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Identification and Classification of Colorants Used During Mexico's Early Colonial Period

Six important hand-drawn maps from the Benson Latin American Collection at the University of Texas at Austin underwent treatment at the University's Preservation and Conservation Studies laboratories in the spring of 1996. These objects, from a group of maps and manuscripts known as the *Relaciones Geográficas*, were created for Philip II of Spain between 1578 and 1585 as part of a survey of New Spain (Mexico), Central America, South America, and the Spanish West Indies. The *Relaciones Geográficas* were produced in Mexico's Early Colonial Period (ca. 1521-1600). Manuscripts from this transitional period merge native (i.e. Mixtec, Aztec, Zapotec) and European pictorial and design elements. The author initially assumed that the colorants on these six maps, like the pictorial elements, would combine native and European technologies. Twenty-two colorants were sampled and analyzed by polarized light microscopy. This paper will identify the samples and compare them to documented colorants from the Mexican Early Colonial Period. An inventory of known colorants from this period and region is provided.

INTRODUCTION

Prior to the arrival of the Spanish, native Mexican cultures enjoyed a rich technological history. These various cultures made paper, books, and pigments, painted murals and manuscripts, erected elaborate sculpture and architecture, cultivated crops and botanical gardens, and engaged in medical practice. The Mexican Early Colonial Period (ca. 1521-1600) immediately followed the Spanish invasion of Mexico. It was a time of rapid change during which "the outward signs and formal apparatus of Mexican native societies disappeared before the proselytizing energy of Catholicism and the superior technology of Renaissance Europe." Christianity quickly supplanted the various indigenous Mexican religions, and within a short time most native technologies either assimilated European technologies or were supplanted by them. Native architecture and sculpture were rapidly and systematically destroyed by the Spanish in an attempt to eliminate any connection with Mexico's "pagan past." Donald Robertson observes that "only in the fragile medium of the manuscript painter did the vocabulary of form and artistic conventions of the old civilization and proscribed religion survive, changing continually under the impact of the new European ways" (Robertson 1994). Given this observation, it seemed reasonable to believe that manuscripts created by native painters in sixteenth-century Mexico may clearly reflect the combination of indigenous and European pictorial elements and technologies.

RELACIONES GEOGRAFICAS: HISTORY AND PROVENANCE

The *Relaciones Geográficas* (RG) are a group of maps and manuscripts created during the Early Colonial Period in response to a questionnaire developed for Philip II of Spain to survey the diverse regions of New Spain (Mexico), Central America, South America, and the Spanish West Indies during the years 1578-1585. The questions sought information including political jurisdiction, terrain, language affiliation, native traditions, plant names, and mineral sources. In addition to the survey questions a map of each region, called a "pintura" (painting, picture), was required (Cline 1972).

The questionnaire was widely distributed to Spanish officials and priests in various regions of the newly founded Spanish colonies. These officials and priests supervised the replies to the questionnaire, which often included maps made by native painters. The RG maps vary in graphic style from native, or pre-Columbian, to European Renaissance characteristics. Many of the maps show neither predominately indigenous nor European influences, but a blending of both artistic styles. Donald Robertson aptly summarizes the significance of the *Relaciones Geográficas* as "primary sources for the study of the acculturation of native artists during the first 60 years after the Conquest. The pinturas are thus a measure of the strength of European penetration into the native life of even small and remote villages of their time" (Robertson 1972).

Howard Cline estimates that of the 283 *Relaciones Geográficas* items recorded for New Spain, including texts and maps, 243 are extant (Cline 1972). RG collections currently exist in three institutions including the Benson Latin American Collection of the University of Texas at Austin, the Real Academia de la Historia in Madrid, and the Archivo General de Indias in Sevilla. After their arrival in Spain in 1583, the *Relaciones Geográficas* were relocated several times. In 1787 the Archivo General de Indias in Sevilla obtained 80 texts and 22 maps (197). Cline indicates that nearly half of the RG's were lost between 1783-1853. In 1853 a portion of the lost manuscripts were purchased by Juaquín García Icazbalceta, and were moved from Spain to Mexico. Luis García Pimentel inherited the book and manuscript collection of Icazbalceta, his father, in 1894. In 1937 the family sold the collection, including the *Relaciones Geográficas*, to the University of Texas at Austin (199-200). Presently, UT-Austin's Benson Latin American Collection houses 43 manuscripts and 37 RG maps. The Real Academia de la Historia in Madrid acquired approximately 46 of the aforementioned lost manuscripts in 1863 (200).

