

A REPORT ON THE DIGITAL RECORDING OF  
THE COMMENTARY ON THE APOCALYPSE OF ST JOHN  
BY  
BEATO DE LIÉBANA



Folio 127, verso - reflected light.



Folio 127, verso - transmitted light.

BEATO DE LIÉBANA  
COMMENTARY ON THE APOCALYPSE OF SAINT JOHN  
BNVIT 14.1

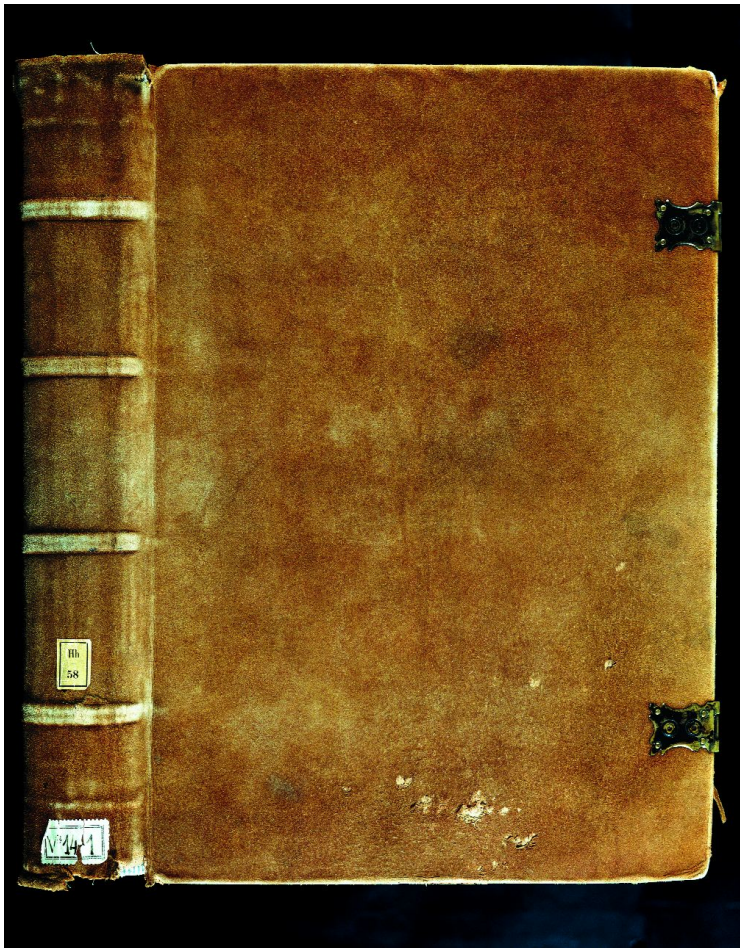
The project was commissioned by Red.ES and all work was carried out in the Biblioteca Nacional and in Factum Arte's workshop in Madrid.

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**FACTUM** arte

Factum Arte  
Madrid 2005



Beato de Liébana, Commentary on the Apocalypse of Saint John.  
 VIT14.1, Biblioteca Nacional, Madrid.  
 10th century manuscript on vellum, 19th century binding  
 in brushed leather over wood boards.

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Folio 127, verso (detail), reflected and transmitted light.

When the page was recorded with transmitted light a figure, that had been over-painted with white body colour, is clearly visible. A direct comparison between the reflected and transmitted light images suggests the alteration was made by the scribe.

## INTRODUCTION

Following a public competition, Factum Arte were selected by Red.ES to record El Beato Primero (Vit 14.1) one of the treasures of the Biblioteca Nacional, Madrid. The digitising of this manuscript was part of a centralised attempt to digitally document Spain's National Heritage.

Most of the work Factum Arte had undertaken before this project was dedicated to the recording, in colour and 3 dimensions, of large scale sculptural objects including the tomb of Tutmosis III, a section of the tomb of Seti I and the Dama de Elche. The opportunity to work with a manuscript on vellum and to increase the resolution of data capture and facsimile production was in line with our interests.

The brief was loose but the aim was to document the manuscript and prepare the information, complete with metadata tags, so that it could be disseminated via the internet. We were not allowed to touch the manuscript, which could not be opened more than 90°. The use of a vacuum or the application of pressure to flatten the vellum sheets was also forbidden.

The first part of the process was to inspect the manuscript, access its condition and meet the relevant people working at the Biblioteca Nacional (these included the conservation staff, the photographer, the administrative staff co-ordinating the digital services and the security personnel).

Once the working method had been selected, tested and justified official approval was obtained from the Biblioteca Nacional. The actual task of recording the manuscript and producing facsimiles on vellum began in November 2003 and was completed by March 2004.

The success of the work undertaken was dependent on various specialists and enthusiasts. As with all projects, the practical development and application of techniques has generated many lines of thought that need to be followed.

The process of digital recording and facsimile production are documented in this book.



## BACKGROUND ASSESSMENT



Folio 75, verso.

This is considered to be one of the earliest copies of Beato's Commentary on the Apocalypse of St John with the drawing style lacking the later influence of the Roman church

## THE APOCALYPSE OF ST JOHN & BEATO DE LIÉBANA'S COMMENTARY

Beato de Liébana's *Commentary on the Apocalypse of Saint John* was written in 776AD, and updated in 784AD, while he was a monk in the Monastery of San Milan de Cogolla. His intention was to muse upon the impenetrable text of Saint John in the Book of Revelations. His commentary not only contains Beato's own thoughts but is a meticulous work of scholarship in which many of his sources and references are noted. These sources demonstrate the scale of the library at San Milan at this time and reveal that Beato had access to important texts from both the Eastern and Holy Roman churches as well as other theological, scientific and philosophical works that filtered from Alexandria and the other centers of arabic scholarship during the time the moors controlled Spain.

The Book of Revelations, also known as the Apocalypse, describes war, famine, plagues, meteorites, earthquakes and other signs from the heavens. These visions were received by Saint John the Evangelist one Sunday in the year 96AD while he was exiled on the island of Patmos. The first three chapters are prophetic instructions given to the seven churches of Asia Minor. The last three chapters celebrate the triumph of Christ, the judgement and the rewards to be given to his saints. In the central chapters John describes a number of complex and obscure symbolic visions. Gog and Magog take their place alongside the whore of Babylon (almost certainly Babylon and Rome were interchangeable and both refer to non-Christian worldly powers). Fantastic creatures line up alongside more familiar iconography. The devil, identified by the numbers 666 appears in the form of a dragon threatening Christ in the form of a lamb. The Antichrist holds the reigns of worldly power (dragon-like in body with the voice of a lamb) and represents evil and material corruption. This force is opposed by the righteous people of God and two prophets or witnesses who appear in Jerusalem and speak against worldly power,



gradually eroding its authority and ultimately overthrowing the system. Jesus returns at the end on a white horse to claim the kingdom for God, a warrior with a sword who will rule with a rod of iron.

The imagery is ornate and lush, peopled by a host of characters whose forms, barely fixed, have the properties of dreamlike spectral presences. In essence Beato's text, as transcribed by the monks during the renaissance that flourished in Spain under Arab rule, is a mix of mozárabe Christianity and Muslim poetry.

The tenth century was a time of enlightenment and learning in Spain during which the Muslims, Jews and Christians peacefully co-existed under Arab law. However, as the new millenium approached many were predicting the coming of the apocalypse and the end of the world. Beato's text became the equivalent of a best-seller in the age before printing and eight copies still remain from the 10th Century as monks copied, annotated and illustrated the colourful text.



## THE MANUSCRIPT, VIT14.1

Known as *El Beato Primero*, it is not the earliest known copy of Beato's commentary. This honour belongs to the *El Beato Magio* from the monastery of San Miguel de Escalada which was produced in 926AD and now resides in the Morgan Library, New York. There are no known copies from Beato's time but eight Mozárabe copies exist from the 10th century. The exact date of *El Beato Primero* is unknown but judging by the character of the illuminations, with their strong Muslim influence, it from the first half on the century

VIT14.1 is one of three copies of Beato's commentary made at the Monastery of San Millán de la Cogolla, Rioja. The other two are later and are in the library at El Escorial and the library of the Royal Academy of History, Madrid.

VIT14.1 was removed from the monastery and taken to Burgos in 1821 along with other codices from the monastic library. It then appears in the collection of the romantic poet, author and bull-fighting correspondent Serafin Esteban Calderón. On his death in 1867 his library became part of the collection of the Ministerio de Fomento. In 1886 it was given to the Biblioteca Nacional.

## DESCRIPTION OF THE MANUSCRIPT

Beato de Liébana, Commentary on the Apocalypse of St John, VIT14.1, 10th century, Vellum, 350x250 mm, 144ff, 2 colour with 27 miniatures, poor condition, 18 pages missing at the beginning, 18 pages missing at the end, more than 30 independent pages missing, 16 pages badly damaged, 4 pages remain as a fragment. The end-paper contains a list of all the missing pages written in pencil by Sanders and added to by Bordona.





Folio 8, verso - transmitted light.

The manuscript has been restored in places with crude paper patches.

## CONDITION ASSESSMENT

The binding is from the 19th century and consists of leather covered wooden boards. It is in good condition with one loose page. The binding is slightly tight and some of the images are partially lost in the gutter.

The vellum used for this manuscript is made from goat skin. It varies in thickness significantly from sheet to sheet. There is a clear difference in colour between the yellow orange of the skin side and the whiter cream appearance of the flesh side.

The vellum has been punched and scored to give a guide for the scribe. The condition of each page varies significantly with more water damage to the first sheets than to other parts of the manuscript.

The text is in brown black iron gall ink with sections written in red ink. There are numerous additions to the text block, marginal notes and graffiti.

The manuscript contains 27 illuminations of various sizes made in colour over a white ground. A range of colours have been used but the most common are a deep crimson red, a bright orange, a strong semi-transparent yellow, a grey turquoise, a blackberry crimson and a paler grey version of the same colour, an olive green, a brighter yellow green, an ultramarine blue, a cerulean-type blue, pink, black and white. The painted areas are fragile with some paint loss and a cracked surface. This is particularly visible in the faces, most notably around the eyes where the white is painted over the pink and the black pupils painted over the white. This build-up of paint is clearly visible in the 3D scan. There is evidence that paint loss could occur if the pages are flattened under glass or recorded using a vacuum bed to remove the natural undulation of the vellum.

