PAINTING SYNCRETISM: A NON-DESTRUCTIVE ANALYSIS OF THE BADIANO CODEX

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ABSTRACT

The De la Cruz-Badiano Codex is a herbal medicine treatise, written in the year 1552 in the School for Indians of Santiago Tlatelolco, in the early Colonial period. The conception of the book combines both the European and Mexica cosmovision: it contains the descriptions and diagnosis of different illnesses, with the cures, recipes based in the use of Mexican flora, fauna and minerals.

The study of the Badiano Codex by means of Infrared reflectography, Ultraviolet imaging as well as non destructive in situ analytical techniques such as X-ray Fluorescence spectroscopy has given important information regarding the book´s materials and construction: the manuscript was written on Italian paper, different inks were used; the inscriptions are of iron gall ink for the general body of the text, a combination of minium, iron gall ink and a red colorant for the red titles. The margins of the book were done with minium, the depictions of plants, fauna and minerals were made with dyes and some inorganic pigments.

This book is an example of early Mexican society; it was done only thirty three years after the Spaniards landed to American soil. The mixture of the local and foreign traditions, material and technological knowledge contained in this small object condense the richness and complexity of the conquest.

Further comparative analyses of material standards using native colorants created for this purpose enables us to present a methodological protocol for the study and interpretation of these cultural objects.

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INTRODUCTION

The De la Cruz Badiano codex is a very unique manuscript because of its content, the context of its production, and its absence in historical records during the colonial period. It was found in the Vatican Library in 1929, and there are few previous notices of its existence [1]. In 1990 the Vatican returned the manuscript to the Mexican government. This herbal medicine treatise, written in 1552 at the College of Santa Cruz, Tlatelolco, Mexico, is considered the first botanical compendium written in America [2]. The difference between this document and others produced to satisfy the need of understanding the plants of the New World and its uses is that two Indians created and signed it.

The manuscript, also named *Libellus de medicinalibus indorum herbis* (Opuscule of the Indians medicinal herbs), compiles antique indigenous medical practices and depictions of Mexican plants. The authors were Martin de la Cruz, a traditional native physician and Juan Badiano, who translated it to Latin, a professor educated at the College of Santa Cruz for sons of Indian noblemen. The codex has been considered as the meeting of European science and native traditions. In spite of its true codex format and general concept, which follows the standard of occidental herbals, the illustrations of the plants have many “pictographic”

conventions, as they were used in pre-Hispanic manuscripts. Scholars had pointed out the iconographic Mexica style in some of its drawings [3].

The combination of the local and foreign traditions gave rise to a new and complex reality that incorporated dissimilar material and technological knowledge. This study focuses on the manuscript's drawings as a product of Indian painters with their particular choices in the use of materials and methods of painting a document created under the supervision of Franciscan friars, and commissioned by Francisco de Mendoza, son of the Viceroy Mendoza. Little is known of the painters, some specialists have proposed that Martin de la Cruz did the illustrations and that Juan Badiano was the scribe, others think that both of them collaborated, or it could be the result of any other of the Indians educated at the College. The understanding of the manufacture of the book can give more insight to the identity of the painters. There is a lack of understanding about the kind of materials used in Mexica manuscripts, very few pre-Hispanic codexes had been analyzed (most of them belong to European collections) and the results are difficult to interpret because there are few written sources. In contrast there is a better insight of painting practices in Medieval and Renaissance Europe because of its critical fortune, and also more documentation on treatises, contracts, etc. This contrast will work in our advantage in order to detect the native traits, materials, and differences from the occidental, as well as their "syncretism" understood as the attempt to reconcile dissimilar practices, to merge and analogize various originally disconnected traditions and thus assert an underlying unity that allowed their authors an inclusive approach.

Until the second half of 16th century native painting practices were maintained in New Spain because of its utility to the Spaniard government in the organization of the Colony and in the understanding of the territory and practices of the Mexica Empire (e.g. maps, lists of tributes, etc), and to the process of evangelization. From the material point of view, the discovery of Mexican dyes (e.g. cochineal, indigo, Campeche wood) and other colorant materials was stimulated by the Spaniards because of their economic importance, so it is very possible that indigenous materials were available at the time.