SELECTION FOR CONSERVATION TREATMENT

Given the historical importance and artifactual value of the *Relaciones Geográficas*, the Benson Latin American Collection considers the stabilization of these maps and manuscripts a priority. In recent years, several items in this collection have been stabilized by UT-Austin's Harry Ransom Humanities Research Center and by Carrabba Conservation, Inc. In Spring 1996, six additional maps underwent conservation treatment in the Preservation and Conservation Studies (PCS) laboratories at the University of Texas at Austin. All of the maps are hand-drawn in water-based paints and inks on hand-made rag paper. The six maps exhibited old repairs, various adhesives, tears, and losses. Conservation treatment removed paper tapes, reduced adhesives, mended torn and weak areas, and filled areas of loss. The media of one map, Ameca, were consolidated with gelatin.

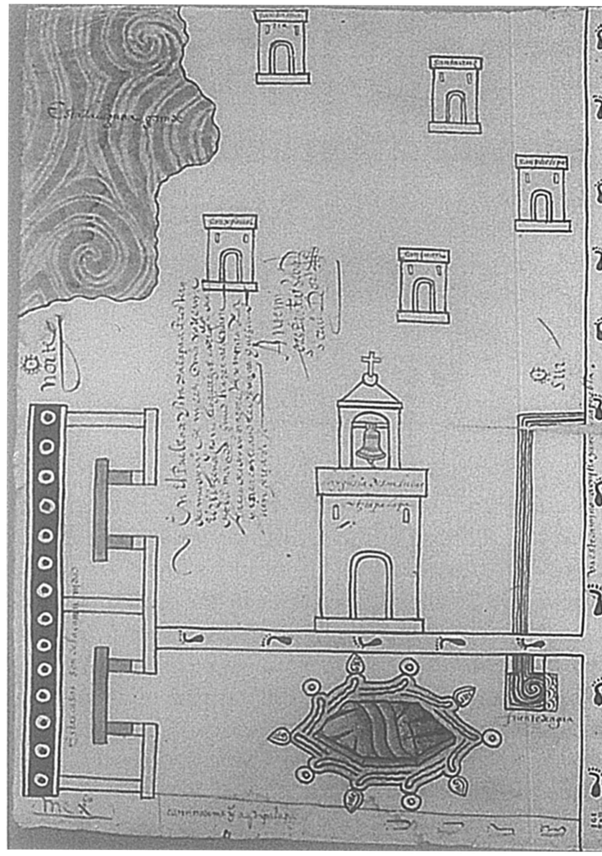

Fig. 1. The *Relación Geográfica* map of Ixtapalapa, 1580. Note a prominent indigenous artistic convention of indicating paths with hand-drawn feet. Watercolor and ink on paper, 43 x 31 cm, the Benson Latin American Collection, the General Libraries, the University of Texas at Austin (JGI xxxiv-8)

The presence of the six *Relaciones Geográficas* maps in the PCS laboratories revealed how little was known about their materials. The treatment of the maps presented an oppor-

MAP	GEOGRAPHIC LOCATION	INDIGENOUS CULTURAL INFLUENCES
Ameca (1579)	Jalisco state in western Mexico	Aztec
Atlatlauca (1580)	Mexico state in central Mexico	Aztec
Cholula (1581)	Puebla state in central Mexico	Aztec
Ixtapalapa (1580)	Mexico state in central Mexico	Aztec
Meztitlan (1579)	Hidalgo state in central Mexico	Aztec
Tehuantepec (1580)	Oaxaca state in southern Mexico	Mixtec, Zapotec