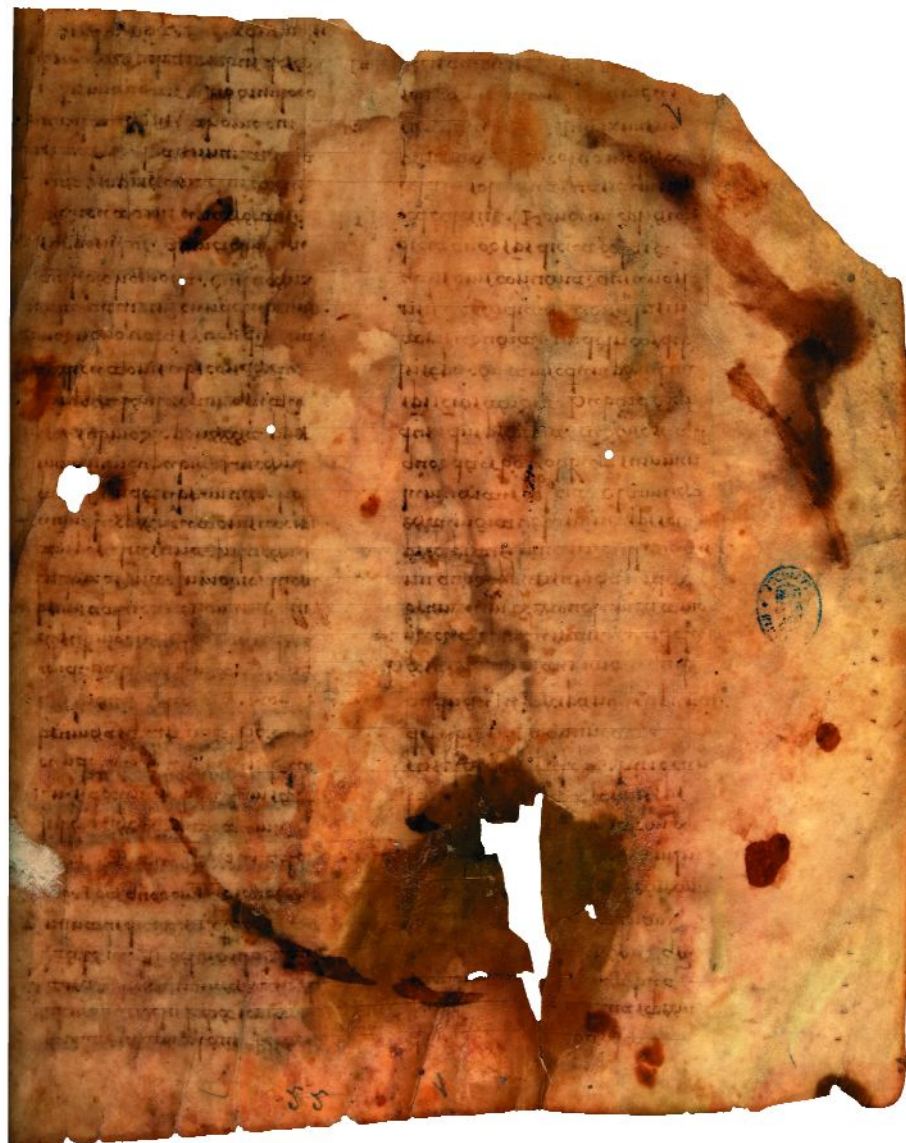
Some paint loss and discolouration has occurred. In many cases the scored lines are now visible as the paint has rubbed off the elevated areas. There is little or no sign of offset onto the facing pages. Several of the illuminated pages show a localised black discolouration of unknown cause.

The pages are significantly cockled with an undulating surface characteristic of vellum of this age and show clear signs of water damage, staining, creasing and some tearing particularly along the edges. The most significant damage has been caused when the illuminations were removed. At least sixty complete pages or illustrations have been cut out at some point in the book's history but it has been impossible to establish when they were removed or their current location.



Folio 75, verso.

In addition to the iconoclastic damage there is also significant wear and tear.



Folio 1, recto.

The first pages of the manuscript show signs of water damage. In places the vellum has rotted and the script is unæadable.



## VELLUM

*A mixture of word and flesh,  
the union of humanity and divinity.*

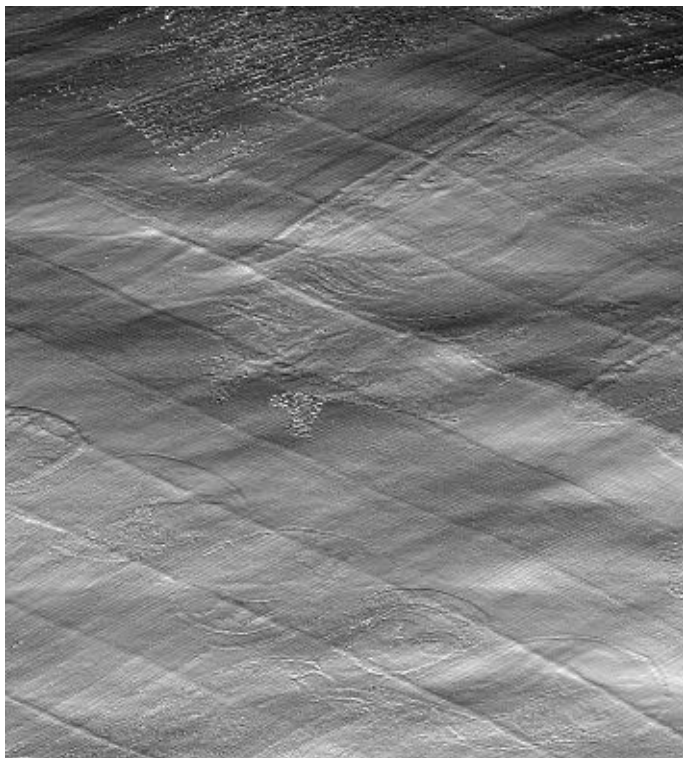
Vellum is a visceral medium that defies intellectual definition. It sets off the lustre of the ink and holds a sharpness of line which is especially important for calligraphy. The translucence of the surface is seductive, both to the eye and the touch. The double sided nature of the sheet is responsible for much of its character; smooth and velvety on one side, slightly textured on the other.

Rarity and expense have led to the growth of a number of myths about vellum and its numinous qualities. Many of the craft skills, which would have been second nature to medieval craftsmen, have been revived by individual enthusiasts but there is no replacement for experience and years of perfecting the skills necessary to completely understand the material.

Most developments in the history of printing are devoted to reducing cost – the use of vellum resists this tendency and has, since the 3rd century, been seen as the preferred material for special editions and documents that need to last centuries. Legend has it that the development of vellum happened in 200BC in Pergamon as a result of the export ban placed on Papyrus by Ptolemy Epiphanes, King of Egypt. In the 2nd century AD the physician Galen propounded the opinion that vellum, with its combination of stains and the shine of the whiter portions, did serious damage to the eyes. In 220AD the lawyer Ulpian raised legal issues as to whether a vellum codex could be considered a book as opposed to a scroll but by the 3rd Century vellum had secured its place as the finest material on which to make records, mainly for conservation reasons.

You can tear paper – not vellum. It can be punched and cut with a knife but is very long lasting and, if kept under good

conditions will remain supple allowing the pages to be repeatedly turned without breaking. However, atmospheric conditions are critical to the conservation and handling of vellum: It responds negatively to low humidity (shrinkage) and to high humidity (the surface is easily marked and spoiled). Water stains the surface and the vellum has a tendency to curl, cockle, stiffen, shrink and warp.



Folio 131, verso,

A detail of the 3D scan of the surface showing traces of the angels delineated by the thickness of the paint. Traces of the writing are also visible as are the deeply indented score lines showing that it was ruled from this side.

## PREPARATION OF VELLUM

There is extensive and often contradictory information on the preparation of vellum. This report concentrates on accounts from the 10th –12th centuries.

Vellum is made from skins of calves, sheep or goats no more than six weeks old and freshly killed. After that age the skins must be tanned and become useless for vellum. There is evidence that rabbits, deer, cats, and birds were also used.

The most highly prized vellum is uterine vellum, supposedly made from stillborn calves. Often it comes from very young animals. The difference between still-born and new-born is imperceptible. Christopher Clarkson has observed that thicker skins were also split into two thin sheets, a skill which is now lost. Skins vary greatly in thickness depending on the preparation and even within a single skin there is significant variation. The thinner more regular skins are best for manuscript use.

In the ninth century at the Swiss monastery of Saint Gall, a monk named Waldramm described his activities:

*I scrape down the skins; I prepare them for books by stretching;  
I gnaw them with pumice; I take the superfluous away;  
And while they are stretched I press down  
While I'm leading my knife across the tight skin.  
The lines are then marked, they're held to straight rules.  
Then, often, I read the small letters  
The writers put down, some with haste and some not.  
I scrape or I add. May the spelling find grace with my lord.*

Poetae Latini Aevi Carolini 4, Monumenta Germaniae Historica

Ed. Paulus de Winterfeld, 1899

Possibly Waldramm did everything with the exception of the actual writing on vellum: he removed the hair from the animal skins, then stretched them while wet - a crucial step because it forces the collagen fibers of the skin into a tight pattern. While the skin was still stretched and wet, he roughly scraped its surface with pumice to remove uneven patches. The pumice has the effect of raising the fibers on the surface to make it more absorbent. Then he scraped the skin smooth with a knife. Once the skins were dry he performed the more common functions of a maker of books: drawing lines, supervising and correcting the scribes. The vellum found in insular manuscripts (manuscripts written in the British Isles under strong Irish influence) is different: it has a peculiar suede-like finish, and the flesh and hair sides have similar colours. It is frequently lined according to a particular system, which suggests that the



Folio 121, verso, detail.

person who lined it was the same person who produced the particular texture. This type of vellum also turns up in many manuscripts produced on the European mainland before 850, no doubt because of the numerous Irish monks who emigrated to the Continent. The difference between Insular and Continental vellum probably lies in the sequence of rough and smooth scraping. Waldramm, for instance, began with a rough scraping with pumice, and ended with a smoother shaving with a knife, but an Irish scribe might have reversed the sequence. Perhaps the Irish initially developed their own particular ways of scraping wet vellum and once outside Ireland they learned to carry out the technique on dried skins.

A sharp blade or knife was used to scrape the hair, flesh, fat, sinew and veins from the surface of the stretched skin. Pumice and finer scraping tools were then used to further clean and smooth the surface. Further burnishing of the surface was carried out using teeth or bone. Teeth from a boar or a dragon were recommended. The main reason for additional burnishing was to prepare the skin to take the iron gall ink. If the skin is not properly prepared the ink will spread. There are many references to bleeding, spreading, running and runoff. Latin words like fluens, defluens, fluxus and defluxus were used to describe the action of the ink on the skin.

The margins and lines were ruled using a sharpened bone or lead tool. From the evidence revealed by the laser scan of folio 131, recto and verso, the lines were ruled from the skin side and the margins were ruled from both sides.

As the techniques, and the problems, relating to vellum production were better understood various attempts were made to coat the surface of the sheet to limit the difficulties of preparation and therefore simplify the production. All of these processes affect the life expectancy of the sheet. In the 10th century it is unlikely that any coatings were used but by the 13th century the most common solution was a coating of slaked lime into the wet, stretched skins, which bonded with the collagen and contributed to their brilliant white colour. Once

the lime dried it would turn back from calcium hydrate to calcium carbonate and would have properties and ingredients similar to the mixture of chalk and gelatin which was popular in panel painting from the ninth century. Sometimes they soaked the skins in lime to turn them white then worked calcium carbonate into the skin before drying. This technique was said to be among the most difficult to master and leads to surface cracking in humid conditions. Other coatings include lead, gum, egg, gelatine, resins and flour.

All coatings affect the character of the sheet. In a good uncoated sheet the translucence is integral and the result of the thickness. It has a slight gloss surface but the sheen is not completely uniform and adds character. While the aim is to produce a perfect sheet imperfections are an important part of its appeal. The shape suggests animal more than right angles. The surface varies, sometimes it is almost completely transparent, sometimes featured with the character of the skin. Patchy discolouration occurs where hairs grew and where the thickness varies.

## SURFACE CHARACTERISTICS OF UNCOATED VELLUM

The list of surface characteristics and defects of vellum is extensive and all affect the appearance of the sheet to a greater or lesser degree.

