TECHNICAL ANALYSIS REPORT

Conservation of the Northern Lobe of the Sanctuary. Study of the materials and methods used during the various painting phases.

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Conservation and Documentation of the Wall Paintings at the Red Monastery, Sohag.

Sub-grant No. EAC-05-2006

Fall Mission: November 1, 2005 – December 20, 2006

The Egyptian Antiquities Conservation Project (EAC)
USAID Agreement No. 263-A-00-04-00018-00

Awarded to

THE AMERICAN RESEARCH CENTER IN EGYPT (ARCE)

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by the

USAID Program Office of Productive Sector Development / Office of the Environment
USAID / Egypt

April 2007

In collaboration with the United States Agency for International Development and the Egyptian Ministry of State for Antiquities

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1. Introduction: materials and methods

Consistently with the method followed in the study of pictorial cycles carried out during the previous research campaigns (November 2003 – February 2004; December 2004 – October 2005), in this last phase the sampling and the subsequent laboratory analyses were aimed at studying in depth the more problematic aspects that had emerged previously. Attention was concentrated in particular on the following points:

- check whether the light renderings on the ground floor, pertinent to the third phase, have a composition similar to that of sample number 20 taken in December 2005 and prepared (presumably lime stucco) and spathic calcite probably obtained by the grounding of carbonate rocks;
- define the executing technique of the paints applied over the light renderings on the ground floor relative to the third and to the last operating phase;
- acquire further data on the executing technique of the 4th pictorial cycle;
- study better the green wax drawings, in the third operating phase, checking to see if there is any painting reintegration using the encaustic technique ([1]);
- acquire preliminary information about the paintings of the warehouse, the external façade and the left transept of the north wall (equestrian from the 14th century), not yet being repaired or analysed in the laboratory;
- correlate the matter characteristics of various portions of the painting in order to acquire data to confirm or deny its belonging to the same operating phase.

The following methods were used to study the samples:

- preliminary examination of all samples by stereomicroscope;
- preparation and study of polished cross sections under reflected light with microchemical and histochemical tests;
- infrared spectrophotometric analysis (FT-IR: *Fourier Trasformated Infrared*).

Roma 24/04/2007 Dott. Domenico Poggi

[1] In particular, in addition to the nature of the construction materials we would like to see if even for the 'greens' there was at least one maintenance operation closer in time, such as the one documented in sample 10 taken in December 2004 and analysed in the September 2005 report, where two pink layers were found, both of them based on Madder Lake dispersed in a beeswax medium, separated by a level of soot.

2. Processing, summary and interpretation of analytical results

2.1 Pictorial cycle relative to the third phase

2.1.1 Ground floor, nature of light renderings pertinent to the last phase

The light renderings of samples 7, 9, 10 and 11 were quite similar to sample 20 taken during the December 2004 campaign. They were made with mortar obtained from mixing lime and limestone 'dust' to produce an effect similar to white stucco that imitates marble ("*false marble*").
The sub-rounded morphology of some of the limestone granules and the presence, though slight, of reddish rings of iron oxide at the edges show that the aggregate limestone based, was obtained, at least partially, by selecting and fragmenting a type of sand (or fine gravel) limestone based. Regarding the degree of evolution of the granules, it could be a sand that was formed by the erosion of limestone rocks and by their sedimentation after a brief move (for example, by temporary transient torrents that flow in the "uadi"). This type of limestone and, hence, the sands formed near it, are found in various areas near the Nile in mid-north Egypt ([2]).
In sample 10 it seems that in addition to the limestone dust, a very few vegetable fibres were used as aggregate.

From the information acquired by studying the polished cross sections (see for example sample 11), the stucco based on lime (or light rendering) and alabaster limestone 'dusts' appears to have been made over a previous lime plaster and siliceous sand, at times with vegetable fibres (sample 12).
Therefore it is difficult to establish whether the stucco can actually be correlated to the third pictorial phase or if it is rather a noble rendering, limited only to the ground floor, present already in the second executive cycle (see the stratigraphies of the samples referred to the 2nd executive phase in the February 2004 report).