Table 1. Geographic Location and Indigenous Cultural Influences

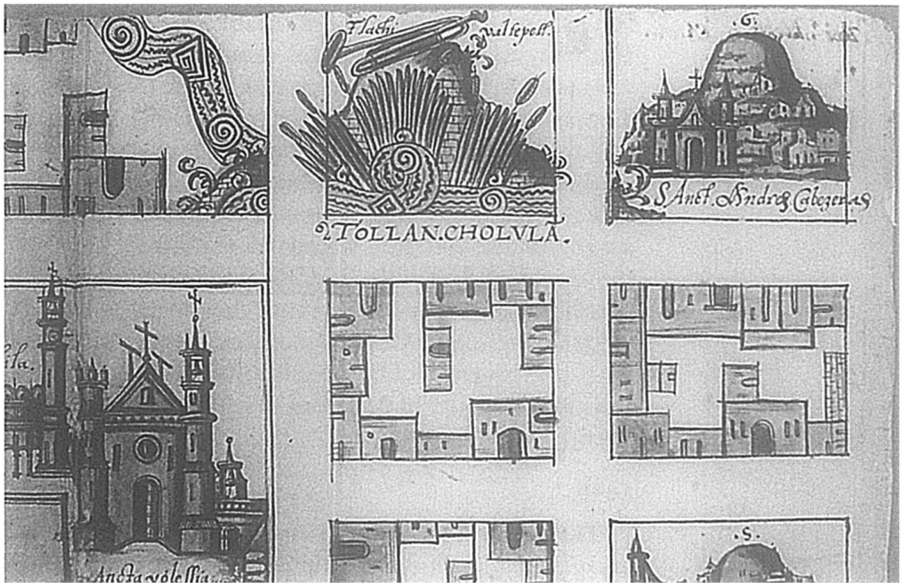

Fig. 2. Detail of the *Relación Geográfica* map of Cholula, 1581, showing the mixture of indigenous and European artistic elements. Watercolor and ink on paper, map dimensions 31 x 44 cm, the Benson Latin American Collection, the General Libraries, the University of Texas at Austin (JGI xxiv-1).

tunity to do colorant analysis in an effort to determine the history and manufacture of these artifacts.

SOURCES

The six maps treated at the PCS laboratories represent a broad geographic and cultural sample. The group includes *Ameca, Atlatlauca, Cholula, Ixtapalapa* (fig. 1), *Meztitlan, and Tehuantepec*. Various indigenous cultures resided in all areas of Mexico, but by 1500 the Aztecs controlled central Mexico, and much of eastern Mexico along the Gulf and western Mexico along the Pacific. Around 1500 the Aztecs embarked on a campaign to conquer Tehuantepec, a large trading center in Oaxaca, but they did not succeed before the Spanish arrived in 1519 (Gruzinski 1992). Table 1 summarizes the location and indigenous cultural influences of each map.

The *Relaciones Geográficas* are typical of Early Colonial Mexican manuscripts in that the native practice of stylized or iconographic representations of objects is often combined with the European convention of depicting objects as they appear in nature. In addition, many of the maps combine varied perspectives (individual objects pointing in different directions), a uniform line for outlining areas of color and making patterns, and flat washes of color that characterize indigenous Mexican design with the European use of a unified perspective (individual objects pointing in a single direction comprising a focused composition), a varied line for outlining contours of rounded shapes and shading to convey mass, and modulated application of color for accentuating form (Robertson 1972). In the map *Cholula* note the indigenous artistic influence in the areas of houses that are stylized, two-dimensional and pointing in different directions, delineated with a unified line, and painted with flat washes of color compared with the European artistic convention in the block with the cathedral and mountain that are naturally rendered, three-dimensional and pointing in the same direction, incorporating a varying line for outlining and shading, and painted with a modulating application of color for accentuating forms (fig. 2). With the exception of *Meztitlan* which seems wholly European influenced (fig. 3), the maps combine native and European artistic styles in varying degrees. The glosses of five of the maps are in Spanish; *Cholula* contains Spanish and Nahuatl glosses. Indigenous logographic place-names are included on *Cholula, Ixtapalapa, and Tehuantepec*. The name

Fig. 3. Detail of the *Relación Geográfica* map of Meztitlan, 1579, showing the European Renaissance artistic convention of forms rendered naturally. Watercolor and ink on paper, map dimensions 42.5 x 58 cm, the Benson Latin American Collection, the General Libraries, the University of Texas at Austin (JGI xxiv-12).