Marks resulting from the growth of the skin while the animal is alive and during killing include; follicle patterns, tightly packed hair roots, stretch marks in the skin (especially around the spine and pelvis and neck), blood staining in the skin caused by imperfect bleeding (this can appear as trapped blood or visible arteries and vessels), indents in the surface caused by veins and arteries and flesh wounds that appear as scars.

Marks resulting from the preparation of the skin are characterised by a marked difference in colour between the skin side and flesh side of the vellum, scraper marks, cuts and slashes on flesh side, remains of hair, flay holes and stitched tears.

Changes resulting from the work on the vellum after the sheet has been prepared include; creasing resulting in breaks in the material, contraction on the reverse side of the illustrations, evidence of bleeding and show through in the ink and painting, distortion due to irregular movement in the skin, evidence of candle wax and sneeze marks.

Organic change and decay is common and includes: mould, fungus, rodent damage, burns, water damage, staining, liquid stain contractions, flaking paint and squashed animals or insects.

Iconophilic and iconoclastic alterations are also common. These include: modifications and alterations to the text, marginal notes, over painting, changes during and after completion of the work, removal of faces or eyes, graffiti, cut out images, removed pages and erasures.

Additional problems are caused by conservation and re-binding. The most dramatic of these are caused by washing and cleaning but this does not apply to VIT14.1. There has been some conservation work to fix tears and to reinforce the creases as they have been damaged by repeated turning. Some of this is clumsy but most has an honesty and does not detract from the book as an object. There is clear evidence of the re-binding, notably a misalignment of punched holes and a loss of information in the gutter. One page is loose.

Parts of this text have been extracted from: Paul T Werner, *Vellum Preparation* (Orange Press).

For further information see:  
Christopher Clarkson; *Rediscovering Parchment: The Nature of the Beast; Vellum and Parchment; Journal of the Institute of Paper Conservators* Volume 16 1992 Editor: Helen Shenton.



## PAINTING & CALLIGRAPHY

No chemical or microscopic analysis was carried out and all the comments below are based on a close observation of the surface during the recording.

The most likely composition of the ink is an iron gall ink made from galls on oak trees. When exposed to acetic acid and water the iron content in the oak galls oxidises to produce a permanent warm black ink.

Colours in medieval art were applied either as dyes or as pigments. A dye is a transparent coloured liquid whereas a pigment is a dry, inert, coloured material bound with a liquid binding agent. Dyes tend to be easier to use on vellum but the colours are less permanent. While pigments have a longer life expectancy the binding agent in the pigmented colours tends to crack and fall off the flexible vellum surface. This can happen when the sheet is exposed to changes in humidity or when it is turned or pressed flat. The binders used in 10th century pigment include egg white, gum from various trees, honey, earwax and gelatin. Medieval painters developed sophisticated balances of these materials, each suitable for a particular colour. The binders were usually mixed with pigment but were also painted onto the surface to seal the vellum.

The paint was used as dry as possible as the presence of water causes the surface to expand and cockle. As in tempera painting, a technique of short, overlapping strokes is the most sympathetic to the medium. This allows each mark to partially dry before the next one is applied. The paint is usually kept thin as any impasto will result in cracking and flaking. In this manuscript there is a build up of paint on the faces. A layer of pink is over-painted with white to define the eyes. Black pupils are then added. This layering results in a physical thickness and there is significant cracking and paint loss in these areas.



## THE DIGITAL RECORDING



Arsenio Sanchez Hernan-Perez, conservator at the Biblioteca Nacional, positioning the manuscript under the APIS system using the Solar M3. The manuscript was never opened more than 90° during the recording.

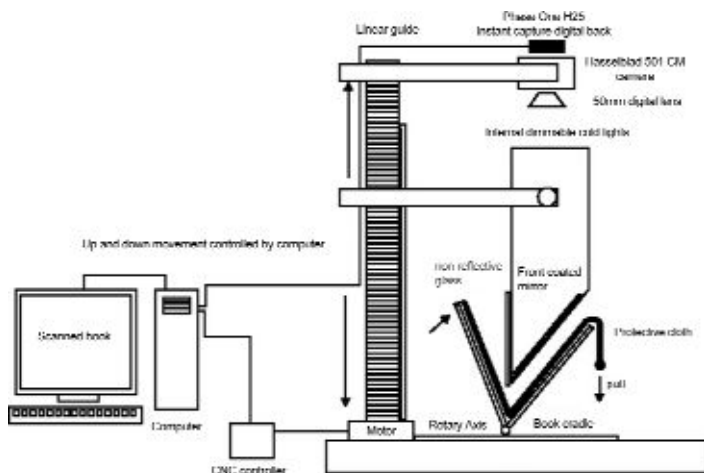
## THE DIGITAL RECORDING

The manuscript, VIT14.1 was recorded under the most rigorous conservation standards while open at an angle of less than 90°. The well-being of the book was of paramount importance at all times. During the recording the manuscript was treated as an object and not as a repository for textual information.

The manuscript was recorded using an Advanced Paper Imaging System and at all times the manuscript was supported in a 90° book cradle with foam supports for the spine. It was only handled by the conservation staff at the museum. No vacuum was used to flatten the pages during photography and only minimal contact with the glass of the APIS was acceptable. 2 cameras were used in the recording, the Phase One H25 mounted onto a Hasselblad body with a 50 mm Hasselblad lens and the Solar M3 with a 47mm Schneider digital lens. Each page was recorded with both reflected and transmitted light. Cold fluorescent light was used to record the reflected light images and a Howard Eaton light-sheet was used to record the transmitted light images. The file size for each image was about 127 megabytes.

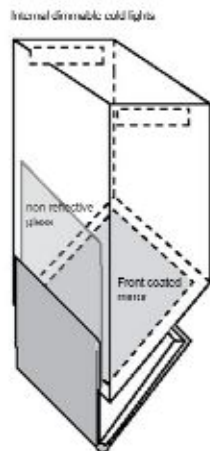
The binding and one page from the manuscript were laser scanned using Factum Arte's Seti Scanner. All laser scanning was carried out at a resolution of 100 microns and the data has been used in its unmeshed form. All the data was routed by Delcam UK at a resolution of 100 microns and the results were cast and used to emboss both sides of a sheet of vellum.

The metadata was specified by Red.es and all files were prepared to these specifications. A total of 4 masters (transmitted, reflected, recto and verso), 24 derivative files and 58 metadata files were prepared for each of the 144 sheets. In total there are 12,410 files. There are also image files for the cover and spine and six 3D files for the cover, spine, edges and both sides of one sheet. The data was supplied to Red.ES on hard disk and in triplicate on DVD.



#### Advantages of the APIS

- Manuscript is in felt covered book cradle at all times.
- Manuscript open at 60 degrees to minimise any risk of damage to the binding.
- Page recorded in vertical position with minimum contact with glass. In this position it is naturally flat.
- Precision movement of mirror unit controlled by computer.
- Camera controlled by computer.
- Integrated cold light source.
- Manuscript recorded with reflected and transmitted light.
- Simple to use.



The printing onto vellum was carried out at Factum Arte using a specially designed piezo printer made by Factum Arte. Extensive testing was carried out into the use of vellum, synthetic vellum and paper. Different coatings were tested and the results are included in this report.

Additional research included: a questionnaire to conservators posted on Stanford University Conservation Distlist, historical research and attempts to locate the missing pages. Some experiments with three dimensional thermal printing were also undertaken.

#### APIS (ADVANCED PAPER IMAGING SYSTEM)

The Advanced Paper Imaging System was designed by Ian Christie Miller and made by Solar Imaging in the UK. It is at an advanced prototype stage.

It consists of a wedge shaped box with a non-reflective glass opening and a front-coated mirror positioned at 45° to the plane of the glass. The system has two internal daylight temperature cold fluorescent tubes and a fan system to keep the inside of the box at a positive pressure minimising the problem of dust on the glass or mirror. The APIS is fitted to a rostrum mount with a touch-sensitive motor to change the positioning of the system and ensure there is no danger of applying pressure on the spine of the book. The book is held in a foam-lined 90° book cradle. This cradle is mounted onto tracks so it can be moved easily to exactly position the page.

The system was fully tested before the recording and test photographs were taken both with and without the APIS to facilitate direct comparison.

The APIS works very well and offers an important safeguard to the manuscript and its binding. However several modifications could be made to improve its performance and ease of use.

It was observed that the glass and mirror of the APIS filter some of the colour, particularly the blue. The refraction of

glass is known to have this effect. More research needs to be carried out to establish if the non-reflective coating adds to this problem. Once the parameters of the problem have been investigated software could be written to correct the colour balance.

The book cradle requires further modifications to ensure that the spine is fully supported at all times. This could be achieved by fitting a curved foam wedge into the bottom of the cradle and re-designing the shape of the cradle. Contact was made with Alan Buchanan, (Conservation by Design, UK) who designed the Preservation Book Cradle. This is a complex book cradle, considered to be the best book cradle for handling rare and fragile manuscripts. It offers complete support to the spine at every angle.

The size of the glass and mirror should be increased to give a bigger capture area and the lights need to be positioned further from the mirror. Optimum results are achieved if the white light balance test has a uniform measurement of 220-222 (RGB optimum white light balance as specified by Phase One). We recommend flexible fittings for the lights so their position can be adjusted. An additional problem was that the lights caused a green flare on the image as they were reflected by the mirror. The solution to this problem was to tie the lights back to the side of the APIS.

The system needs to be designed so that the lens fits inside the hole at the top of the system as the system works better if there is no ambient light. The strength of the Rostrum mount needs to be increased to ensure the system stays in the desired position with no vibration.

## PHOTOGRAPHY

Initial tests with the Phase One H20, Phase One H25 and Solar M3 were carried out in Factum Arte's workshop using a Moroccan manuscript from the 18th century. The results of these tests were presented to Red.es and the Biblioteca Nacional in mid November 2003.

One week was spent in a designated room in the Biblioteca Nacional setting up and running further tests which resulted in approval of the quality of the work between Red.es, the Biblioteca Nacional and Factum Arte. The manuscript was recorded between the 12th and the 21st December 2003.

Observational notes were made about each page as it was recorded. The reflected light was captured first, followed by the transmitted light. All settings were checked for each page and the focus was checked every five pages. The recto of each sheet was recorded. The book was then turned and the verso recorded. Everything was kept constant during the recording.

The camera was mounted to the rostrum above the APIS. The lights were then adjusted to achieve an overall even balance of light. The balance was tested using a feature in the Phase One software which allows the user to select and measure a specific point in the image area. An even balance was determined by taking readings in each corner and the middle.

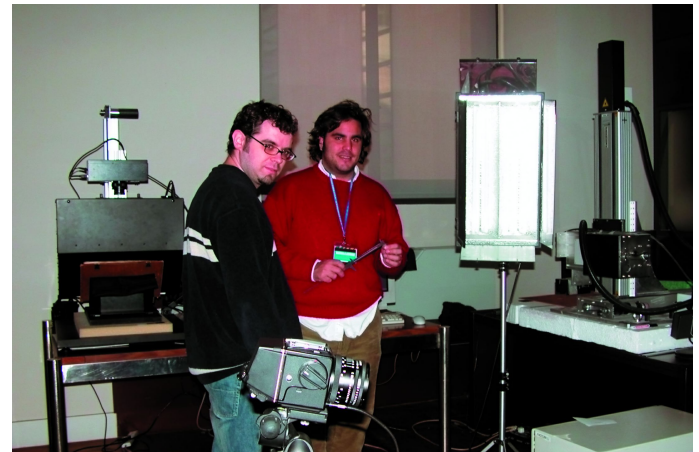
## FOCUS

The camera was focused on the image using a loop through the view finder as well as the built-in focus checker in the Phase One software. The focus was checked during the recording after every five pages and adjusted if necessary. Negligible sharpening was applied during the recording.