2.1.2 Ground floor, pictorial layers on top of the white "false marble" light renderings (or stuccoes).

The red background areas behind the north 'conco' columns were done with thin pictorial layers based on ochre haematite-red ($Fe_2O_3.nH_2O$ - Fe_2O_3) applied to the plaster while still fresh (samples 7 and 9).
The green floral motifs of the South Dom and the East Dom (samples 11 and 12) appear to have been done by dispersing a copper pigment (quite likely verdigris) in a beeswax binder, with the encaustic technique. The green layers, like the red ones made with the '*a fresco*' technique, are in direct contact with the *stucco* and limestone 'dust'.

[2] www.eeescience.utoledo.edu/Faculty/Harrel/Egypt/Quarries/Softst_Quar.html

2.2 Orange background in the 4th executive phase

In the South 'Dom', right central area, near arch near the arch dominating Saints Luca and Matteo, a fragment was taken from the orange background over Saint Luca and analysed in cross section with microchemical and histochemical tests.

The analysis showed that the following were applied in sequence over the white wash based *scialbo*: a discontinuous layer, very dark, based on lamp black, dispersed in an organic medium that is probably proteinic; a greyish drawing of preparation made with a proteinic binder probably mixed with a fine gypsum filler, a little lamp black and a slight amount of jarosite [$KFe_3(SO_4)_2(OH)_6$] and/or natrojarosite [$NaFe_3(SO_4)_2(OH)_6$]; an ochre-orange pictorial layer based on jarosite (and/or natrojarosite) dispersed in a proteinic type of organic medium. The proteinic nature of the surface layers (numbers 3, 4 and 5) was deduced by the results of the histochemical and microchemical tests. The function of the black layer seems to be the 'base coat' over which the various polychromies were applied (see the pictures of the sampling area).

2.3 Green wax drawings relative to the third executive phase and frequent painting reintegration made with the same technique

The green wax pictorial layers are characterised by the same composition, since they were made by dispersing verdigris in a beeswax medium. Regarding the type of support, they are directly applied to the plaster when the plaster is made up of lime and limestone dust (samples 11 and 12), or on top of a *scialbo* if the underlying plaster is made up of lime and siliceous sand. This latter is the case of sample number 1, taken from the green motif at the base of the tympanum in the 2nd niche of the transept on the 1st floor of the East 'Dom'.

In sample 1, even though it was taken just a few centimetres from sample 10 analysed in the September 2005 report, no presence of painting reintegration was found ([3]).

2.4 Paintings in the warehouse

2.4.1 Stratigraphy

The two fragments including the plasters were taken from the south wall, respectively from the lunette (5B), from the edge of the decimetric gap on the chest of Christ, and from the veil on the southwest side (6), from the edge of a lesion.
In both of them there was a similar stratigraphic succession, including a base plaster, a lime based preparation layer, the pictorial layers applied '*a fresco*', a further intense gypsum based preparatory layer and, lastly, the painting reintegration layer.

[3] In sample 10 from 2005, two pink layers were found, both of them based on Madder Lake dispersed in a beeswax medium, separated by a level of soot.

2.4.1 Plasters

The two fragments including the plasters were taken from the south wall, from the edge of the decimetric gap on the chest of Christ (5B), and from the veil on the southwest side, from the edge of a lesion (6).
Both samples are characterised by the same type of plaster, made with lime, sand that is prevalently siliceous and a small quantity of very fine granulometric (variable between 0,05 and 0.2 mm) brick dust. The granulometric characteristics (extreme dimensions of the granules and their degree of selection) and structural characteristics (volumetric relationship between the binder and the aggregate) are quite similar in both samples.