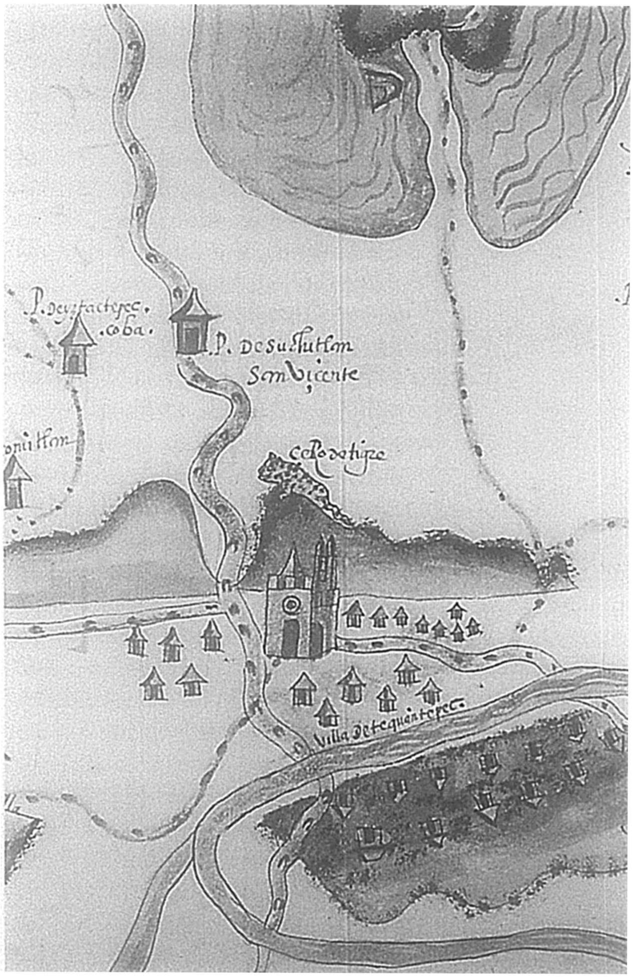

Fig. 4. Detail of the *Relación Geográfica* map of Tehuantepec, 1580, showing township of Tehuantepec written pictographically with a jaguar sitting atop a hill. Watercolor and ink on paper, map dimensions 56 x 42.5 cm, the Benson Latin American Collection, the General Libraries, the University of Texas at Austin (JGI xxv-4).

Tehuantepec is pictographically written in the center of the map with the figure of a jaguar atop a hill; in the Aztec language Nahuatl, "Tehuantepec" translates as "hill of the jaguar" (fig. 4) (Mundy 1996).

MATERIALS

Paper Supports

The supports of all six maps are laid rag paper, possibly Spanish-made, and the dimensions range from 31 x 42 cm to 42 x 58 cm. *Ameca, Atlatlauca, Cholula*, and *Ixtapalapa* share similar watermarks of pilgrims. These watermarks were common in the 16th-century in Spain, Italy, and France. It is likely that the pilgrim watermark originated in the Catalan region of Spain since the earliest example of this watermark (ca. 1500) is located in the Catalan archives. The watermark of *Tehuantepec* is a mermaid. Mermaid watermarks were common in France, Italy, Spain, and Germany in the 15th and 16th centuries, and probably originated in the Provence region of France (Subria 1970). The paper support of *Meztitlan* has no watermark. The first mill for making rag paper in the European tradition was established in 1575 in Culhuacan near Mexico City (Hunter 1978). The paper from the Culhuacan mill lacked a recognizable European watermark (Mundy 1996). Since the township of Meztitlan is relatively near Culhuacan, it is possible that the paper support of the *Meztitlan* map was manufactured at the Culhuacan mill; it is also possible that the paper support is of European manufacture. Regardless, the paper support of *Meztitlan* is rag paper made in the European tradition.

Media

The media of all six maps are water-based paints and inks. Colors include red, orange, yellow, blue, green, brown, black, and white; these vary in hue. The range of color is similar on all six maps. No map contains more than seven colors, including ink. Donald Robertson's *The Pinturas (Maps) of the Relaciones Geográficas, With a Catalog* is the only source which discusses their media. Robertson indicates that much is known about the supports (European rag paper, amatl paper), but "pigments and inks permit less clear-cut statements, since less is known about them" (Robertson 1972).

METHODOLOGY AND PURPOSE

Laura Gutiérrez-Witt, Head Librarian for the Benson Latin American Collection, generously granted permission to remove small colorant samples from the six maps. Twenty-two colorants were sampled. The maps contain more than twenty-two colors, but the media are thinly applied in many areas. Sampling was restricted to areas of heavy application. The colorants sampled from the *Relaciones Geográficas* are likely typical of the sixteenth-century Mexican palette. The purpose of this paper is to identify these colorants and to provide a general overview of colorants used in sixteenth-century Mexico.

ANALYSIS OF COLORANT SAMPLES

The colorant samples were analyzed under 10x and 25x magnification by transmitted and polarized light using a Leitz Laborlux 11 POL microscope in the Painting Conservation laboratory at UT-Austin's Huntington Art Gallery. The samples were compared to McCrone colorant standards and Sara McElroy's standards (Painting Conservator, Huntington Art Gallery), and several were identified. Microscopically, the samples range from 0.007 to 0.02 millimeters. This paper will describe the identification of individual colorants sampled from the maps. Table

2 summarizes the color of the media, the identification of colorants, the optical characteristics of the colorants, and the maps from which they were sampled.

Cochineal

Three red samples were removed from *Ameca, Atlatlauca*, and *Cholula* and were identified as cochineal. According to Helmut Schweppe and Heinz Roosen-Runge the optical characteristics of cochineal include red particles that are translucent, granular, and isotropic (Schweppe and Roosen-Runge 1986). In transmitted light the red particles of the samples appear bright, cool red, translucent, and granular. In polarized light the particles are isotropic, exhibiting the same physical properties in every direction as the microscope stage is rotated.