#### CONTRAST AND EXPOSURE TIMES

Tests were carried out to determine the best settings for the camera and the software to ensure that the information recorded was correct in terms of detail and colour accuracy. These settings are controlled through the settings on the camera and the settings in the software and once established were kept constant.

In addition to fixing these parameters a Kodak colour bar and a grey scale were used to calibrate the camera and were present on every photograph for use in post processing. The use of colour bars (industry standard colour reference) in the photographs provides a fixed reference which can be referred to on screen or during printing and allows the file to be accurately matched to the colour reference swatch when direct comparison is not possible. The colour bar and grey scale were fitted to both the inside and the outside of the glass in order to allow us to calculate the filtering effect of the mirror and glass on the colour. A linear measure was also included in each photograph.



Factum Arte's equipment installed in the room in the Biblioteca Nacional where the manuscript was recorded.

### SETTINGS USED IN THE SOFTWARE

The settings used in the software effectively replace the control that is applied to conventional photography during the process of developing the film. With digital photography this is done in the software and the quality and style of the image is controlled at this stage. Once finalized, the same settings were used for the transmitted and reflected light. The settings are applied at two stages in the process; firstly during capture and secondly during developing or output.

*Phase One H25 Outdoor daylight (colour) - ISO – 100 ASA*

*Output workspace. Adobe RGB (1998)*

*White balance set at 220 R 220 B 220 G*

*Colour Temp 5000K*

*No Lens Cast Correction*

*Focus – Soft Look – amount 34 with a threshold of 3*

Each image was developed through the Phase One software to a specific format. Whilst it is possible to process the files with a number of additional features it was decided to keep the master files uncorrected and adjust later as required. The settings used for output are as follows:-

*Scale: 100%*

*Pixel size: 5440 X 4080*

*Resolution: 300dpi*

*File type: TIFF*

*Bit depth: 16Bit*

*Final file size: 127MB*

*Camera settings using the APIS*

*Camera: Hasselblad 502W*

*Lens: Hasselblad 50mm*

*Digital back: Phase One H25*

*Camera setting: Reflected light*

*Lens aperture: F16*

*Speed : 1/2 second*

*Camera setting Transmitted light*

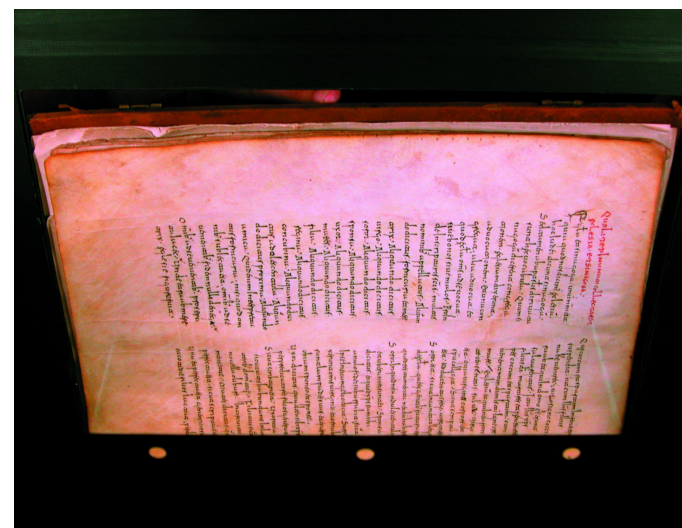
*Lens aperture: F5.6*

*Speed: 1 second*

The only difference between the recording of the transmitted light and the reflected light are the aperture and speed settings on the camera.

A number of tests were carried out using the Solar M3, a camera made by Solar Imaging in the UK with Schneider digital lens and Silverfast software. It uses a large format 30 megapixel scanning back and records a page at high resolution in 20 seconds.

The colour range and resolution of the data captured with the M3 were significantly better than the data captured with the Phase One. High speed scanning backs like the M3 are well suited to certain types of work and are used by the Public Records Office (UK) and many other institutions. Solar also make a high resolution version of this camera, the Solar M5 which can capture 100 megapixels of information. However the time taken to capture the image is increased and the resulting files are about 1 gigabyte for a 25x35cm capture area.



An image of the manuscript seen from the inside of the APIS.

## POST PROCESSING

This is a simplified account of the complicated task of preparing each page for both screen based uses and printing. All the work was carried out at Factum Arte unless otherwise stated. The following equipment and software were used to post process the data:

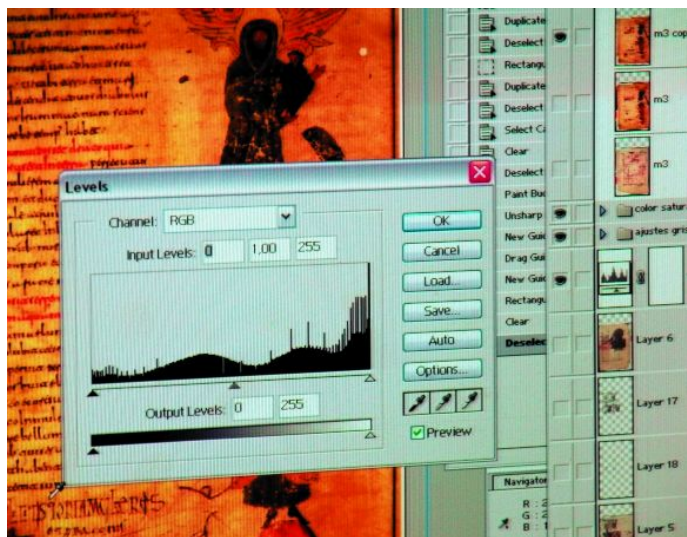
*Macintosh G5*

*Mitsubishi 21inch monitor, Diamond Pro 2060U*

*Adobe Photoshop 7.0*

*Pentium 4 PC ( this was only used for the metadata)*

The files were processed as per requirements (all process information is detailed in the Metadata). Each file was run through Photoshop and various corrections made. Once a process was determined a batch file was made containing all the actions required for the specific changes. This was then saved as a master. The batch process is run on all files in a group ensuring that all files are treated in exactly the same way. A different colour correction was applied to the reflected light and transmitted light files.



On completion of the batch process each section was catalogued and named using a proprietary programme called I-View.

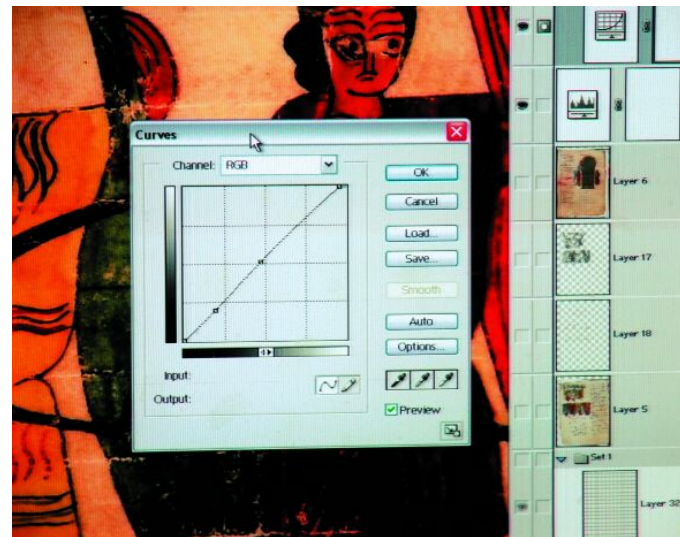
All files were opened in the application allowing them to be sorted and named easily. Low resolution output files can be created and printed as required. Once the files were completed the metadata was created and added to the related files. Everything was then archived on DVD.

### POST PROCESSING FOR SCREEN VIEWING

Working in SRGB, adjustments were made to the levels and saturation to produce an image on screen that resembles the original.

### POST PROCESSING FOR PRINTING

There is a fundamental difference between preparing images for screen and for print. All work was done using Adobe Photoshop. This work is dependent on an understanding of the software, the printer and the substrate.





## THE METADATA

The aim of the metadata is to facilitate the use of the digital data within a digital platform. Maintaining a library of digital objects requires maintaining metadata about those objects. The metadata required for the successful management and use of digital objects is both more extensive, and different from, the metadata used for managing collections of physical books. The aim of the Metadata is to aid the dissemination of the digital information for academic and commercial purposes. In preparing the metadata the demands of the end user need to be considered. Most of the people using this data are searching for information, they are not necessarily computer experts with access to sophisticated equipment. In order to maximise the use and applications of the data it is desirable to follow accepted library standards wherever possible. While there are few internationally accepted standards there are various institutions who are leading the way and whose lead is followed. The Library of Congress and the British Library are both leaders in this field. They offer clear guidelines for the preparation of metadata for library and inter-library use.

The digital platform (in this case Red.es) stands between the provider (Factum Arte) and the front end (the user). The first task is that the digital platform has to be well conceived and designed to facilitate access by the users that have been identified. Until this has been done the platform cannot function to its full capacity. All the applications of the data need to be studied, identified and catered for. Once the platform has been designed a series of applications need to be created to facilitate the introduction of the metadata. Various tools and a good knowledge of XML programming are required to create the metadata.

The Library of Congress has developed METS (a digital Library Federation initiative) which provides an XML document format for encoding metadata necessary for both the management of digital library objects within a repository and the exchange of

objects between repositories. It contains an encoding format for descriptive, administrative and structural metadata for textual and image based works.