METHODOLOGY

Through an interdisciplinary non-destructive scientific analysis we aim to characterize the nature of the materials used in this particular object, which will provide more information on the painting resources, pigments, tools and procedures used at manuscript making in early colonial society. This manuscript is a very complex object, every page was painted in a different way; imaging recording by digital photography, examination under infrared (IR) reflectography and ultraviolet (UV) lighting were performed in the entire document in order to carry out a general examination and to have an accurate vision of possible combination of pigments and colorants. Afterwards, a general analysis was carried out by X-ray fluorescence in situ in order to determine the composition of inks and the identification of colors materials.

We used fluorescent tubes illumination daylight color temperature (Hanckok) and a Mac Beth spectrophotometer in order to measure color temperature at 5700K. All the photographs were taken with a digital camera Nikon D2x with and a 50 mm objective. IR reflectography was performed with a lead sulfide vidicon tube (Hammamatsu C2741) with a sensibility range from 400 to 1800 nm and led array lighting (940nm). IR images were obtained by a digital shot directly to the monitor. Limited UV examinations were carried out by low power lighting (8 W) at 365 nm and registered by digital photography. On the other hand, portable X-ray fluorescence (XRF) was performed with an equipment (SANDRA) developed at IF-UNAM [4]. Two sets of measurements were carried out by two different X-ray detectors (CZT and Si-

Pin) with a 75 W Mo X-ray tube. CZT detector is more suitable for pigments analysis while the Si-Pin detector may detect lighter elements. Measuring time was 90 s at 40 kV and 30 mA with a X-ray spot of 1 mm dia. About 600 hundreds measurements were done using both X-ray detectors.

RESULTS

Structure of the Manuscript

The Badiano Codex (Fig. 1) is divided in thirteen chapters, each related to ailments of a particular part of the body. Starting from the head, and moving towards the feet, the last chapters relate more to general diseases or causes of discontent, childbirth and children, and ends with the signs of a person who is about to die. It has an introductory text, an index, and a closing text. Both authors are referred in the first pages, but only Badiano's name appears on the last page. In the body of the document, each folio describes the remedy of an ailment and the illustration of one or more plants or trees used for its treatment. The images are arranged in the upper half of the document, in total there are 184 plant depictions unevenly distributed in 89 pages, each of them has its Nahuatl name in the upper part, and a subtitle below that indicates the disease treated in the page, both in a different tint of red than the margins.

