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“Circolo Amerindiano” Onlus

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Investigation of the palimpsest of Codex Añute (Selden)

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Abstract

Since the 1950's it was known that the codex Añute or Selden is a palimpsest. Fifteen pages on the reverse side are to be investigated using a new technique called photothermal tomography. This technique which is developed in collaboration with the technical University of Delft has the potential to reveal the colour of subsurface fractures independently of their physical and chemical structure. Combining this technique with state of the art 3D scanning, high resolution photography and infrared reflectography, a better understanding of the different layers that are to be found in this document is achieved.

The codex Añute, also known as the codex Selden 3135 (A.2) (JANSEN - PÉREZ JIMÉNEZ 2004), is a precolonial Mesoamerican book detailing the history of the Mixtec town of Añute (present day state of Oaxaca) and its relation with its neighbours over a period of more than six centuries (JANSEN PÉREZ JIMÉNEZ 2007). The history starts in a period of deities with the first founders of the lineage of Añute being born from a sacred tree. As such these codices not only give historical information in the strict sense that western science defines it. They also provide information on the worldview of the Mixtecs. The codex Añute is colonial, as the last ruling couple recorded in the book is also known from colonial Spanish documents, allowing the manuscript to be dated around 1560 A.D. (JANSEN - PÉREZ JIMÉNEZ 2007: 31). It is however always considered together with the precolonial codices as the style, way of writing, the content and the materials used show no European influence. The Mixtecs wrote in a pictographic system, i.e. a system where complex figures were composed to express meaning (see Fig. 1).

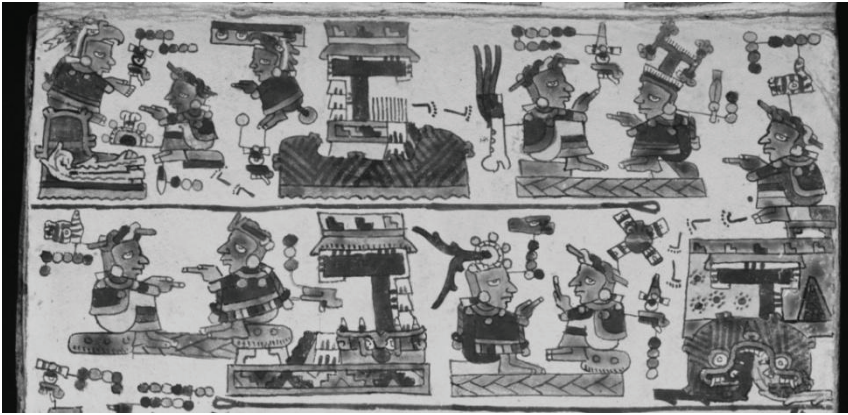


Figure 1. Example of the Mixtec writing system, Codex Añute, page 10 recto lines III & IV (MS. Arch. Selden A.2, courtesy of Bodleian Libraries, University of Oxford)

To create books, the Mesoamerican scribe would use a long strip of flexible material which could be folded into pages. Though some Mesoamerican books were made on amate bark paper, all five remaining Mixtec codices are made on a kind of leather. Multiple elongated strips of leather were attached end-to-end to form the base of the codex. The longest of these, the codex Yuta Tnoho (Vindobonensis) measures 13,5 meters in length, though the codex Añute is a modest 5,5 meters long. This strip of leather is folded with a concertina fold into pages and covered on both sides with a layer of gesso. Dark and Plesters (1958b: 532) investigated the material composition of the codex and concluded that this gesso was a mixture of mostly gypsum with some chalk bound with an animal glue. This is in line with more recent analysis of materials on the Mixtec codex IyaNacuaa (Colombino) (ZETINA ET AL., 2011: 354) as well as one of the Mexican ritual codices, the codex Tlamanalli (Cospi) (MILIANI ET AL., 2012: 4). This gesso layer formed a resilient, white background for the polychrome painted figures.