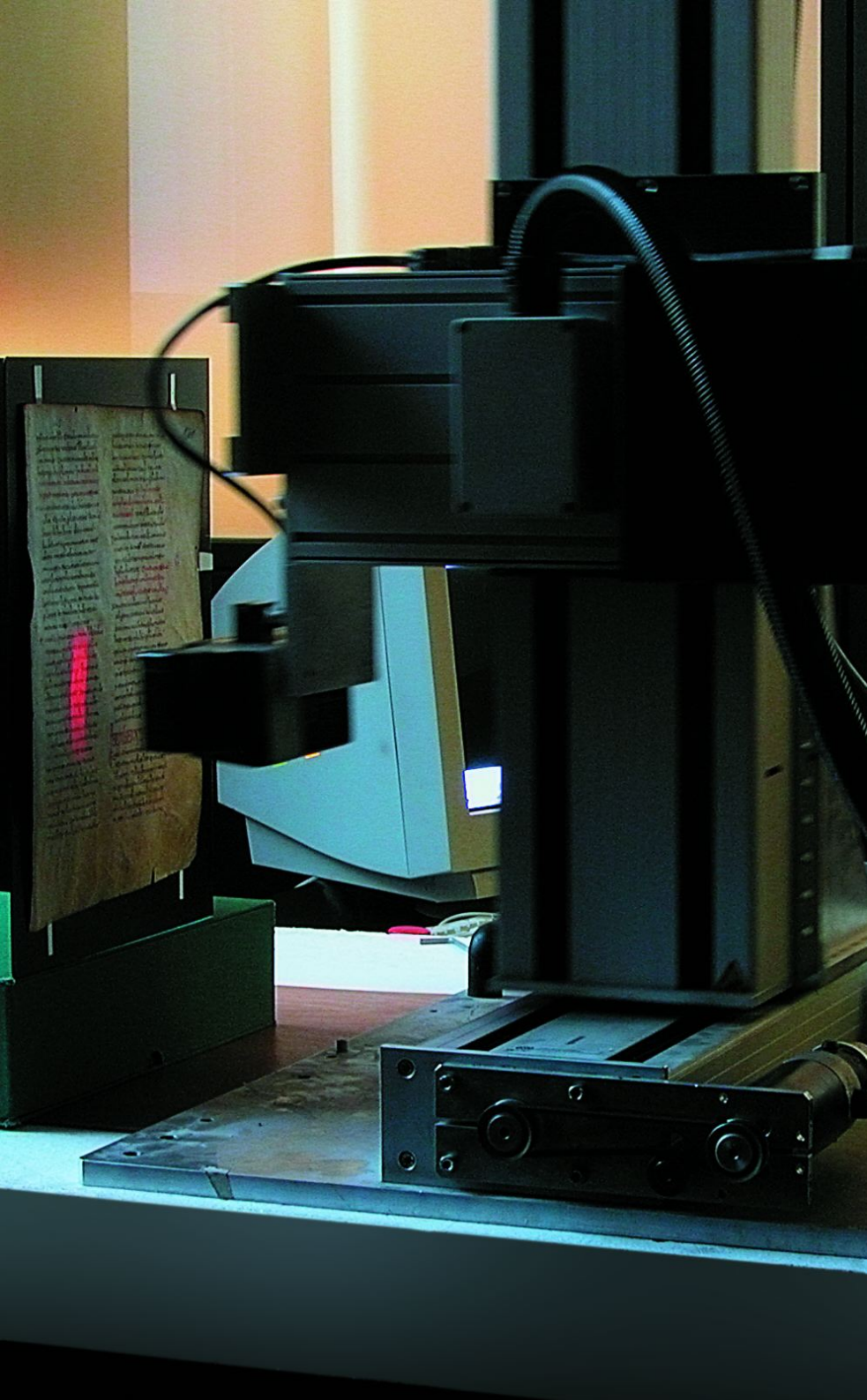
METS consists of 7 major sections - a METS header, descriptive metadata, administrative metadata, file section, structural map, structural links and behaviour. METS has been designed for library and inter library use. Dublin Core is the system used within METS to tag the digital information with a pre-selected list of properties that define the characteristics of the physical object.

When preparing the metadata Factum Arte encountered a number of difficulties:

The guidelines failed to accurately identify the nature of the digital object and as a result the metadata is over-complicated. Each page of the book has been identified as an object which runs contrary to common sense and generates an abundance of repetitive information. The important characteristics of the manuscript were not correctly identified and as a result neither the manuscript as an object nor the manuscript as a repository of information are adequately accounted for in the metadata. More descriptive metadata would add to the usefulness of the digital files and highlight the content of the manuscript but this requires the skills of a trained librarian.

The complexity of an un-translated manuscript text in Latin makes it difficult to extract the meaning of the text. Written descriptions of the images and the notations about the variations between this and other copies of Beato are of particular relevance to scholars and should also be identified in the metadata.

The digitisation of Cultural Heritage is a specialised area and a bridge needs to be constructed between the objects in their physical state and the objects in digital form. The digitisation of the object is the first stage. The description of the content is another task requiring different skills.



### 3D SCANNING

One page of the manuscript and the binding were recorded using Factum Arte's Seti scanner. This was done at a resolution of 100 microns. The resulting point cloud is used in its raw form with no meshing or optimising. For the purposes of study it is essential that the data retains its objective integrity and is not altered in any way. It is often hard to predict what can be learnt from new recording methods but, since the development of photography, different objective recording methods facilitate an increasingly intimate understanding of the nature of the physical object.

The results obtained from recording both sides of the page provide important data that facilitates an understanding of the nature of the sheet. The punched holes and scored lines are clearly visible and reveal that the lines were scored from the skin side of the sheet. There is a clearly visible indent showing the pressure on the nib of the pen and much of the text can be seen in the 3D data. The half chalk ground, brush marks and damage are clearly visible in the illuminated areas. Creases, holes and surface undulation are also recorded and give a good impression of the condition and character of the sheet.

The scanning was carried out in the Biblioteca Nacional. Recto and verso of folio 131 were recorded. This is the loose sheet. It was removed from the manuscript and fitted to a board using conservation fasteners. It was scanned in a vertical position. Small modifications will be required to the scanner to record pages that are bound into the manuscript. The front and back covers, spine, and edges of the book were also recorded using the Seti Scanner.

When the 3D information is coupled with the colour data and printed the results have an enhanced realism.



Folio 131, verso.

A black and white rendering of the 3D data recorded with FactumArte's Seti Scanner at a resolution of 100 microns.



Folio 131, recto.

A black and white rendering of the 3D data recorded with Factum Arte's Seti Scanner at a resolution of 100 microns.



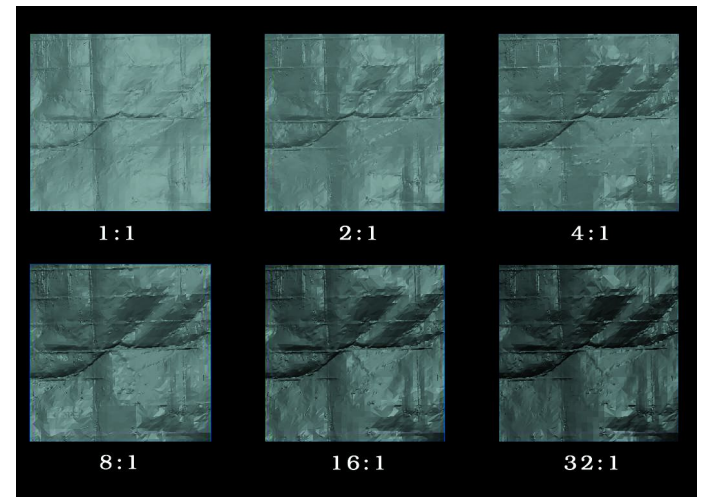
The Matsuura MC-800VF at work in Delcam's tool room.

## ROUTING THE 3D DATA

All routing was carried out by Delcam UK using a Matsuura router and cutting tools of varying diameter and shape. Both sides of folio 131 were cut at a resolution of 100 microns. The data from Factum Arte's Seti Scanner was prepared using Delcam's PowerMill NC software and was then cut on a three-axis Matsuura MC-800 VF Vertical Machining Centre using a spindle speed of 15,000rpm. The material used was Alchemie Modelling Board 959W, which has a density of  $1.2\text{g}/\text{cm}^3$ . The CAD data translation and preparation was carried out by Tony McKenzie and Dave Cooper, with NC programming and machining by Steve Taylor Toolroom supervision was by Gary Mills and the job was managed by Brian Hawkshaw.



Routing tests with varying degrees of distortion to the Z axis to exaggerate the relief. The surface is very subtle and the exaggerated Z axis facilitates a detailed study of the superficial characteristics.



Visualisations of the distortions to the surface of the sheet of vellum manipulated in Delcam's Power Mill software.

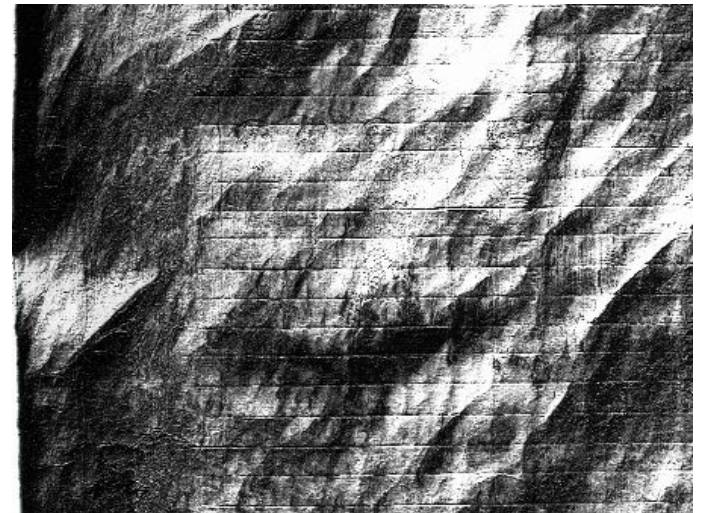
## ZYCHEM PRINTING IN 3D

In addition to the routing, tests were also carried out using Zy-Tex Tactile Paper and a Zy-Chem Heat Printer. This system was designed for printing Braille. The paper is first printed with a black pigment and the sheet passed through the heater unit. The black ink absorbs more heat than the white paper and the surface swells to a height of one or two millimetres as the process works by thermal expansion. Tactile prints can therefore be produced from both 2D and 3D data. It is very difficult to control the expansion with any precision. However, the results are very promising and resulted in a tactile print. The resolution is not as high as the routed data and the depth of the relief cannot be controlled but this approach has important implications as a tactile display for the visually impaired and as a didactic display device. With further research this approach could be an important application for the data recorded.



Folio 131, verso.

The 3D data is cut into a sheet of high-density polyurethane at a resolution of 100 microns.