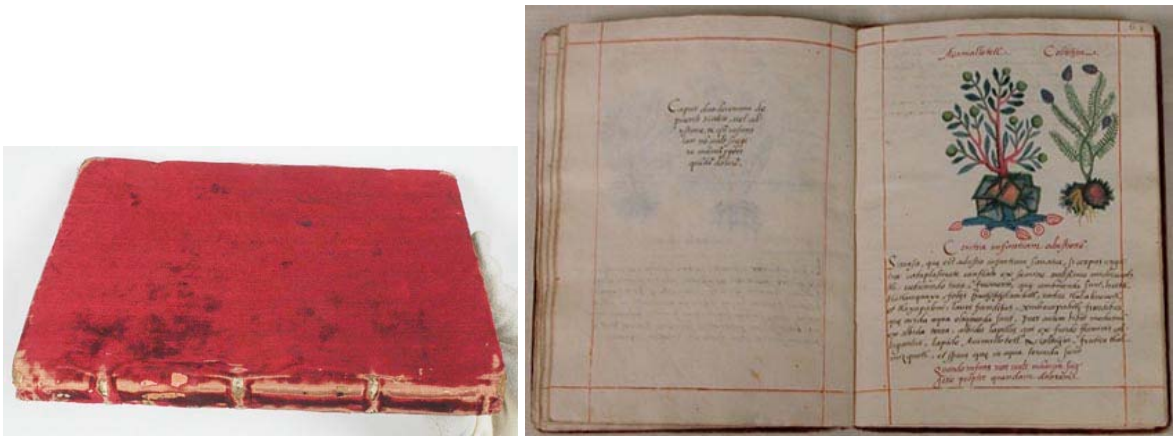

Figure 1. The Badiano Codex

The book is composed of folded sheets of linen paper, recognized because of its watermarks as of the Basili Acinelli mill on Genoa, Italy, a very common paper in early colonial New Spain [5]. The leaves were sewn in 8 quires or booklets, bound in red velvet with a six cords spine. The final dimensions are 15.2 x 20.6 x 2 cm and the edges of the sheets are gilded. It was foliated in the right upper corner with ink; the signature starts in the second leaf.

Many inconsistencies surround the process of making the book. The quires differ in number of sheets arranged, and also one of them has lost 1 leaf (Table I). Leaves must have been trimmed to accomplish gatherings of 24 pages. It is very possible that the binding was repaired at some time, because folio 6r was jointed facing inwards. But the signatures are complete and the contents of the book in each quire seem to be as they were supposed to, the first and last quires have a total amount of 19 pages with no information or reason. Six pages between the introduction and the first chapter's title were left in blank, and nine after the final text are also empty.

Gathering	Number of sheets	Chapters	Folios	Total amount of leaves	Number of pages
I	3	Introduction, index	Endsheet to 5v	6	12
II	6	I, II, III, IV, part of V	6r to 17v	12	24
III	4	Part of V, VI	18r to 25v	8	16
IV	5	VII, VIII	26r to 35v	10	20
V	5	Part of VIII, IX	36r to 45 v	10	20
VI	5 to the left 4 to the right (half of the sheet missing)	Part of IX, X	46r to 54v	9	18
VII	4	Part of X, XI, XII, XII	55r 62v	8	16
VIII	4	Final text	62v to the endsheet	8	15
Total	35		68	70	142

Table I. Quires or gathering

Pages were ruled with orange red lines, which delimited the writing area. These lines are not always perpendicular to the edges, and were placed irregularly. The separations range from 1 to 2 cm. Red rulings are absent in folio 23v. A detailed examination of the margin lines in each leaf show's the process of constructing the manuscript (Fig. 2): in 24 pages the illustrations were painted before the red margins were drawn, margins "skip" the places where the miniature was going to superimpose with them. In 103 pages the margin was traced prior to the depiction, the main figure may overlap with the borderline. On other examples one is able to see that the red subtitles were done prior to the ruling. The only constant pattern observed is that the margin lines always preceded the text, they were in fact used to help the calligrapher delimit the placement of the text, even though the text lines did not use any ruling.

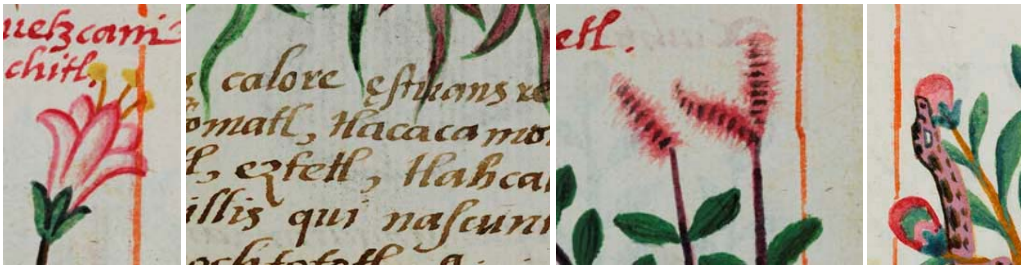

Figure. 2. a) Margin over drawing. b) Text superimposed on drawing.
c) Illustration over red margin. d) Margin interrupted, placed after drawing.