2.4.2. Preparatory layers

The first of the two pictorial phases documented in the two samples (5B and 6) is characterised by the presence of a white application of lime, applied as a preparation for '*a fresco'* painting (see below).
The painted layer of the more recent phase (painting reintegration) was spread over a gypsum preparation, realized "dry made" *(a secco)* by several applications.

2.4.3. Pictorial film of the oldest phase

The pictorial layer was applied '*a fresco'* on the lime based preparation, dispersing ochre haematite-red (Fe_2O_3 - $Fe_2O_3.H_2O$) to obtain red colourings, and a mineral of the jarosite group to produce yellow colourings.

2.4.4. Pictorial film of the more recent phase (painting reintegration)

The red and yellow painting reintegration was realized using the same pigments (ochre red-haematite and jarosite) used in the paintings underneath but with protein type of binders

2.5 Paintings on the external façade and the left north wall (equestrian from the 14th century)

On the external façade, from the cornice of the arch of the 1st niche from the left, two samples were taken a few decimetres from each other.
The stratigraphies seen in the study of the respective polished cross sections show a much different sequence.
The first one, 13-A, is made up of the following layers:
1) dense white *scialbo* lime based;
2) dense gypsum based layer, animal glue and very little fine calcium carbonate; applied in two coats: the first slightly pink due to the presence of fine haematite particles; the second reddish-yellow due to the presence of jarosite and, toward the top, little haematite;
3) thin haematite-based red layer applied at the same time as the preceding one;
4) discontinuous slightly translucent pictorial layer, light yellow in colour, with heavy 'craquelure'. It is made up of jarosite probably dispersed in a proteic medium, maybe egg-based.
The second stratigraphy, 13-B, was found to be made up of the following layers:
1) plaster, based on lime and sand of a essentially siliceous type, in two applications (1A and 1B), of which the latter coloured with jarosite and/or natrojarosite;

2) pictorial layer in yellow (number 2) realized '*a fresco*' dispersing minerals of the jarosite group in water (or water lime).

Regarding the type of layers included in each of the two sections, sample 13A could have been taken from an area that was the object of repair works. Sample 13-B should represent the original phase.
In the left transept, north wall, from the edge of the painting of the equestrian of the 14th century, the microstratigraphic study on cross section displayed the following stratigraphic sequence:

1) plaster based on lime, vegetable fibres (F) and siliceous sand, prepared with two layers, the last of which is relatively thin (with a thickness about 0.2 mm), and serves as preparation;
2) the red pictorial layer with purplish tones (number 2) based on haematite applied "*a fresco*".

2.6 Altered Fixatives - protective agents and particulate levels

On the third phase pictorial layers and on the underlying second phase there is nearly always a thin blackish level due to soot produced by the church lighting systems and/or by the combustion of essences during ceremonies. The soot is often mixed with or preceded by wax-based protective agents.

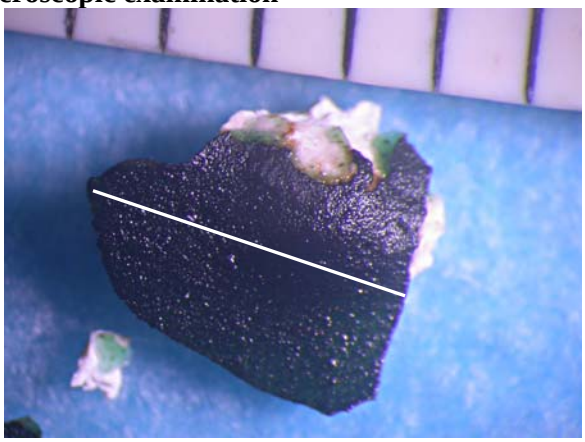
4. Analytical Sheets

Sample n. 1

Sampling area

East "Dom", transept, 1st floor, 2nd niche, base of the tympanum, green motif. The sample was taken by bistoury just a few centimetres from where sample 10 was taken, analysed in the September 2005 report. The sample consists of a few small millimetric flakes comprehending the white preparation and the pictorial film.