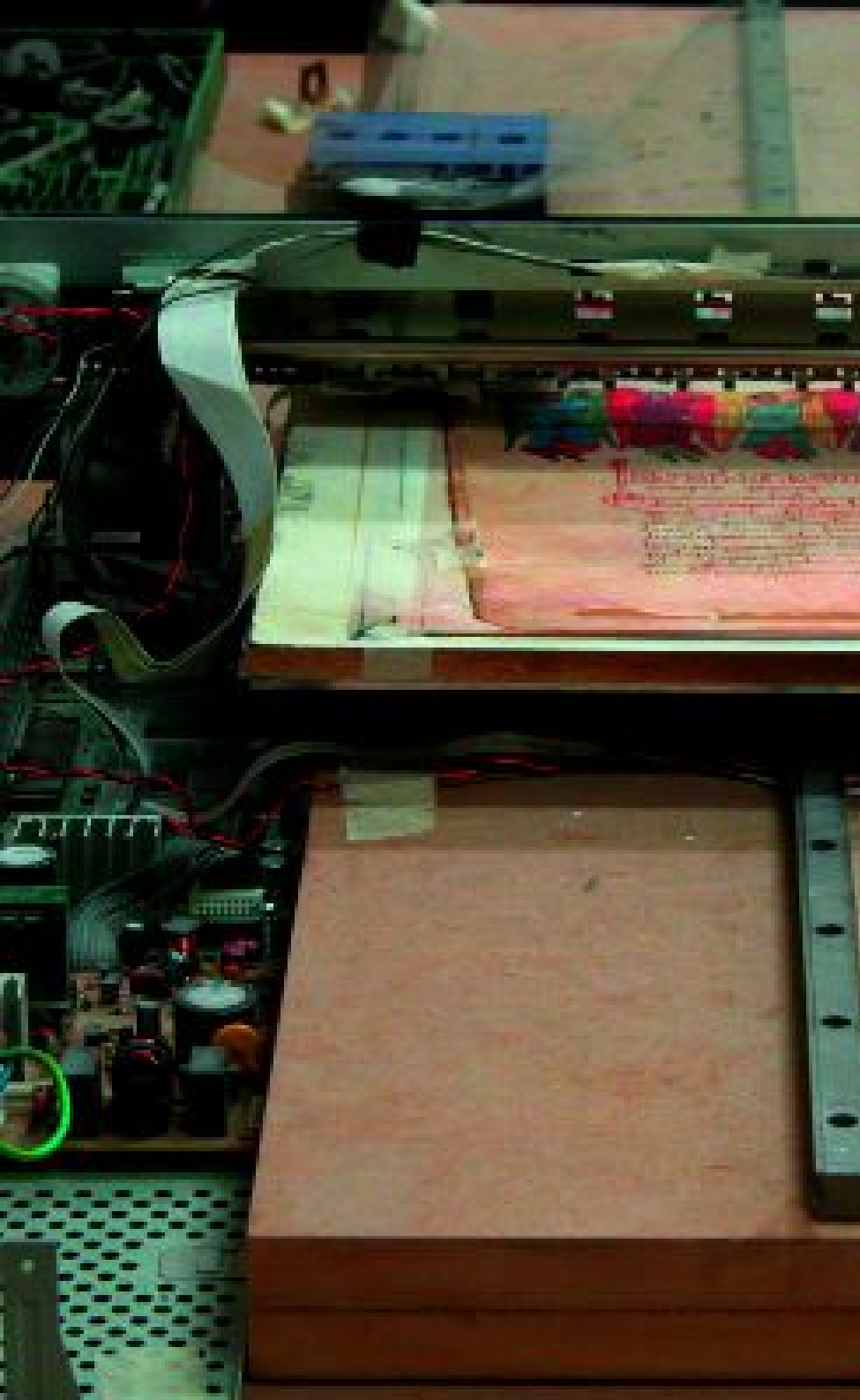
Detail of the Zychem print

THE PRODUCTION  
OF THE FACSIMILE

## PREPARATION OF MOULDS & MATERIAL TESTS

All moulds were made at Factum Arte using liquid silicon as the moulding material. The mothers were made in plaster. The moulds were made directly from the routed blocks. Dimensional distortion is minimal in the moulding stage and plaster supports were made to keep this to a minimum. Plaster positives were made from the moulds and compared directly with the routed blocks.

In order to make the double sided sheets both sides of the sheet were scanned. A cast from each side was taken and made into a two piece mould. A sheet of vellum was placed between the two moulds and clamped in a nipping press.



A selection of silicon moulds in the casting workshop.

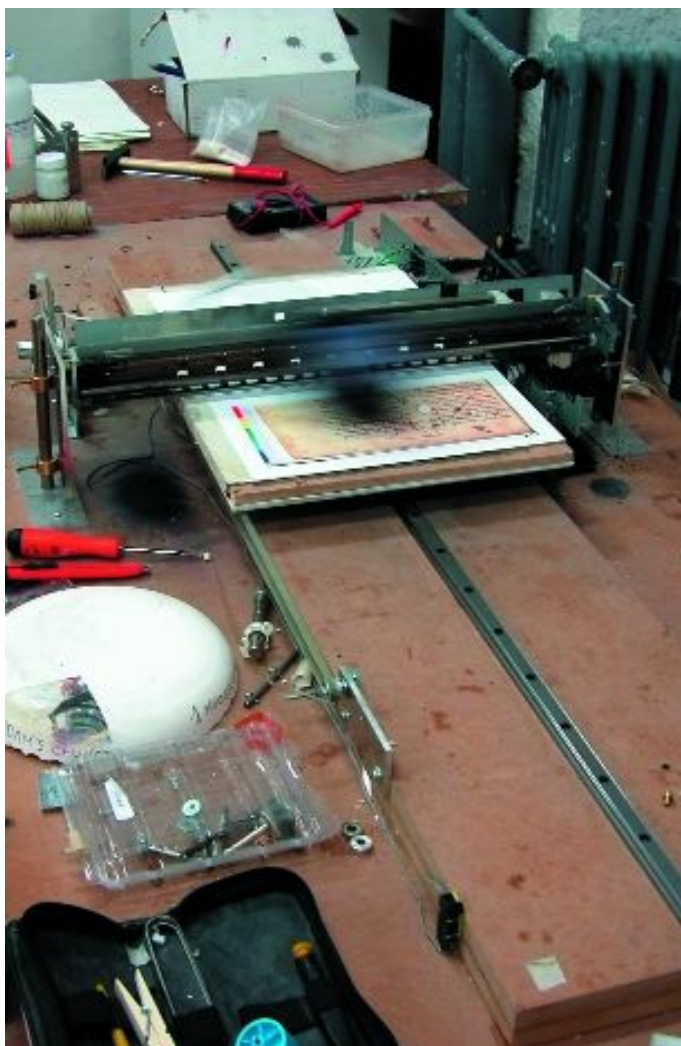


The male and female mould of the surface of both sides of Folio 131.



Removing the double-sided cast from the mould. Tests were first made in plaster before the final vellum sheets were produced.

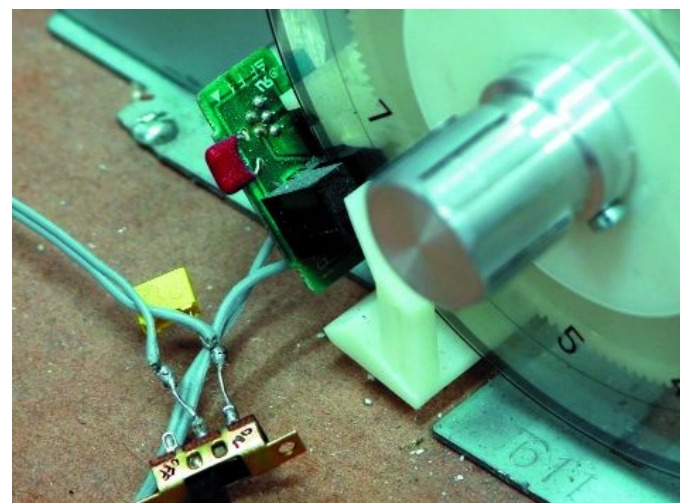




Factum Arte's Facsimile Printer is still at an advanced prototype stage but is able to overprint with great accuracy. The most important aspect of the design concerns to the movement of the bed in relation to the print heads. In order to control the subtle variations in the colour and sheen each sheet of vellum is printed several times.

## THE PRINTER

The printer is a modified Epson 2000P, piezo pigment printer that prints at a resolution of 2880 x 2880 DPI with a 4 picolitre drop size. The printer was completely stripped down and only the bridge, the firmware and the circuit boards re-used. A new bed was made that can be positioned and re-positioned with a tolerance of less than 5 microns. The bed is held on a linear guide and driven by a cog and belt system. A new encoder strip was made to control the movement of the bed in relation to the print heads. The essential design feature is the relationship between the movement of the bed and the print heads. The dimensional accuracy is such that a single pixel can be printed, the bed repositioned and the pixel overprinted so that it hits the same spot. There is virtually no dimensional distortion. This accuracy means that the same sheet can be positioned on the bed and overprinted changing the printing file each time to subtly modify the colour and sheen of the print. Tests were carried out between September 2003 and February 2004 and the prints were made in March 2004.




## PREPARATION OF VELLUM FOR PRINTING

Vellum is the preferred material for calligraphy. Printing on vellum, however is one of the greatest tests for any printer. Letter press has been used successfully for various editions and is notoriously difficult due to the varying surface characteristics and the movement that occurs as the atmospheric conditions change. It is necessary to print with the vellum damp to insure the ink takes well but this causes dramatic movement in the sheet. This effectively means that accurate registration is impossible without stretching the sheet and as a result lithographic printing can only be done on a flatbed press. Collotype has traditionally been the preferred print processes for the production of archival documents and high resolution facsimiles on vellum. Due to the necessity of a coating no inkjet printing has successfully been carried out on vellum. For this work Factum Arte carried out historical research and analysed the properties of vellum and different coatings.

Manuscripts prior to the 12th century used natural, slightly abraded vellum but no coating. By the 12th and 13th centuries coatings were becoming increasingly common. The aim was to give a better writing surface but it had the result that if the manuscript got wet the coating would wash off taking the text with it. In one of the most important early descriptions of the production of vellum Maximus Planudis writes to Melchisedek of Akropolis requesting that the vellum he purchases is not encrusted with egg.

*'Now you should never encrust these membranes with egg, for this is the very thing from which they suffer, the letters from the egg, that is, and not the parchment leaves themselves. For if they should somehow see water, the writing on them erupts and quakes with the egg, and the work of the scribe turns into air, clean gone. For the egg lies between the writing and the parchment leaf, and when it is wet it washes away, the writing with it.'*

*Maximi Monachi Planudis Epistulae,  
Ed Maximilian Treu Amsterdam: A.M Hakkert, 1960*



The coating has a tendency to crack and detach from the vellum, a phenomenon described in 13th century accounts of coated vellum. The final coating used is water soluble but is firmly bonded to the vellum.

## STAGES OF THE PRINTING

The first task was to locate a supply of vellum with similar characteristics to the manuscript. After extensive research the best supplier of vellum was found following conversations with Rob Hadrill at Book Works, London. The sheets used to produce the facsimile tests were made by Henk de Groot in Rotterdam. They are a goat skin vellum prepared using traditional methods. Henk de Groot is one of the few people producing vellum of a quality comparable to medieval vellum.

The sheet of vellum has two sides with different qualities. The skin side tends to be a rich yellow colour with a smooth surface and evidence of the hair follicles and a slight sheen. The flesh side is whiter, matt and can show evidence of the scraper used to remove the flesh. It normally has a slightly rougher surface. If the vellum is well prepared the differences are less dramatic but still visible. Both sides can feel slightly waxy. The oily and non-absorbent character of the vellum resists the ink and causes it to spread losing detail. If the surface is sanded the result is slightly improved but still unacceptable.

Tests were carried out using a number of special treatments in order to produce a surface that will accept the pigment printing ink. As documented by Maximus Planudis the main problem is finding a material that can be successfully applied onto vellum. The vellum has very specific characteristics and moves continually. Most materials will not have the same dynamic range and will crack or peel off the vellum as it moves or comes into contact with water.

The coating we finally used does have a tendency to scratch and can be removed with water. However if the sheet is kept dry and protected it should be stable. The main problems that were addressed were the spread of the ink, the drying of the ink and the colour gamut. Controlling the surface qualities of the print has also been an important consideration. Introducing natural variation, while it may differ slightly from the original page, enhances the realism of the facsimile.





Extensive tests were carried out to find a coating that does not alter the character of the vellum and that will print accurate colour without bleeding, reticulation or loss of information.

Following close analysis of the manuscript it was decided that a transparent coating was essential to keep the character of the vellum. In the original manuscript the areas with illumination are painted with a white ground. The surface of these areas is different from the text and raw vellum both in terms of intensity of colour and surface characteristics. The surface is brittle, matt and has a tendency to crack.