Earlier investigations

In the early Fifties it was discovered that the codex Añute is a palimpsest (CASO A. 1964: 15-16; DARK - PLESTERS 1958b). The term “palimpsest” comes from the Greek expression for “scraped again”, referring to the practice of scraping

a text from a parchment document and re-using the writing surface. The investigation of Dark and Plesters has shown that a similar process preceded the creation of what is today known as the codex Añute. An older document of fifteen pages long was repurposed by the scribe by adding two new sheets of leather to it, and covering everything up with a new layer of gesso. The codex Añute was written on one side of the resulting twenty page long document. On the first fifteen pages on the reverse however traces of the older document can still be seen through the cracks in the covering gesso. Dark and Plesters (1958b: 533) applied a range of techniques to uncover these texts, including infrared photography, and x-ray radiography. The latter technique showed nothing, which can be explained by the organic nature of the paints used by the scribe of this codex (DARK - PLESTERS 1958b: 532). The infrared photography did not give results until the codex was wetted with xylene, thus improving the penetrability of the codex for infrared radiation (DARK - PLESTERS, 1958a: 9). What could be recovered however were only the smallest fragments of what once were the carbon black outlines of the painted figures. It could thus be concluded that either the document was already worn when re-used or indeed scraped in order to clean it before re-using. Since none of the imaging techniques yielded sufficient results, it was decided to physically uncover the palimpsest on select areas. Page 11 was uncovered entirely (see fig. 2) and select areas of pages 12, 10 and 5 were also treated with sandblasting, scraping with a scalpel or cotton wool and a solvent (DARK - PLESTERS, 1958a).

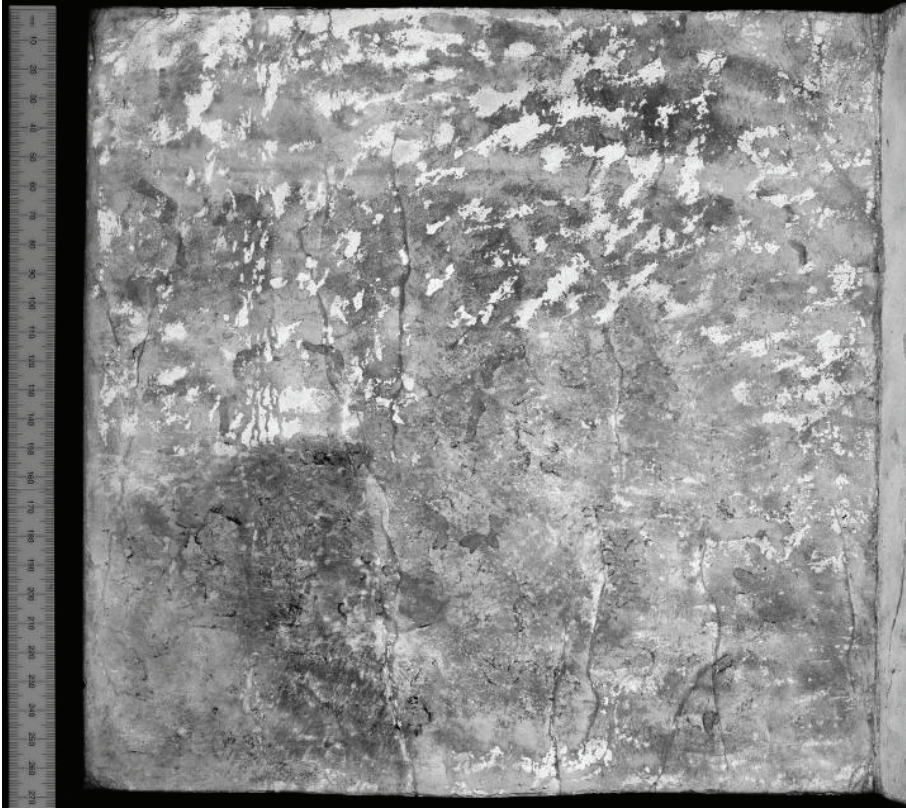


Figure 2. Codex Añute page 11 verso, showing traces of the images once covered with gesso. (Courtesy of Bodleian Libraries)