Red Lead

The other red particles in the yellow-orange colorant sample from *Meztitlan* were identified as red lead. In transmitted light the red particles are orange in color. In polarized light these particles exhibit "blue-green interference colors" which Elizabeth West Fitzhugh indicates is characteristic of red lead (Fitzhugh 1986).

Maya Blue

Seven green, blue, and blue-green colorants were sampled from *Ameca, Atlatlauca, Ixtapalapa, Meztitlan*, and *Tehuantepec*, and all were identified as Maya blue. In transmitted light the colorant samples are bright green-blue in color and translucent. In polarized light the colorant samples are pleochroic, appearing blue in one direction and pink in another (pleochroism refers to the color change of particles in polarized light as the microscope stage is rotated). Gettens and Stout describe Maya blue as blue in one direction and yellow in the other (Gettens and Stout 1966), but close microscopic examination of the Maya blue standard revealed a strong pleochroism from blue to pink in crossed polars. Given the blue to pink pleochroism of all seven colorant samples, the samples were identified as Maya blue.

Green Earth

A yellow-green colorant sample from *Meztitlan* was identified as green earth. Microscopically the sample contains green particles of various shades and a scattering of yellow, clear, brown, and bright blue particles. The particles are pale, rounded, and translucent, with some exhibiting a grainy texture. In polarized light the particles

COLORANT IDENTIFIED	MAP FROM WHICH COLORANT WAS SAMPLED	COLOR OF MEDIA	OPTICAL CHARACTERISTICS OF THE COLORANT
Cochineal	*Ameca* *Atlatlauca* *Cholula*	Brownish-red Pinkish-red Pinkish-red	Translucent, granular, isotropic red particles
Red Lead	*Meztitlan*	Orange-yellow	Orange particles that exhibit blue-green interference colors in polarized light
Maya Blue	*Ameca* *Atlatlauca* *Ixtapalapa* *Meztitlan* *Tehuantepec*	Blue-green Blue Green Blue Dark green Blue Blue	Bright green-blue, translucent particles that are pleochroic from blue to pink in polarized light
Green Earth	*Meztitlan*	Yellow-green	Rounded, translucent green particles of various shades that are moderately birefringent in polarized light

Table 2. Summary of Identified Colorants

are moderately birefringent, or doubly refracting, blinking as the microscope stage is rotated. Carol Grissom describes the optical characteristics of green earth as "particles of various shades of green intermixed with traces of yellow and brown earths" that are rounded, translucent, and low to moderately birefringent in polarized light (Grissom 1986). In addition, Gettens and Stout indicate that green earth consists of clear and bright blue particles (Gettens and Stout 1966).

LITERATURE REVIEW

Before beginning the colorant analysis it was necessary conduct a thorough review of the literature to help guide the identification process. It was discovered that a considerable amount of information exists on sixteenth-century Mexican colorants, but that this information is widely scattered throughout disparate fields of study. This paper compiles the existing information into one source.

SOURCES

Two sixteenth-century sources were useful in researching Mexican colorants. The most complete work with descriptions of native colorants is the *Florentine Codex*, also known as *Historia General de las Cosas de Nueva España*. It is a three-volume encyclopedia of twelve books produced by Fray Bernardino de Sahagún in Tlatelolco, Mexico, 1575-1580. The Florentine Codex documents several colorants used by Aztec scribes, including names and descriptions, in the Aztec language, Nahuatl, and in Spanish. Charles E. Dibble and Arthur J.O. Anderson translated the Nahuatl descriptions of the *Florentine Codex* into English during the years 1950-1969. The second useful source for sixteenth-century Mexican colorants is the *Badianus Manuscript*, also known as the *Libellus de Medicinalibus Indorum Herbis* and the *Codex Barberini*. This work was produced by two Aztec scribes in 1552 at the Colegio de Santa Cruz in Tlatelolco, Mexico. Emily W. Emmart translated the work into English in 1940.

Both the *Florentine Codex* and the *Badianus Manuscript* provide the native names of sixteenth-century Mexican colorants in Nahuatl. Over one hundred native languages were spoken in Mexico when the Spanish arrived in the sixteenth century, but Nahuatl is the best known for several reasons (Gruzinski 1992). By the sixteenth century Nahuatl was the universal language of Mesoamerica. Nahuatl was an "established language of commerce, of political administration, a *lingua franca* for an enormous expanse of territory" (Harvey 1972). Because of the work of Fray Sahagún and other Christian clerics, many works were produced for the purpose of translating Nahuatl into Spanish (Williams 1990). This paper provides the indigenous names of colorants in Nahuatl unless otherwise nous names of colorants in Nahuatl unless otherwise specified.