The following coatings were tried:

*AG555 – A commercially available coating made by Masterpiece.*

*Rabbit skin glue – varying strengths.*

*Glycerol with Rabbit skin glue – varying strengths.*

*Cellulose – varying strengths.*

*Wallpaper paste – varying strengths – this is similar to the cellulose but not a conservation material.*

*Gum Arabic – varying strengths.*

*Silica and Poly Vinyl Alcohol – varying strengths.*

*Silica, Poly Vinyl Alcohol and cellulose.*

*Mechanical abrasion.*

To whiten the vellum under the painted areas the following materials were used:

*Gesso – brushed and wiped.*

*Tempera – brushed and wiped.*

*Cellulose mixed with calcium carbonate.*

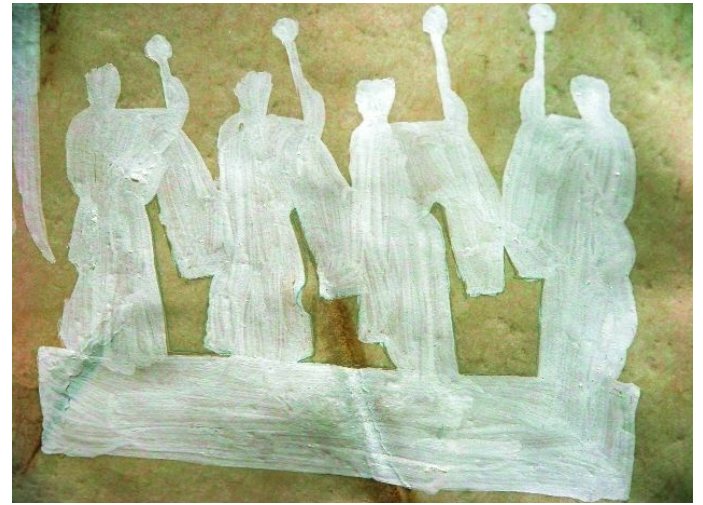
The white pigment was applied both under and over the cellulose and onto sanded vellum, raw vellum and vellum abraded with wire wool.

## THE PRINTING

Once the final coatings were selected the vellum was stretched onto MDF boards while damp. When the stretched sheet was dry and taught masks were made and the white surface applied to the areas with illumination. The coating was then applied with a brush and evened out using the palm of the hand. The vellum was then left to dry completely. Using a pin registration system an acetate overlay



The vellum is stretched to a sheet of board before coating. Once coated the surface is flat and taught.



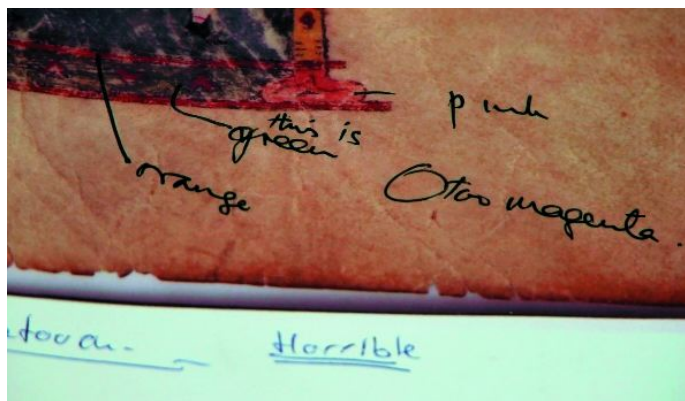
Using masks the painted areas are coated with a ground of gesso before printing. This not only enhances the colour but gives the surface another layer of complexity.



An image printed onto waxed paper and cut out to provide the stencil used to apply the gesso to the vellum



The vellum is positioned on the bed of the printer using a system of pin registered acetate sheets printed with outlines as a guide..



Print showing notes made in the Biblioteca Nacional while comparing the print on vellum to the original. Attention is paid to both the colour and to the character of the surface.

was printed with the outlines of the dominant shapes and the stretched vellum was placed on the bed of the printer in the correct position. As far as possible the vellum was matched to the original to ensure that the natural figuring and marks were as similar as possible to those on the original. The printer was then set up to print and a layer of corrected colour applied. Subsequent layers were then built up as required to produce the desired colour balance and the right density of colour. The colour proofing was done by making notes in the library and comparing the printed page to the manuscript.

Further improvements could be made by fitting a capillary feed system to the printer and printing matt and satin varnish to match the reflectivity of the surface to the manuscript.

Using the moulds one piece of vellum was embossed with the specific damage and creasing of the original sheet. This sheet was then printed on both sides. Ten pages were printed as single sided prints. Prints were also made on a simulated vellum, onto paper, and onto gesso coated aluminium.

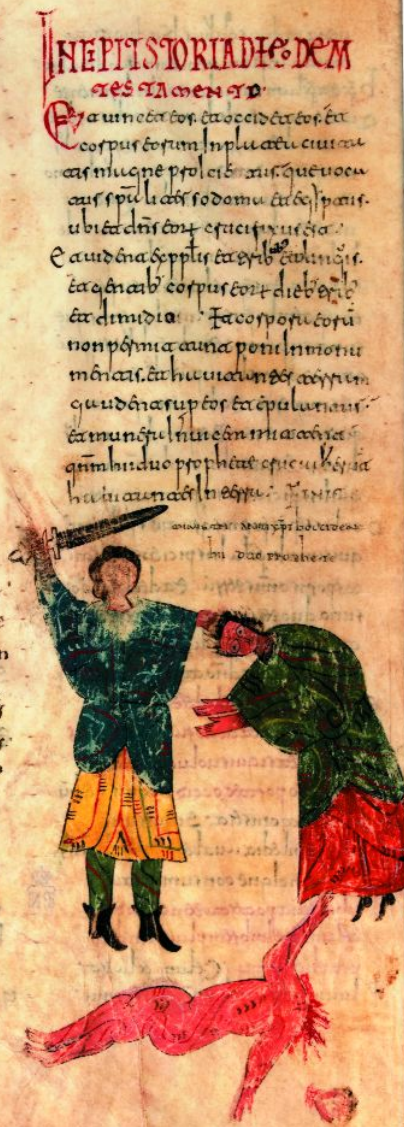




ADDITIONAL RESEARCH



lau cum multas cum iocundis su  
 bra du bolus in linnu ar po  
 pte nce occidit duos et dicit  
 etia ta quicunq; uera uisus  
 uulca puana cum elu gre  
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 e u m d i c a f i c u a u s d i c a r e t.  
 P r i u s q u a m d e f o r m u s a n l u s t e  
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 H i s t o r i a i n c a n a b p r o p h e t a u  
 n o n f u a. s e d s o l u i n s t i l.  
 I d e o u s b u m d i u s t u x n e c e s s e  
 h u b e r u a l n e a n a b i n a p r o p h e  
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 I d e o u d m o n u i a u a s i n u l i o l o q s  
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 d i x i m. n u n c u s b u t u d e n  
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 s p i r i t u a l i a d d i s t i p m u s.  
**E X P L I C I T E X P L A N A T I O**  
 e l i e e a s h e z e a r e.



## LOCATING MISSING PAGES

Since receiving the commission in September 2003 various attempts have been made to locate some of the illuminations that have been removed from VIT14.1.

From the library description we know that there are 18 pages missing at the beginning, 18 pages missing at the end, more than 30 independent pages missing, 16 pages badly damaged, 4 pages remain as fragments. In order to identify the exact content of the missing pages it will be necessary to study all the existing copies that are known to be complete and to identify the pages that are missing. The map, one of the most famous images in the manuscript is missing and it is likely that this page still exists as there is a community of map collectors who prize this image.

The initial research revolved around tracing the history of the manuscript from its time in the Monastery of San Milan until its arrival in the Biblioteca Nacional. We have been able to establish that it was removed from the monastery and taken to Burgos in 1821 along with other codices from the monastery. It then appears in the collection of Serafin Esteban Calderon. There appears to be no record of its condition when it was purchased and further research is required to establish the circumstances surrounding its purchase. It was not uncommon for the pages to be removed while in the monastery and it would be wrong to assume that the damage was caused to the manuscript between 1821 and 1886 when it was deposited in the library. However it does seem likely that the pages were removed during this time. Esteban Calderón who was a bibliophile of some repute, would have been aware that removing the illuminations would not only have damaged the integrity of the book but would also have significantly affected its value.

It also seems likely that he was responsible for the re-binding. Many of the pages appear to have been cut from the manuscript in its present bound state. The extensive water

damage on the first pages of the manuscript, and the fact that there are missing pages at the beginning and end of the manuscript suggest that it was at some point in very poor condition and the original binding had presumably been spoilt beyond repair. It therefore seems unlikely that Esteban Calderon was responsible for the removal of the images, but it should be noted that attitudes towards value, connoisseurship and care have changed over the years and many collectors removed pages to fix into their albums. On his death in 1867 Esteban Calderon's library became part of the collection of the Ministerio de Fomento and it was not until 1886 that it was given to the Biblioteca Nacional. We were unable to obtain information from the Ministerio de Fomento about its state when it arrived in their custody. We know the pages were missing when a condition report was prepared for the Biblioteca Nacional by Sanders and Bordona and written in pencil in the first page of the book.

The two academic texts that exist and refer specifically to the manuscript were consulted but contain no clues as to when the pages were removed. The most useful was Peter Klein's thesis in German. Experts like Sr. Sanchez Mariana and Marie Vitoria Alberola were consulted as was the monastery at San Milan. All referred us back to the two reports in the Biblioteca Nacional. Enquiries were made to various antiquarian dealers in an attempt to trace any loose pages from 10th century manuscripts that have been sold since 1900. We visited Sotheby's in Madrid and went through the archives there and were referred to Sotheby's, London. Following a correspondence with Sotheby's we received a reply from Camilla Previte, department of Western Manuscripts. In her reply she observed;

*As you are no doubt aware we are talking about one of the world's greatest manuscripts and I do believe we can be absolutely certain that if any of the missing leaves had ever been recorded anywhere that we and every major institution would know about them so sadly we cannot offer you any assistance in tracking them down.*



Folio 134, recto.

One of the many examples of mutilated pages where an image has been crudely removed. Further research is required to establish when these pages were removed and to locate any that may still exist. If found, the missing pages can be digitally recorded and re-integrated into the files and facsimile of the manuscript.

Despite this response, it is our view that some of the pages are likely to exist, possibly in a public collection but catalogued as drawings of unknown origin. While this sounds surprising it is not uncommon and discoveries of this kind are being made regularly.

## THE QUESTIONNAIRE TO CONSERVATORS

From July onwards Factum Arte started to address specific questions about which aspects of surface information were most important for conservators of manuscripts, prints and drawings. Preliminary conversations were held with Ali Conteh at the British Library and Christopher Clarkson, a world renowned authority on the conservation of Vellum.

On 12th December 2003 a message was posted on the Conservation Dist List. The initial response from the moderator, Walter Henry, was very positive describing it as a 'very important topic'. Sadly we received very little response although everyone agrees it is a subject of fundamental importance. The general view is that little or no work has been carried out on the subject and few institutions are equipped to carry out the work without significant research budgets. Perhaps the most interesting response came from Piers Townshend, head of paper conservation at the Tate, London. He is interested in being able to quantify the change that occurs to the surface of paper during washing.

The importance of the topic is confirmed in all the replies we received but there is so little published material that many academics feel unqualified to comment.

## SUGGESTED USES FOR THE DATA

VIT14.1 is a very important manuscript but it has too many pages missing and is in too poor condition to find a market as a straight-forward facsimile edition. There are several facsimile editions of Beato de Liébana in existence and while many of these are not as important academically they are more complete with brightly coloured illuminations.

There will be an audience for a specially prepared publication which will form a didactic exhibition for museums, institutions and libraries. It will also appeal to the community of collectors of vellum books and manuscripts. The quality of the facsimile prints is the key to the success of the publication.