The widespread European practice in the production of late 15th century illustrated manuscripts was that the page was first ruled, then the text was written, and finally the painting of the miniatures was done in a collective effort, various artists working in series. Habitually, the binding of the booklets was the last process, performed by another specialist, so at this stage they could correct mistakes and avoid blank pages. The laborer's division of binders, calligraphers, and illuminators was well established [5]. In the Santiago Tlatelolco College students were educated on liberal arts, they spoke and wrote in Nahuatl, Spanish and Latin; writing included training in the creation of ornamental capitals, the manufacture of books, and illumination [6].

Simultaneity of the processes that would normally be done in a sequence of steps is evident on the Badiano Codex. This could mean that the manual labor was not divided in specializations because few people were involved on the manufacture of books, this was a school not a convent; or that the program for producing the book was not so accurate. The presence of blank pages with no apparent function between the first and last texts could be

explained if the manuscript had been bounded before initiating the ruling, writing and illuminating procedures.

The Illustrations: Materials and Technique

The depictions of a wide variety of plants was achieved in a delicate manner, each motif uses diverse shades of color, the use of different tools is observed through traces of brushes and quill pens. It is not easy to define a palette because a lot of pigment mixtures were used. It is also evident that the nature of colors varies; some have a transparent quality, while others have a strong hiding power and appear opaque.

Contour and Shading

Some of the main differences between the western and native painting traditions are: 1) Illusion of three dimension obtained through shading in European illuminations, 2) Use of regular outlines in Mexican manuscripts, while the use of line values or no lines in the West, 3) Color laid in flat in pre-Hispanic manuscripts, modulation of color in Europe, 4) Pictographic representation in Mesoamerican codices, while reproduction of a model in nature in others [7]. In Badiano Codex, both strategies are used, there are pictographic representations of stones painted with regular outlines and flat colors, but also shading, line value, and three dimensional depictions of that same pictogram.

It is impossible to detail in this space all the diverse painting resources used by the Badiano illuminators. The *Huizquilitl* example on folio 8v (Fig. 3) gives a good example of the use of these concepts: with exception of the roots, no contour lines were applied, the depiction of maguey leaves was achieved with delicate green and purple washes, a more pictorial shading technique than those in folios 41r and 32r where, even though there is some shading with black transparencies, the basic construction of the forms was done with black outlines. Yet, a comparison with the depiction of a maguey plant in folio 6 of the Codex Borbonicus shows that the three depictions in Badiano denote volume.

Figure 3. a) Huizquilitl representations in folios 41r, 32r and 8v,
b) Mayahuel emerging from a maguey plant in Codex Borbonicus.

The use of a preliminary drawing with graphite or a carbon ink has been detected with infrared reflectography in very few particular. On other illustrations an iron gall ink and a quill pen are used to make the general forms of some of the parts of a plant (the leaves or flowers), but never of the complete composition. More “calligraphic” designs, based in the change of colors, also with vivid contour lines, contrasting with the color of the object can also be seen (Fig. 4).

Figure 4. a) Tetl (stone) pictographic convention, b) Contour lines, c) Carbon ink of previous drawing

Color: Elemental Composition, Mixtures, and Palette

In order to interpret the IR and UV images of the codex, a comparison with reference of pigments, colorants, inks and other materials commonly used in manuscripts and illuminations was fundamental. Reference standards were prepared on 100% cotton paper with carboxymethyl-cellulose used as binder (Table II). Some interesting observations had been made with IR reflectography on the standards: Gypsum has a brilliant appearance but iron gall inks have a medium absorbance and some iron oxides (raw umber and burnt umber) appear very opaque. On the contrary, different dyes and colorants (prepared as lakes or fixed into clays) are transparent in different grades, only dragon's blood has a medium opaque response. Orpiment, minium and lead-tin yellow present a medium to high transparency. Under UV lighting gypsum had a bright violet fluorescence while weld, cochineal lake, madder lake, dragon's blood and *achiote* showed also some kind of bright fluorescence. Orpiment presented a slightly yellow green, opaque response. Iron oxides and iron gall inks (even mixed with cochineal) had a dark violet response to UV.