The images thus uncovered proved severely damaged, making it impossible to make more than general inferences about the structure of the underlying document. The covered text is definitely a Mixtec historical document (CASO A., 1964: 16), though it differs from the known codex Añute in style and in orientation of the text. Where the later codex was written from the bottom to the top when the book is held vertically, the covered text is written with the book held horizontally, in a fashion similar to the codex ÑuuTnoo-NdisiNuu (Bodley) (JANSEN - PÉREZ JIMÉNEZ, 2005). The series of figures uncovered on page 11 verso were too damaged to be interpreted beyond indicating the number of persons and their orientation (CASO A., 1964: 16). Dark and

Plesters (1958b: 535) were surprised to see traces of sub-surface paint also on the front of the codex. No photographic record of this seems to have been made, so it is difficult to determine whether they truly saw part of a different text, or *pentimenti* i.e. underdrawings of the known codex Añute. It thus remains to be determined if the older codex was fifteen or in fact thirty pages in length. Because of the lack of interpretable results the investigation of the palimpsest was discontinued. The codex Añute was until recently only reproduced by Caso (1964). In this edition the choice was made to reproduce only select areas of the reverse. The images are very faint and can indeed not be interpreted beyond what Caso already included in his commentary. Although the existence of the palimpsest is mentioned in the recent work on the codex by Jansen and Pérez Jiménez (2007) it only reproduces the front of the codex. A re-evaluation of first the uncovered parts of the palimpsest, and secondly the technical possibilities for uncovering the rest, is thus surely needed.

Feasibility and applicability

The codex Añute is one of the most fragile of the mesoamerican codices due to the inferior leather that was added at the end of the document. This leather is more flexible, causing the gesso layer to flake off. It is thus of the utmost importance to limit the handling of the original document. It is also no longer allowed, nor desirable, to do the type of highly invasive investigation done in the Fifties. The caretaker of the codex, the Bodleian Library, rightly allows only completely non-invasive investigation. Thus the initial stage of the renewed investigation of the palimpsest was twofold: justify the handling of the original codex, by showing it contains information worthwhile recovering; and prove the applicability and non-invasivity of the proposed techniques for investigation. The first step was relatively straightforward as it could be achieved by reconstructing the black outlines of the figures uncovered on page 11 verso by simple adjustments of a digital photograph in a program like Photoshop®. The combination of digital photography and computer editing is a first major technical advance over the Fifties investigation. The resultant image (see fig 3a) already shows more than was described by Caso (1964: 16). In the mixtec pictorial writing style, one of twenty calendar signs combined with a numeral (one to thirteen) expressed as a series of dots, is used as a calendar name for a person. A second “given” name can also be incorporated

either next to the figure or in the costume of the figure. Together these names generate unique individuals within the larger historical narrative. Figure 3b gives an example of this system. In the preliminary reconstruction of page 11 verso of the palimpsest none of the persons can be securely identified yet. There are partial numerals and some partial calendar glyphs visible, though no complete combination of the two can be made. Nor is it completely clear which calendar glyph is connected to which character. Nonetheless, it is clear that a lot of information is still waiting to be uncovered in this palimpsest. There is no reason to assume that the other pages contain significantly less information than was revealed on page 11 verso. In fact, the invasive removal of the gesso is may have somewhat damaged the underlying paint layers, making this a likely worst case scene.