Preliminary stereo-microscopic examination



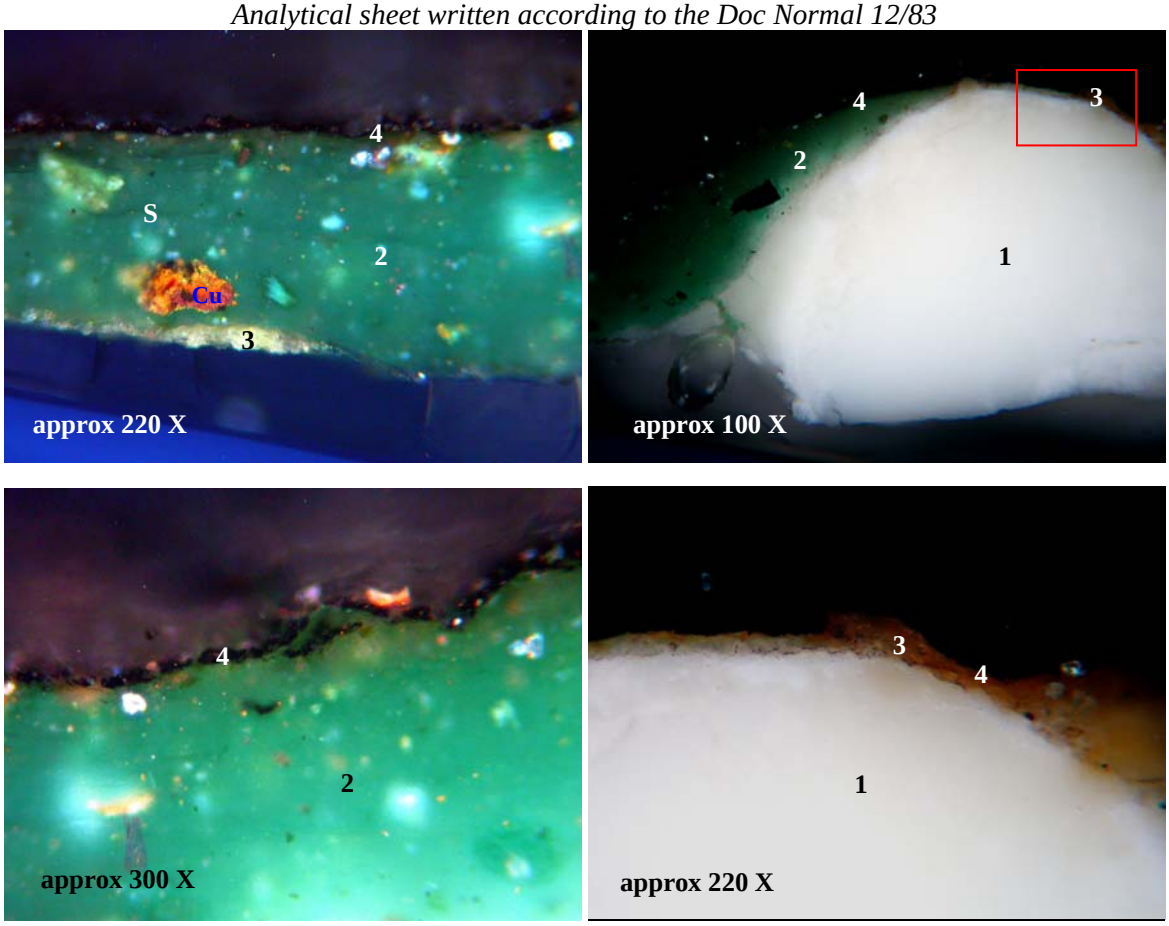
Stereomicroscope, reflected light, approx. 14 (photo on the left) and 22 X enlargement, respectively

The image on the left shows the internal side of the scale used to prepare the cross section. The image on the right shows the surface of the same scale.