The organic colorants detected in Badiano Codex's illustrations had a different fluorescence under UV lighting than the lakes prepared in the European manner used as reference standards (mainly wald, cochineal carmin lake, Dragon's blood, madder lake), although they had a similar transparency under IR reflectography (Fig. 5). The comparison of UV imaging of the codex with standards was not exact. Almost all the pigments had a dark appearance, but it did help to bear in mind the presence of calcium sulfate, because of its bright violet whitish fluorescence (Fig. 5). We are aware that mixture of materials was something common in both painting traditions, and these reference standards must be done. We also bare in mind the fact that the tests already done cover mainly European lakes. The brown pigments were opaque in IR as the earth's pigments. We may as well expect the use of carbon black.

The identification of the pigments and the organic nature of some colors were established by XRF. The measurement results were compared with the IR and UV imaging. In the colors used in the illustrations, mainly Ca, Fe, S, As, Pb and traces of Sr and Mn were observed by the XRF SANDRA system equipped with the CZT detector. With this detector an intense signal of Pb was registered in the red margins and red subtitles. Cu was found in some green stains not associated with the illustrations. Besides the mentioned elements, the study of the codex with the Si-Pin detector permitted the clear definition of Si, S, Cl, Ti and K signals throughout the illuminations. This feature was very important for the study of the colors composition and the identification of the materials in the codex.

Standard number	Sample reference
1	Weld dye *Senelier*®
2	Cochineal carmin lake *Nochestli*
3	Madder lake *Zecchi*®
4	Weld dye *Zecchi*®
5	Asphalt *Senelier*®
6	Indigo dye *Kremer pigmente*®36000
7	Cochineal lake *nochestli*
8	Achiote dye fixed on attapulgite
9	Grinded cochineal insects
10	Dragon's Blood
11	Lead tin yellow Kremer
12	Orpiment laboratory preparation from European mineral
13	Burnt umber Kremer
14	Minium Kremer
15	Cinnabar *Zecchi*®
16	Lead white Kremer
17	Natural umber Kremer
18	Iron gall ink prepared in laboratory
19	Iron gall ink *Senelier*®
20	Iron gall ink *Zecchi*®
21	Iron gall ink *Zecchi*® mixed with grinded cochineal insects
22	Gypsum

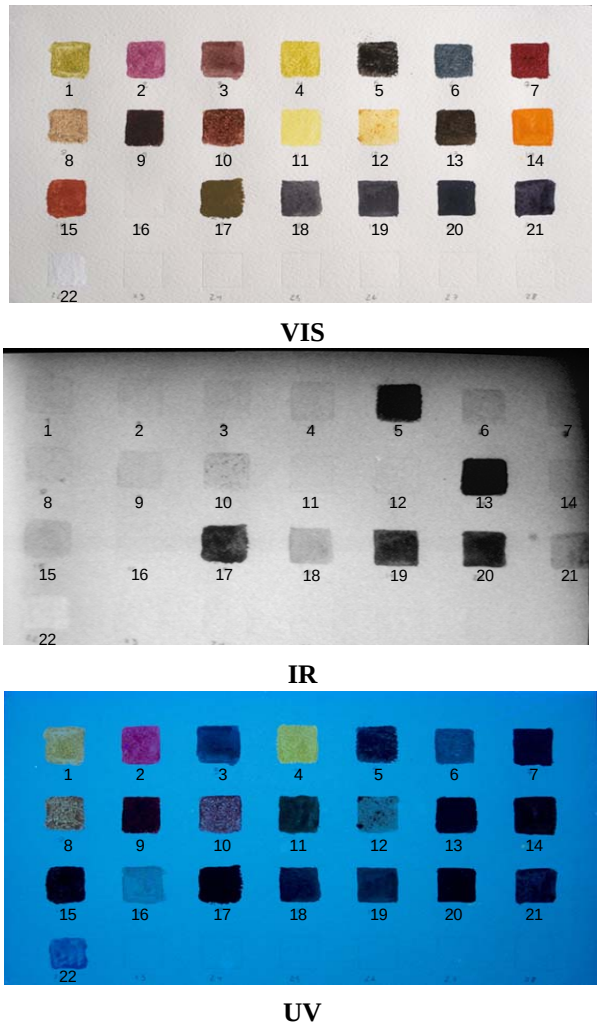

Table II. Reference samples of colorants, pigments and iron gall inks.