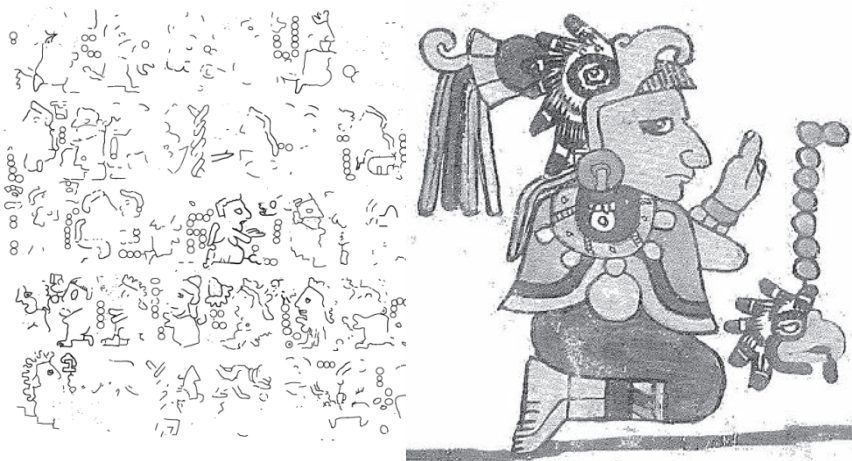


Figure 3a. Preliminary visual reconstruction of page 11 verso of Codex Añute

Figure 3b. Lady 8 Eagle, Eagle of Codex Tonindeye (Nuttall) (after Anders, Jansen, Pérez Jiménez, 1992 facsimile p. 13)

The investigation of subsurface paint layers is relatively common. The European Master painters working with oil paints often re-used their works when they were not satisfied or could not get them sold. Being able to see subsurface paint layers gives great insight into the mind of the painter as he continuously changes the composition. It has also been a very effective tool for determining of authenticity of such works. The study of sub-surface features in

oil paintings faces some similar challenges as are encountered in the study of the Añute palimpsest. One of the most advanced techniques used is scanning XRF (ALFELD ET AL., 2011; DIK ET AL., 2008). A regular X-ray Fluorescence device measures the re-emitted radiation after irradiation with X-rays. As each element has a specific spectral response this device can measure what chemical elements the object is composed of. With scanning XRF a mapping of the elemental distribution is made of the entire surface. Comparing the elemental composition of paints used at the time of the painter with the elements measured allows this mapping to be translated into a distribution of paints and thus colours.

The big difference between these oil paintings and the mesoamerican codices however is the use of pigments as opposed to lakes. Pigments are inert, often minerals particles that have a colour. Pigments were also used in Mesoamerica, though mostly on murals (see MAGALONI 1998; MAGALONI, KERPEL, FALCÓN ÁLVAREZ 2008) and on pottery (COE - KERR 1998: 140-141). A lake is an «organic dye... affixed to an inorganic colorless carrier powder» (BALL 2001: 65). There are two main reasons for making a paint in this way. First of all there are not many metal containing minerals in Mesoamerica that can be used to make bright paints (HOUSTON ET AL., 2009: 64-66). Second of all affixing dyes to an inorganic powder allows the creation of a much wider range of colours than available in the form of mineral pigments (HOUSTON ET AL., 2009, p. 61). Good green and blue mineral pigments are especially rare as many lose their colour when they are ground to a powder. The problem when making lakes however is that they are often susceptible to discolouration by deterioration of the organic molecule. The Maya perfected a way of making a blue lake called Maya Blue by affixing indigo to a specific clay called palygorskite (VAN OLPHEN 1966). The structure of the clay is such that it encapsulates and protects the indigo from deterioration (JOSÉ-YACAMÁN ET AL., 1996). From an analytical point of view the problem with these lakes is that on the level of the chemical elements they contain they are identical. The three major categories of dyes, anthraquinones (mostly reds), flavonoids (mostly yellows), and indigoids (blues and purples), contain differently structured complexes of carbon, oxygen and hydrogen (KIRBY 2014: 23-24). These relatively light elements are impossible to detect using x-ray based techniques, especially when covered with a layer of heavier gypsum. In an attempt to overcome this problem a new technique was developed called photothermal