CLASSIFICATION OF COLORANTS

Colorants are generally categorized as organic, inorganic, and synthetic. Organic colorants are compounds that contain carbon, hydrogen, oxygen, nitrogen, sulfur, and other elements. They are derived from vegetable or animal sources and include such examples as indigo and cochineal. In general, organic colorants are fugitive, especially with exposure to light (Gettens and Stout 1966). Inorganic colorants are manufactured from minerals and ores and include such colorants as yellow ochre, cinnabar, and green earth. For the most part, inorganic colorants are considered stable and permanent (121). Synthetic colorants are "made by processes of chemical synthesis from chemical elements or compounds," and may be organic, inorganic, or a combination. Synthetic colorants include alizarin crimson and Maya blue. Gettens and Stout indicate that synthetic colorants, such as verdigris, were manufactured in ancient times. The stability and permanence of synthetic colorants are variable (160).

This paper categorizes colorants as organic, inorganic, and composite (mixture of several colorants).

ORGANIC COLORANTS

Red and Orange Colorants

Annatto (*Bixa orellana*) is a red, light red, or yellow colorant made from the dried seeds of an evergreen shrub that grows in Mexico, Central America, and South America (Donkin 1977). The Aztecs called the red dyestuff "achiotl," and the Spanish referred to it as "achiote" (Emmart 1961). Annatto was used as a dye for fabrics, cosmetics, and food, and as a painting medium (Krochmal and Krochmal 1974). R.A. Donkin indicates that along with cochineal, annatto was a reddish-brown colorant commonly used for Mexican manuscript painting in the sixteenth century and before (Donkin 1977). It is still used as a dye component in cosmetics and foods. As with most organic colorants, annatto fades with exposure to light (Donkin 1974).

Cochineal (*Coccus cacti, Dactylopius coccus*) is a carmine red colorant made from the dried bodies of female insects. These insects are native to Mexico and North, Central, and South America (Schweppe and Roosen-Runge 1986), and are parasites of cacti belonging to the genera *Opuntia and Nopalea* (Donkin 1977). The Aztecs called the carmine red colorant "nocheztli;" the Spanish referred to it as "grana cochinilla" or "cochinilla." Cochineal was employed in a variety of uses: as a paint for manuscripts and decorative objects, as a dye for fabrics and textiles, as a coloring agent for cosmetics, and as a medicine. Today, cochineal is used as a coloring agent for medicines, foods, and cosmetics (Donkin 1977; Schweppe and Roosen-Runge 1986). Cochineal is susceptible to fading and color changes with prolonged exposure to light. In addition, it will change color when exposed to acids and alkalis (Schweppe and Roosen-Runge 1986).

In pre-Columbian times cochineal was cultivated for local use and trade in western and south-central Mexico (Donkin 1977). Arnold and Connie Krochmal indicate that "the Aztec leader, Montezuma, received some of his taxes in the form of cochineal" (Krochmal and Krochmal 1974). The Spanish discovered the brilliant red dyestuff not long after their arrival in Mexico in 1519 and "it is possible that samples of cochineal were among the first Mexican products to be shipped to Europe." Donkin suggests that cochineal became the third most valuable export product, below gold and silver. Until the late eighteenth century, it was mainly cultivated in central and southern Mexico and parts of Central America, especially Guatemala and Honduras. By the mid-nineteenth century the cultivation of cochineal spread to Peru, India, Java, and the Canary Islands (Donkin 1977).

Logwood (*Haematoxylum campechianum*) is a red dye made from the heartwood of a tree that grows in Mexico, Central America, and northern South America (Donkin 1977; Emmart 1961; Krochmal and Krochmal 1974). Paul Standley indicates that the *Haematoxylum brasiletto* tree is often confused with *Haematoxylum campechianum* tree, and in the area of commerce there is no distinction between the two. The use of dyestuffs from the two trees is identical (Standley 1967). Depending on the alkalinity or acidity of the logwood dyestuff preparation, the resulting colors include red, reddish-purple, purple, blue, or black. The Aztecs called the tree from which the logwood dyestuff was extracted "quamochitl," "huitzeuahuitl," and "uitzquauitl," while the Spanish referred to it as "brasil" (Emmart 1961). The term "brasil" should not be mistaken for the dye brazilwood. Harley states that "the word 'brasil' originally meant red, from the same root as the Latin 'rosa' " (Harley 1982). The logwood dyestuff was used for manufacturing writing inks and watercolors, and for dyeing fabrics and textiles (Gettens and Stout 1966; Krochmal and Krochmal 1974). As with cochineal and indigo, it was an important New World product that was exported to Europe. It is still used for dyeing fabrics (Ponting 1973). Logwood dye is fugitive to light; it is insoluble in water and alcohol, but changes color with exposure to acids (blood red) and alkalis (bluish violet) (Gettens and Stout 1966).