Figure 5. a) Visible light image folio 38r, b) IR reflectography, the darker areas correspond to iron oxide, c) UV imaging, corrections and bright areas may be observed (gypsum), d) Visible light image folio 9r.

In the Badiano Codex, the minerals detected were: Orpiment in some yellow and orange colors as well as in some green colors (probably prepared with a blue colorant). The use of orpiment has been reported in the pigments of stone benches of Templo Mayor precinct of Mexico-Tenochtitlan at the IV stage (c. 1470 A.D.) [8]. Iron oxides and calcium sulfate are present almost in every color. Traces of Ca and Fe were found as part of the composition of the paper. Clays are present because of the presence of Si and K. Most of the bright colors are a product of organic colorants; some of them were mixed with clays, possibly as in the Maya

blue preparation. Red and yellow were achieved with organic materials as well. No blue or green inorganic pigments were found. Red rulings were identified as minium due to the intense signals of Pb.

Analysis of folio 38r gives an example of the composition of the painting materials in the Badiano Codex, and the methodology used in its study (Fig. 6). In IR images some regions are very opaque; those sections correspond to dark brown colors, but also to bright yellow ochre. XRF points 174 (ochre) and 175 (brown) present an elemental composition clearly defined. Both have a strong intensity of Fe which are related to iron oxide, but the brown has a higher proportion of Mn, possibly related to manganese dioxide the naturally occurring mineral pyrolusite common in dark iron oxides as burnt umber [9-10]. Yellow ochre, has a higher content of As, both iron oxides must have been mixed with orpiment (As_2S_3). The intense yellow tones, transparent in IR are composed of two different pigments: orpiment and ochre on the petal shaped root (178) and in the center of the flower (165); an organic colorant or dye in other small details (168, 173). In those organic yellows and in a pink red color (166) the Ca signal increased, possibly due to an addition of calcium sulfate to produce whiter shades.