tomography (see ZAMAN 2015). This technique was designed to circumvent the chemical composition of the paints entirely by measuring the thermal response of a surface after illumination with coloured light. The colour of a substance is the result of partial absorption of light and partial reflection. Thus a red object gets its colour by absorbing much blue and green light, but reflecting most red light. As absorption results in the production of thermal energy, when a red object is illuminated with blue or green light an increase in temperature can be detected which is greater than that detected when the object is illuminated with red light. As light penetrates in part into a light surface, such as the white gypsum layer, thermal variation at the surface can give indications about the colours hidden below. To test the applicability of this technique on the codex, a mock-up was made. On leather a layer of gypsum and animal glue gesso was applied on which figures were painted using lampblack ink, cochineal red, old fustic yellow and a blue made of indigo and clay. These images were partially covered with gesso until completely invisible. With a FLIR high sensitivity thermal camera the temperature variation on the surface was recorded when illuminated with red, green and blue light. The results of these tests were promising. First of all the image became clearly visible and all colours could be seen. Second the thermal fluctuations that were measured were around 0.01° , thus smaller than would be introduced by simply touching the document. Furthermore, since a thermal camera is used to do the recording, a continuous real time temperature monitoring system is in place. It can thus be considered a non-invasive technique.

Anticipating difficulty when examining an object less perfect than the mock-up, the range of recording techniques was not limited to this technique however. The first of the auxiliary techniques was digital Infrared photography. For this an adjusted Nikon D80 camera was used from which the internal Infrared filter was removed. The main objective here was to obtain a complete dataset of infrared photos of all the pages. During the 1950's infrared images were taken only of pages 1, 2, 5 and 11 verso and pages 1 and 2 recto (DARK – PLESTERS: 1958A). Infrared photography is a non-invasive technique as long as the exposure to the needed infrared radiation is limited and controlled. In difference to the earlier investigation there was no (highly invasive) application of solvents to make the object more transparent in the infrared.

The second auxiliary technique was macro photography and with that RTI imaging. The latter is a technique where by a series of images is taken while changing the angle and direction of illumination. From this a single image can be calculated with known surface orientation for each pixel (MALZBENDER, GELB, WOLTERS 2001). For the investigation of the codex, Zaman build a dome containing 60 LED's which could be mounted onto the lens of a camera. In this case a Nikon D800E was used to take 40 Megapixel images from an area of about 7 x 10.5 cm. These images are bordering on the microscopic so that details such as the flakes of gesso and clumps of paint and even hairs from either the brush or perhaps the scribe can be seen attached to the surface. The resulting highly detailed surface information the RTI provides is crucial for reconstructions as it helps distinguish painted features from shadows cast by the relief of the surface. Since the thickness or relief of the covering gesso layer does not correlate with subsurface features, this technique is more useful for the interpretation of the sections already uncovered than the sections that are still completely covered in gesso.

First results

When the investigation of the original codex started in March 2015, it quickly became clear that the photothermal tomography did not work as expected for this particular object. The mock-up turned out to be too perfect. The measurements obtained were disturbed by internal structural faults of the gesso layer of the codex that prevented the transmission of thermal energy to the surface. Thus the technique could only be used to give important information about delaminations and other pockets of air inside the gesso, but no information on the colours hidden underneath it. This set-back led to an initial re-orientation of the research goals to try and document as thoroughly as possible the areas that were already uncovered. At fifteen scans per page both page 11 and 10 verso were documented using RTI. The sections uncovered during the investigation of the 1950's on pages 5 and 12 verso were also documented using this technique, as well as the sections laid bare by wear on page 3 verso.

Serendipitously, during the investigation of the original document, the Bodleian Library took possession of a new piece of equipment for the study of their manuscripts: a Hyperspectral scanner. The sensitivity of this technique allows for more precise discrimination between paint layers as well as

distinguishing traces that are no longer visible. This technique was applied on select areas on the front and back of the codex.

The process of reconstructing the uncovered images requires constant comparison of the recorded images with each other. Comparison with the other known mixtec codices also helps to interpret fragmentary scenes within the conventions of mixtec writing style. It is important however to take into account that what is understood as the Mixtec “writing convention” is based on a dataset that is actually too small to make statistically meaningful claims. As such it is important to stay close to the data at hand and avoid over-interpretation during reconstruction.