Factum Arte proposes that the data is used in two ways: a publication and an exhibition. These two initiatives are separate but inter-related.

### A FACSIMILE PUBLICATION

A high quality version of the complete manuscript could be lithographically printed on parchment paper. This book could also contain a copy of the Latin text transcribed using optical character recognition software and accurately translated into English and Spanish. The typographic design and the relationship between the image and text will be critical for the success of this book.

VIT14.1 contains a number of illustrations. Many are missing but the ones that remain are of a very high quality and show a clear Arab influence. They are of great importance for scholars.

Ten images printed on vellum should accompany this facsimile book. They will be printed at the highest quality pushing the possibilities offered by new technology. They will be printed on vellum in pigment using Factum Arte's Facsimile printer which combines high resolution digital printing with additional over-printing in specially prepared colours and varnishes.

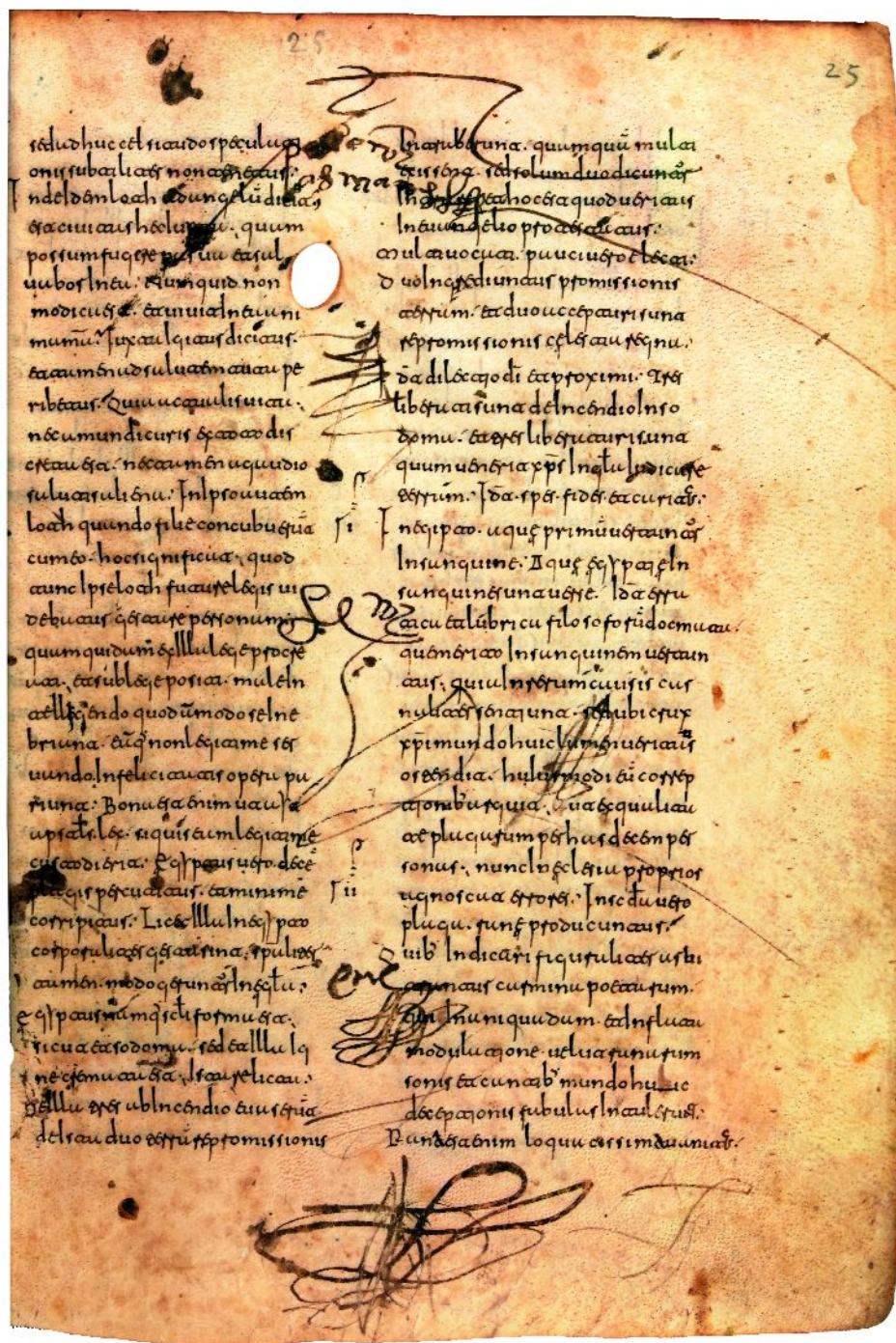
These ten images should be incorporated into the publication as loose sheets presented in window mounts. One page should be printed onto embossed vellum on both sides and could be accompanied by information about the laser scanning and an unprinted page showing the relief.

This publication will effectively be an exhibition in a box. The publication could also include the images and translation on disk. The complete publication will appeal to museums, institutions, collectors and specialists.

#### THE EXHIBITION

An interactive exhibition could be produced aimed at libraries and museums. The exhibition should be built specifically around the recording and dissemination of this copy of Beato and would seek to present the data in innovative ways. It should be an exhibition that aims to address questions of great importance to libraries and the bibliophilic community but it must also appeal to the general public. It should be an exhibition that mixes art, science and technology. It should be modular in design and could be offered to libraries for a reasonable hire fee. The advantage of the exhibition is that it could run for many years. Exhibitions of this type are rare but have proved very popular. The emphasis should be on:

- The history of the development of the Apocalypse.
- The history and story behind VIT14.1.
- Creating new methods of visualizing data to extend academic research and provide access to works in national collections.
- The development of new web interfaces to enhance the study and dissemination of the information.
- Interactive exhibition design incorporating both screen based and physical elements.
- A display relating to the method of image capture and photography.
- Display about vellum and printing onto vellum.
- The production of a broadcast quality film of 30 minutes.



norantim qui uocatur eos in con-  
pccatum diuino eode. Falpi-  
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ca ppropab' ad ca monum totu.  
carion dilicta una uim uis uis  
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**F** Caquum uis sic druco qui  
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tra mul'ctm que p'p'ha mur  
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ua uolupte In h'ctm In lo cu  
cuum ubi: nu d'ru. Ill' d'emp  
ca ca n'p'ru ca d'im' d'um d'cu  
p'ris u fucit r'p'raat:

**F** Ca m'ia s'p'p'at r'ostuo p'ora mu  
lic'cu aqua u' uelua flum'cu  
ua tum u' flum'cu u' f'p'ra:  
ca u d'labia ca'p'ru mul'ctm.  
ca u p'rua d'ru of f'um' ca  
u' r'or buia flum'cu quod m'ia  
d'ru co d'ro s'uo; Fal'rua u' r'ca  
d'ru col' m' mul'ctm. ca hab'ia  
fucit bellum cum r'iqu' r'oni  
m'ct' qui d'ru u'na m'ndu'cu  
di ca hab'ia p'ra m'oni u' l'hu' p'i.  
ca ca ca u' p'rua m'ru'is.

PLENISTORIAM IERAS  
ET PA. COMIS



## CONCLUSION

This research project has resulted in a high resolution digital archive of an important manuscript and a selection of facsimile prints on vellum and other substrates. The digital files have been archived as masters with derivative files in high, medium and low resolution, all complete with metadata tags. Using these files the manuscript can now be studied and its academic and historical importance realised. Optical character recognition software can now be used to transcribe the hand written Latin text into type. As this is considered to be one of the earliest copies of Beato's Commentary on the Apocalypse of St John a detailed study of the text is important.

The fact that all pages were recorded with both reflected and transmitted light is of great importance and significantly enhances our appreciation and understanding of this manuscript. This is particularly evident on Folio 127 (verso). This sheet contains a very beautiful illumination in which one figure has been over painted in white. Using the transmitted light it is possible to see this figure again and to access if it was over painted at the time or if its removal is a later change. The transmitted light facilitates a detailed analysis of the changes and modifications to the text. It is possible to see subtle differences not visible to the naked eye.

The experimental use of the APIS was very successful. The system allowed the book to be recorded without applying pressure to either the binding or the individual vellum sheets. The design of the APIS requires further modification but is an important innovation for the recording of rare and fragile books and manuscripts. Factum Arte is now in communication with Solar Imaging to discuss and implement the required modifications.

The results obtained with the Phase One H25 are very good. This is probably the best medium format digital capture back on the market. However the results obtained using the Solar

M3 are superior and better suited for the recording of the Beato. The research aspect of this project enabled us to run direct tests between different commercially available equipment and analyse the results. The main difference between the two cameras, apart from the price, is that the Phase One H25 is an instant capture back fitted to a Hasselblad body and the M3 is an integrated scanning back using Schneider optics. While the Phase One records in less than one second, the M3 takes about 15 seconds. Unless there are conservation issues relating to the added exposure we would recommend the use of the M3, or even the Solar M5, for future projects.

The three dimensional laser scanning has also generated some very interesting results. This is the first time that such high resolution laser scanning has been carried out on a 10th century vellum manuscript. The 3D data reveals many characteristics of the surface of the sheet that are not visible in conventional photography and could not be achieved by cross lighting or multiple light sources. The relief in the painted areas is clearly visible and the shoes of the figures and wings of the angels can all be clearly identified. The text can also be partially read and the impression of the nib and ink are clearly present. The undulation, creases and surface characteristics are also visible. Further work to modify the scanning system would be desirable if the whole manuscript were to be recorded in its present binding. One application of 3D scanning that became clear during the work is for the study and monitoring of fragile bindings, particularly bindings with blocking where there is a pronounced relief. Further research is recommended.

The printing onto vellum has been particularly successful resulting in some of the most accurate facsimile prints produced to date. The design and build of the flatbed manuscript printer has established a new benchmark for accurate digital printing and a great deal of interest has been

expressed in making the printer commercially available.

The results to the questionnaire clearly demonstrate that innovative high resolution digital documentation in colour and three dimensions is an important area of research for libraries and institutions. However, as there is little published material many of the specialists do not feel in a position to make a contribution to the debate. Further work, in the form of research and publications is essential. The task of locating missing pages proved unsuccessful but it is still our belief that some of the pages exist and that with more research they can be located. The location of even one page will be a major news event and of great academic importance. It is most likely that the map page still exists as maps from this period are highly sought after. We propose that an article, commissioned by *Mercator's World*, or a similar special interest publication, is the best way to proceed, both to raise awareness and to make contact with map collectors. Further contact with antiquarian book dealers is recommended.

A specialist publication about the work carried out will be important for the growing community of museums, archives and libraries involved in digitising different aspects of national heritage. Conferences and academic presentations are also important ways to disseminate the research.

This research project has been highly successful in terms of the results and innovative in terms of the recording and printing. Factum Arte will now add the skills and equipment that have been developed for the specific task of recording and printing Beato de Liébana's manuscript to the wide range of mediation skills that characterise the way we work.

Specialist Suppliers:

APIS: Ian Christie Miller

APIS and Solar M3: John Beckingham at Solar Imaging.

Phase One: Danish Photo

Materials consultant: Rob Hadrill at Book Works

Vellum supplier: Henk de Groot

Software development: Stuart Lock

DVD copying: MPO

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Christopher Clarkson for his advice on the conservation of Vellum, Colin Franklin for his advice on antiquarian books on vellum, John Purcell for advice on alternatives to vellum and the many experts who have generously provided information.

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