The black and red segments on the scales approximately show the cutting line of the cross section prepared for the microstratigraphic study and described in the following pages.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests

Analytical sheet written according to the Doc Normal 12/83



Cross section, reflected light

The four images were arranged to highlight all the layers, somewhat discontinuous, observed in the study of the cross section. In particular, the image on the upper right, with medium enlargement, shows the entire stratigraphic sequence. The dark green (no. 2) pictorial layer, made by dispersing verdigris in beeswax, was applied over a dense whitewash (no. 1). On the upper part, a discontinuous brown translucent layer (no. 3), attributable to a protective wax base, followed by a slight level of soot (no. 4: particulate). This last layer and the other more external layers are better documented in the following further enlarged images. The one on the upper left shows the continuation of the green pictorial layer. At its base, a strip of the protective agent based on wax (no. 3) penetrated between the pictorial layer and the white preparation (compare also with the image under the stereo microscope). The green pictorial layer is partially divided by a continuity solution (S) and includes a small fragment of copper (Cu [4]).

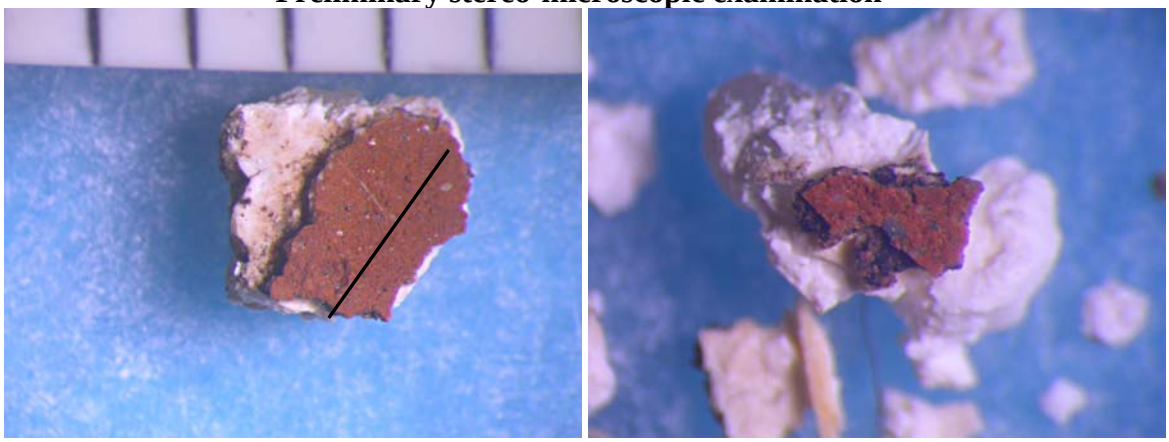
The two lower images show layers 3 and 4.

[4] The presence of metallic copper residues confirms the use of verdigris. Verdigris (copper acetate) was prepared by placing sheets of copper in contact with vinegar vapours (concerning this, see in "B. Provinciali, A.M. Marinelli, U. Santamaria, D. Poggi – 2006, "Histoire de la fabrication et de l'emploi des pigments noirs à base de carbone produits artificiellement; expérimentation pour la fabbrication artisanale. Comparaison avec les pigments industriels". In Couler & Temps. La couler en conservation et restauration, 12° journeè de la SFIIC, Paris, Inst. Nat. du Partimoine – 22 – 23 juin 2006, Ed. SFIIC – Champs-sur Marne)

Sample n. 2

Sampling area
South 'Dom', centre right area, arch above Saints Luca and Matteo. The sample was taken by bistoury from the orange background above Saint Luca. The sample consists of a few minute millimetric flakes that include the rendering and the layers above it.