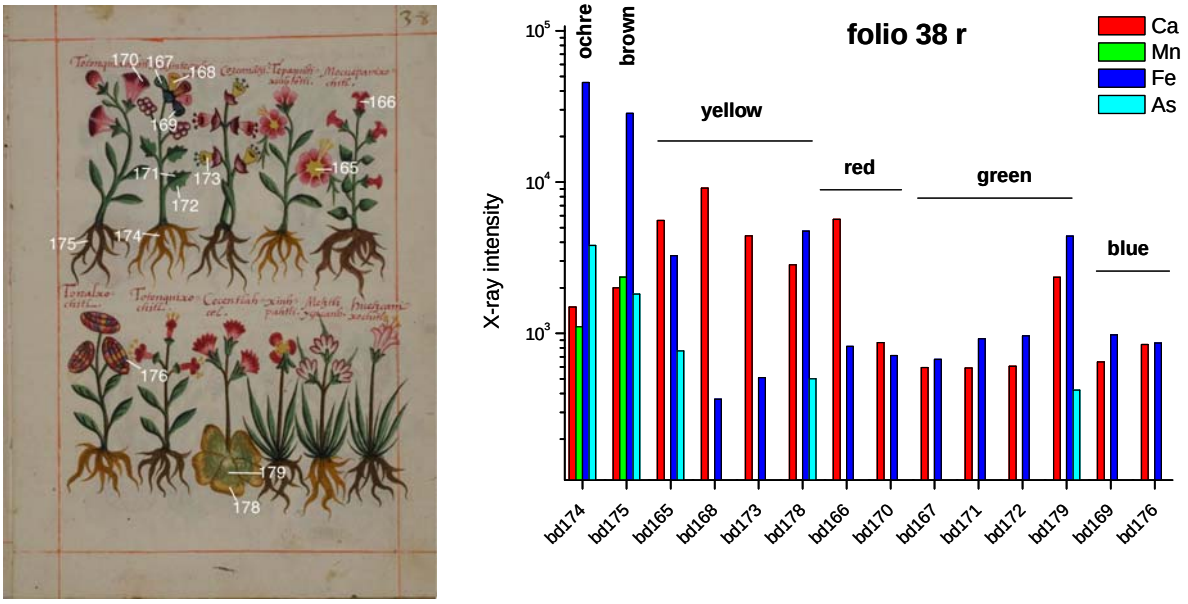

Figure 6. XRF analysis of the folio 38r.

The Inks

Figure 7 shows a general overview of the X-ray intensity ratios Fe/Ca, Cu/Zn and Pb/Fe for the inks of the codex. The measurements indicate that most of the used ink in the codex is an iron gall ink rich in Fe but a similar ink with significantly higher amounts of Fe is also present in few regions, especially in the corrections. A different ink with Fe and Pb contents was used too, but is generally found on capital letters. The ink of the ex-libris of Diego de Cortavila y Sanabria in folio 1r is clearly different due to Cu and Zn contents and non contemporary to the original text. From a detailed examination of the inks composition patterns we consider that the codex was written using mostly the Fe ink, afterwards some capitulars were written and marked using another ink (rich in Fe and Pb), then a general correction was done with the richest Fe ink contents. This way of writing is similar to the European pattern of the XVI century. The grouping of inks may be observed in figure 8 for two folios. Finally, due to the

Pb, Fe and Ca contents, the pink ink used to write the names in Nahuatl and titles of the recipes might be a mixture of minium with an iron gall ink and probably a red colorant.