Although the process of reconstructing page 11 verso is not yet complete, the general method can be described here by taking the example of the central figure of that page. As can be seen on even on a normal photograph of the section (fig 4a), a sitting person facing right can be distinguished. This figure is in a relatively good condition. The person is sitting on the knees, in a position also found in the codex Tonindeye (Nuttall), though only on women (see fig 3b). She has a red cape and a red section on the top of her head. It is unclear whether this red section was red hair, part of a headdress, or if the red was simply a base over which some other, now removed, colours were painted. Somewhat less clearly visible, though still distinguishable are her eye, the bridge of her nose and her feet. As in the other codices most seated figures make specific hand gestures, it stands to reason that the traces in front of her chest are remnants of her arms and hands, though the exact posture cannot be seen. It seems in this photo as though her chin is visible in the dark and rounded stain below her eyes. When this photo is compared with the infrared image that was made in the 1950's however this dark area is no longer visible (fig 4b). In this photo the codex had been wetted with xylene which made it possible to look through the remnants of gesso and distinguish all traces of black outlines. The outline of the face, the arm, stomach and knees are clearly visible. Also the hand can be better distinguished and a stretched out finger, as if she is pointing at something, can be seen. This gesture indicates that this lady is instructing (JANSEN - PÉREZ JIMÉNEZ 2011: 227). It seems that in the IR image a black line connects the knees of the female with a series of dots. This would indicate that her calendar name is to be found in front of her. If the RTI image of this section is studied however it becomes clear that this dark line is a surface shadow cast by an elongated remnant of the covering gesso.

Although the dynamism of the RTI image does not translate well to static photographs, the four images in figure 5, each illuminated from different angles, do show these differences in surface shadow.

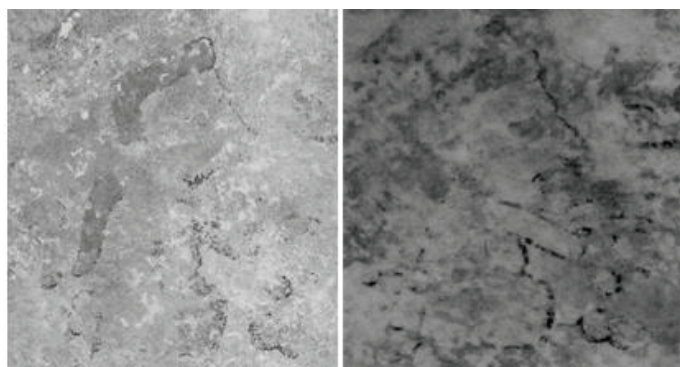


Figure 4a. Central image of page 11 verso Codex Añute (Courtesy Bodleian Library);

Figure 3b. Infrared image made in 1952 of the central area of page 11 verso of Codex Añute (courtesy of Bodleian Libraries and National Gallery London)

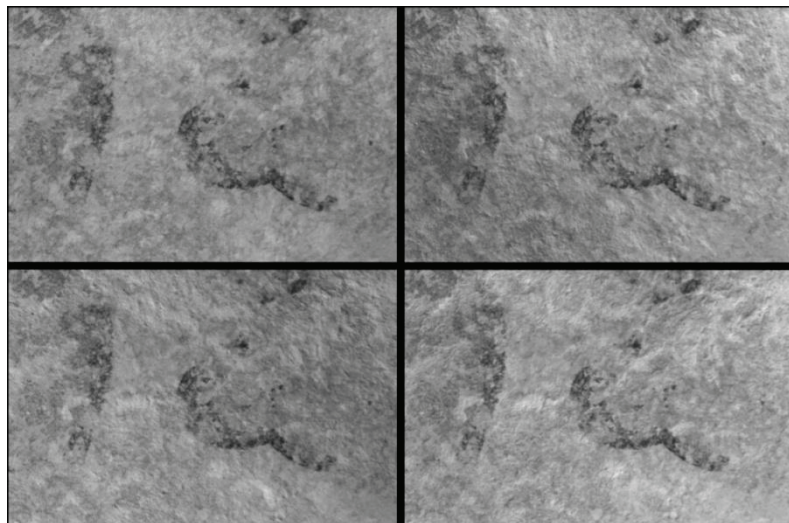


Figure 5. Macro Images from the central image of page 11 verso of Codex Añute generated from RTI image, illuminated from four different angles

By combining the hyperspectral imaging with the RTI and the infrared photos a more thorough reconstruction is possible. With this technique it is possible to distinguish between visually similar materials. For example the yellow paint is difficult to distinguish from the yellowed leather background. Multiple computations can be performed to analyse the hyperspectral data. One function of a program called ENVI allows the reduction of noise in the image and the localisation of areas which with a different spectral response (fig 6).

