humidity refers to the amount of water vapor content in air relative to the maximum equilibrium water vapor content possible for the air at a given temperature. In a tropical climate, the relative humidity typically is higher than in a cooler northern climate. High relative humidity encourages pests and growth of microorganisms such as fungi.

In addition, humidity and temperature have other effects on wood. Temperature and relative humidity have an interrelation that is roughly inverse. As the temperature goes up, the humidity goes down for a specific volume of air (assuming no other changes), and vice versa. As humidity goes up and down, the moisture content of the wood changes and causes change in the dimensions of the wood and can cause the wood to split.

Large changes in temperature (10 to 20° F [5.6-11.2°C]) will affect the dimensions of *santos* due to the expansion or contraction of wood as the moisture content changes. When a wooden object is moved from high relative humidity to low relative humidity, contraction in the wood can cause the surface paint to flake off. The key to avoiding this type of damage is slowing down the changes and gradually lowering the relative humidity. Sudden and drastic changes in temperature and relative humidity are a serious problem with wooden *santos*.

Preservation and Restoration: An Example

In preparation for exhibition the *Virgen de Monserrate* underwent minor conservation treatment based on the considerations mentioned in this section. A brief summary of that process is:

- Removed surface dirt with deionized water on cotton swabs.
- Consolidated loose repaints, filled most noticeable paint losses and inpainted with pigments ground in non-yellowing synthetic resin (Polyvinyl Acetate AYAC)
- Another synthetic resin (MS2A) was used as a varnish to even the gloss of the repaints and inpaints. The *Virgen*'s face and the Child were left untouched. Most of the inpainting was on the white cape.
- The border of the cape and robe were regilded with gold leaf using oil gilding.

12. Selected Bibliography

Bomford, David. *Italian Painting before 1400*, (exhibition catalog). London: National Gallery, 1989.

Carr, Dawson W. and Leonard, Mark. *Looking at Paintings: A Guide of Technical Terms*. Malibu, CA and London: The J. Paul Getty Museum in association with The British Museum Press, 1992.

Gettens, Rutherford J., and Stout, George L. *Painting Materials: A Short Encyclopedia*. New York: Dover, 1966.

Hedley, Gerry. *Measured Opinions: Collected Papers on the Conservation of Paintings*, edited by Caroline Villers. London: United Kingdom Institute for Conservation, 1993.

Lange, Yvonne. *Santos: The Household Wooden Saints of Puerto Rico*. PhD dissertation, University of Pennsylvania, 1975.

Steele, Thomas J. *Santos and Saints: The Religious Folk Art of Hispanic New Mexico*. Santa Fe, NM: Ancient City Press, revised edition, 1994.

Van Schoute, Roger and Veroustraete-Marcq, Hélène, editors. *Scientific Examination of Easel Paintings*, Journal of the European Study Group on Physical, Chemical and Mathematical Techniques Applied to Archaeology, PACT, 1986.

Veliz, Zahira, editor and translator. *Artists' Techniques and Golden Age Spain: Six Treatises in Translation*. Cambridge and New York: Yale University Press, 1986.

Vidal, Teodoro. *Los Espada: Escultores Sangermeños*. Princeton: Polychrome Press, 1994.

Xeroradiographic image of *Virgen de Monserrate*. Xeroradiograph by Camie Thompson.