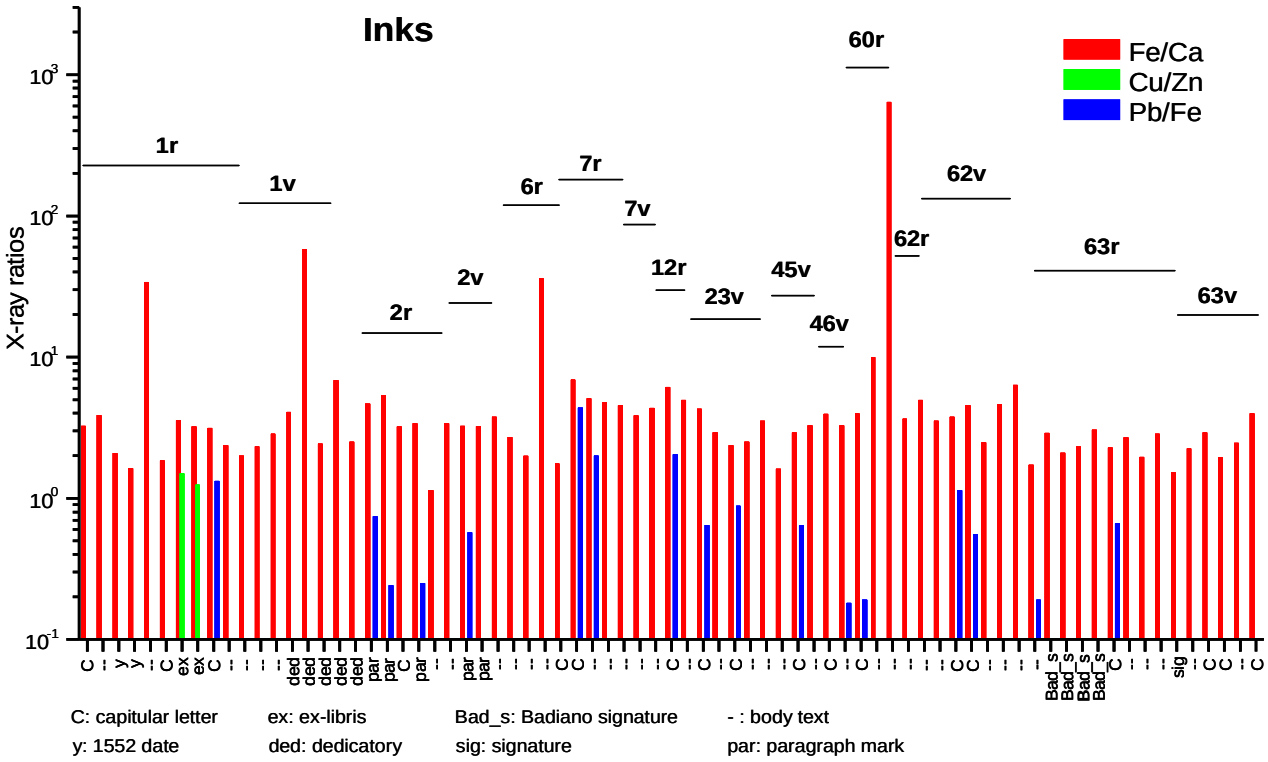

Figure 7. X-ray intensity ratios Fe/Ca, Cu/Zn and Pb/Fe for the inks of Badiano Codex.

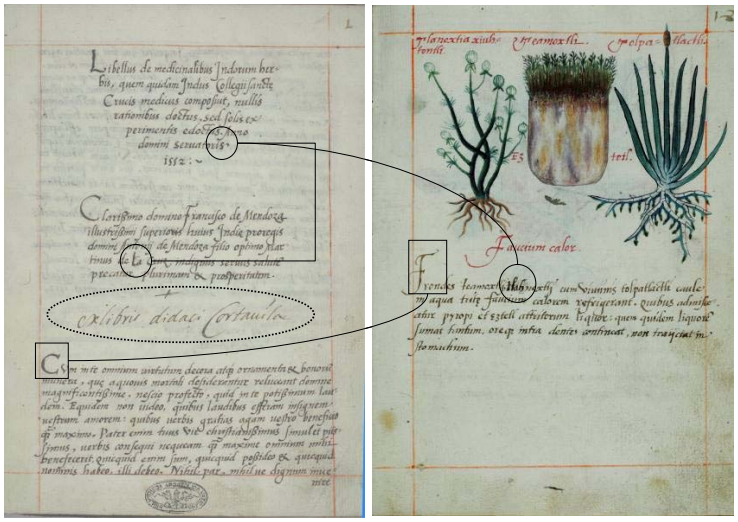

Figure 8. Patterns of the elemental composition of the inks of Badiano Codex: Most of the text was written with a rich Fe gall ink. Circles indicate corrections (very high Fe content) while the rectangles point out the Fe-Pb ink. Folio 1r and 18r.

CONCLUSIONS

The Badiano Codex has a singular technique; the painting materials found are a synthesis of two different traditions reconciled in a harmonic space. The structure and concept are completely delimited by European notions, as the cotton paper, minium and inks delimit the drawings, but the content retains an indigenous substance, probably not absolutely

decipherable. The inorganic pigments identified in the illustrations, have also been found in pre-Hispanic contexts at the precinct of Templo Mayor of Mexico-Tenochtitlan: pyrolusite, orpiment, gypsum, iron oxides and ochre. They can also be found in European manuscripts, but in combination with other pigments like copper based greens, blues, and minum, to mention some of them. It is quite notable that none of the paintings have minium, this pigment was only used on the margins of the page, and to write the subtitles. The writing materials were absolutely European. On the other hand, most of the painting materials used in the plant depictions follow the native tradition: they used colors prepared with organic dyes and colorants mixed with gypsum and clays. The amount of tints obtained is surprising: red, pink, orange, blue, yellow and green, but also with an important number of variations in the mixtures, contour and shading techniques. Some of the painting strategies are without a doubt acquired during the contact with European images, but others, like the use of pictographic conventions give us an insight of the native identity of the painters.

More research needs to be done in terms of learning the nature of the colorants used during pre-Hispanic times by analytical techniques for organic materials and historical and botanical research. This work will only be achieved with an interdisciplinary approach.

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