Yellow Colorants

Two organic yellows are mentioned in Sahagún's *Florentine Codex* and are described by Arie Wallert in *On Some Natural Organic Yellow Colorants in Aztec Codices: The Florentine Codex.* Their Aztec names are "çacatlaxcalli" or "zacatlaxcalli," and "xochipalli" (Sahagún 1963, book 11). No Spanish or common name is given.

"Zacatlaxcalli" ranges from light to bright yellow in hue. The colorant was obtained from the plant stems of various dodder species (*Cuscuta tinctoria, Cuscuta americana, Cuscuta odontolepis; Cassytha filiformis*) that grow in Mexico, North America, and Central America. Wallert emphasizes that "the plants taxonomy does not always seem to be clear, and there is some confusion in the literature concerning the differentiation in the *Cuscuta* and *Cassytha* species." He implies that different yellow hues result from various ages of the plants. "The younger stems appear greenish yellow, the older stems are an orangy yellow, and the oldest stems have a bright and strong orange colour. These differences in colour correspond with differences in composition during the life cycle of the plant" (Wallert 1995).

"Xochipalli" ranges in hue from yellow to orange-yellow. The colorant is derived from the petals of a flowering plant (*Cosmos sulphureus*) that grows in Mexico (Wallert 1995).

Both yellow colorants were used as painting mediums and dyes for fabrics, but "xochipalli" was used for medicinal purposes as well (Sahagún 1963, book 11; Wallert 1995). Donald and Dorothy Cordry state that the mustard yellow colorant "zacatlaxcalli" "was used in Mitla, Oaxaca, until about 1940 (Cordry and Cordry 1968).

Blue Colorants

Several blue colorants were manufactured from native Mexican plants. Indigo is a blue made from the leaves of the *Indigofera suffruticosa* plant that grows in Mexico, Central and South America (Torres 1988). The Aztecs called the blue colorant "xuiquilitl" whereas the Spanish referred to it as "azul de añil," or simply "añil." Indigo was used as a dye for fabrics and textiles, and as a cosmetic by the Aztecs (Emmart 1961). It is possible that the Aztec dark blue colorant "tlaceuilli" is the same as "xuiquilitl" since it is made from "the leaves of the *xuihquilitl pitzauac (Indigofera añil)*" (Sahagún 1963, book 11). *Indigofera añil* is the Old World species of indigo (Emmart 1961). The *Florentine Codex* indicates that "tlaceuilli" was made from the juice of the macerated leaves of an herb that Wallert has identified as *I. suffruticosa*, the New World species of indigo. "Tlaceuilli" was used as a painting medium and a dye (Sahagún 1963, book 11). Indigo also became a valuable New World export product and is still used as a dye for fabrics. It fades with exposure to light (Gettens and Stout 1966).

Another blue colorant, "texotli," is described in the *Florentine Codex* as varying in hue from light blue, blue, to green (Sahagún 1963, book 11). "Texotli" was made from the leaves or flowers of the matlalin plant whose taxonomy is unclear. Arthur J.O. Anderson suggests that the plant is

Indigofera suffruticosa, in which case the blue colorant is derived from the leaves (Anderson 1948). Luis Torres indicates that the plant is *Commelina celestis* , from which a blue is derived from the flowers. The "texotli" colorant, Torres says, was manufactured in western Mexico in the state of Michoacan (Torres 1988). The exact uses of "texotli" are unclear.

INORGANIC COLORANTS

Red and Orange Colorants

The *Florentine Codex* describes "tlavitl," a red colorant manufactured from the mineral red ochre (Sahagún 1963, book 11). Anderson indicates that the red colorant was used as a painting medium (Anderson 1948). Red ochre is an iron oxide red that is colored by anhydrous ferric oxide (Fe_2O_3). Gettens and Stout indicate that red ochre is stable, unaffected by light and dilute acids and alkalis, but that it can darken with exposure to heat (Gettens and Stout 1966).