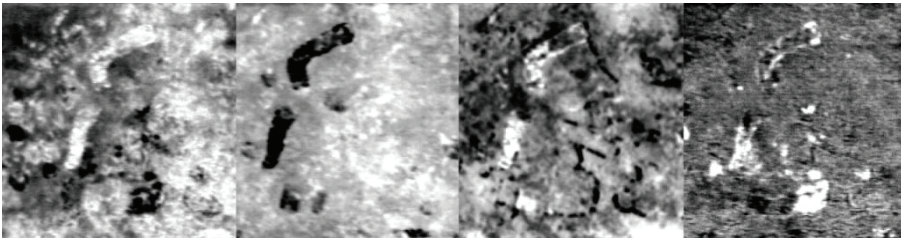


Figure 6. Results after noise reduction of hyperspectral image of central area on Codex Añute page 11 verso

Since the surface of this image is very rough due to the scraping of the gesso, during the interpretation of the hyperspectral data it is important to refer to the RTI images as well. Combining all the data, it becomes possible to reconstruct this small section in detail, including the different colours that it had (fig 7a).

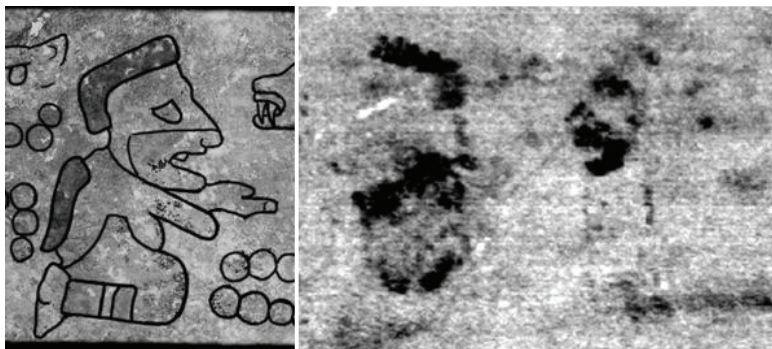


Figure 7a. Reconstruction of the central figure of page 11 verso of codex Añute based on RTI, NIR and Hyperspectral Imaging;

Figure 7b. Hyperspectral image of the still gesso covered page 7 verso of codex Añute. The red paint here revealed shows remnants of two figures facing left.

Complete reconstruction of this page, including the calendar signs and numerals, will allow for a comparison with the other known codices and determination whether the codex belongs to the known mixtec historical narrative or if it is completely new. The calendar signs that have been uncovered thus far suggest that this scene is not found in any of the other documents.

Scans of pages that were not cleaned have proved that here hyperspectral imaging can reveal part of the palimpsest as well. Figure 7b shows the distribution of cochineal red on the lower left section of page 7 verso, which is still completely covered with white gesso. Two persons can be seen, one with a red “hair” similar to the figure described above, though with a complete red body instead of a red cape. To the right of this figure another can be seen of which only the red face can be well distinguished. The fact that these figures can be made visible even though they are covered with the white gesso is a true breakthrough. The processing of these images is however more difficult and time-consuming as the signal of the underlying painted feature is relatively weak and thus easily obscured by the gesso. The red coloured areas, which due to the unique spectral profile of cochineal are easier to distinguish, only yield part of the picture. As has been shown above, the other colours can also be distinguished when the surface is uncovered. Whether they can be uncovered from under the thick gesso layer is still uncertain. Even if only the red areas can be uncovered on all the pages of the palimpsests however, a much better understanding of the hidden codex is assured. Though we are only just starting to get glimpses of the hidden images, this investigation is a clear first step towards recovery of this important document.

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