Yellow Colorants

In the *Florentine Codex* a yellow colorant is described as being made from the grinding of a yellow stone (Sahagún 1963, book 11). Anderson states that the Aztec colorant "tecoçauitl" is yellow ochre. It was used as a painting and writing medium (Anderson 1948). Yellow ochre is colored by various forms of hydrous ferric oxide ($Fe_2O_3 \cdot nH_2O$), especially goethite. It is unaffected by light and dilute acids and alkalis (Gettens and Stout 1966).

White Colorants

The *Florentine Codex* describes an inorganic white colorant, chalk, that the Aztecs called "tetiçatl." The colorant was made from ground, heated limestone, and was used as a painting medium (Anderson 1948; Sahagún 1963, book 11). Chalk is manufactured from various forms of calcium carbonate ($CaCO_3$). It is stable when exposed to light, but deteriorates when exposed to acids. In addition, chalk can discolor alkali-sensitive colors (Gettens, Fitzhugh, and Feller 1993).

COMPOSITE COLORANTS

Blue Colorants

Maya blue is a bright blue, slightly green colorant that was manufactured in Mexico and Central America. It is a synthetic, and is a complex of an inorganic clay and an organic blue colorant. Most sources indicate that Maya blue is made from palygorskite, a white clay, that is dyed with indigo and heated. Some sources refer to the white clay base as attapulgite, which is a type of palygorskite (Gettens 1962; Arnold and Bohor 1975). Additional examination of Maya blue reveals the presence of other white clays including sepiolite and montmorillonite. Maya blue is a stable colorant that "is resistant to diluted mineral acids, alkalis, solvents, oxidants, reducing agents, moderate heat, and even biocorrosion" (José-Yacamám et al. 1996).

Maya blue was used as a painting medium for murals, ceramic objects, and manuscript illumination. Dean E. Arnold and Bruce F. Bohor state that in pre-Columbian times Maya blue was used exclusively for ceremonial purposes. They further indicate that the colorant was associated with sacrifice: "the human sacrificial victims and the stone altars on which they were laid were painted blue before their beating hearts were removed" (Arnold and Bohor 1975). Use of Maya blue extended from pre-Columbian times to the twentieth century in Mexico and the nineteenth century in Cuba (José-Yacamám et al. 1996).

Green Colorants

The *Florentine Codex* describes two green colorants, "iiappalli" and "quiltic" (Sahagún 1963, book 11). "Iiappalli" is dark green and "quiltic" is green or dark yellow (Anderson 1948; Sahagún 1963, book 11). Both greens are a mixture of blue and yellow colorants. Anderson says that "iiappalli" was made by mixing the leaves of an unidentified plant with a composite of the blue "texotli" (matlalin) and the yellow "zacatlaxcalli" (various dodder species). Similarly, he indicates that "quiltic" was a composite of "texotli" and "zacatlaxcalli" (Anderson 1948). The green colorants "iiappalli" and "quiltic" were most likely painting mediums. (Sahagún 1963, book 11).

CONCLUSION

Manuscripts created during Mexico's Early Colonial Period reflect a combination of indigenous and European artistic styles. At the outset of this project it was believed that colorants used on the six *Relaciones Geográficas* maps would also combine native and European colorants. Prior to the arrival of the Spanish, native Mexican painters manufactured an extensive variety of organic, inorganic, and composite colorants. Thus many colorants were available for the creation of manuscripts under Spanish supervision. In addition, the Spanish exploited the cultivation of certain native colorants, such as cochineal, indigo, and logwood, solely for export to Europe.

The literature review and colorant analyses have shown that certain colorants (cochineal, annatto, indigo, and Maya blue) were used and traded in various regions of Mexico before and after the arrival of the Spanish. The presence of cochineal, indigo, and Maya blue on several *Relaciones Geográficas* maps shows the abundance of these colorants and the widespread pattern of their use in Mexico during the sixteenth century. Inorganic colorants such as green earth and red lead, both of which were identified on the maps, are not widely documented in the historical literature as being indigenous Mexican colorants. Although the literature fails to mention these mineral colorants, they occur naturally in mineral deposits throughout Mexico (Panczner 1987). Since these inorganic colorants were manufactured in Europe in the sixteenth century and there is little support in the historical literature for their manufacture in Mexico, it cannot be claimed that all of the colorants of the six maps from the *Relaciones Geográficas* are strictly of indigenous origin. In the author's opinion, it is reasonable to believe that the colorants of the six maps are native given the presence of these minerals in Mexico and the manufacture of a variety of inorganic colorants by indigenous painters. In conclusion, this project has revealed that more research is needed on the identification and classification of colorants used during Mexico's Colonial Period.

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