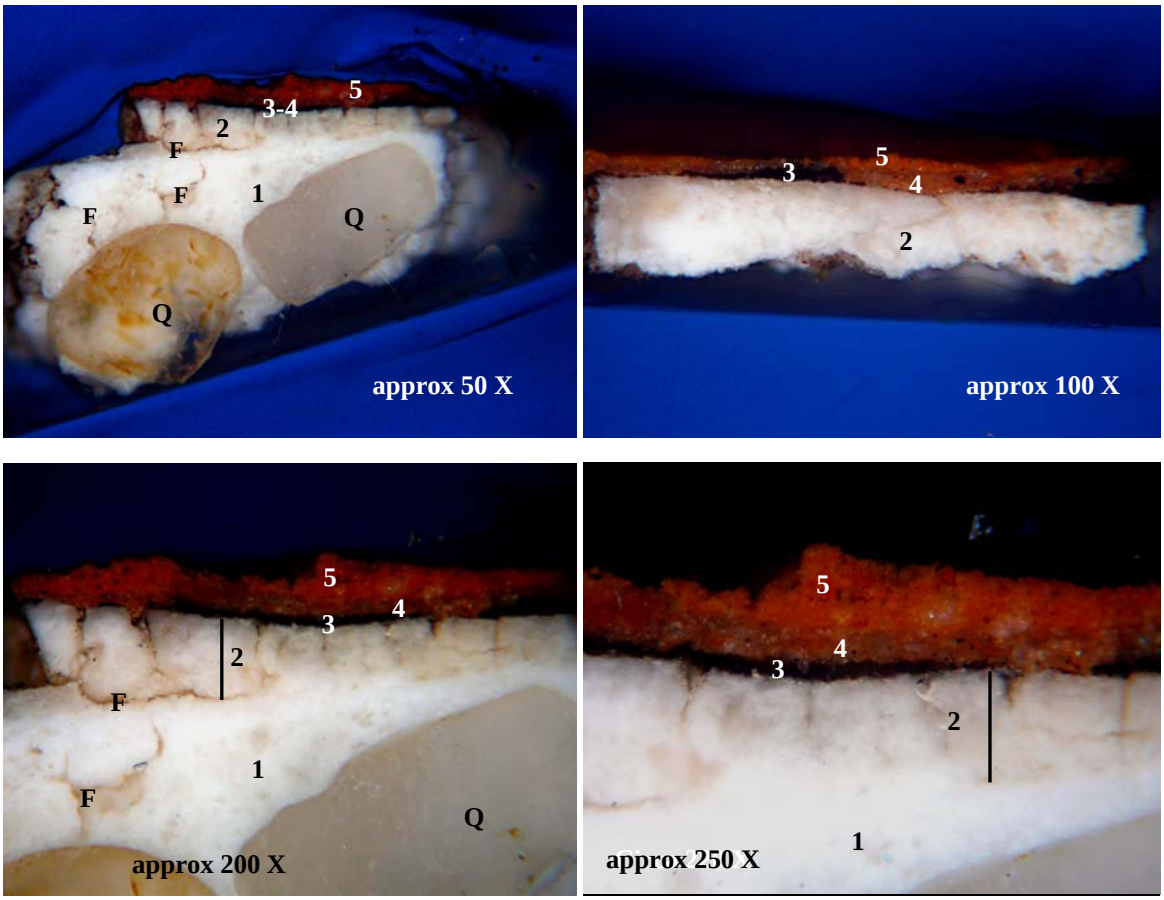
Preliminary stereo-microscopic examination



Stereomicroscope, reflected light, approx. 18 (photo on the left) and 25 X enlargement, respectively

The two images show two of the millimetric fragments taken. The granular aspect of the ochre surface pictorial layer is well documented in the left one. In the image on the right we can sense the presence of the rendering and the pictorial layer made up of a black layer and the ochre-orange layer. The microstratigraphic study in cross section highlighted the presence of other layers with characteristics that will be described in the following pages.
The black segment on one of the scales approximately shows the cutting line of the cross section prepared for the microstratigraphic study.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
Analytical sheet written according to the Doc Normal 12/83



Cross section, reflected light

The four images describe the entire stratigraphic succession. In particular, on the upper left, it shows the structure of the plaster (no. 1), composed of lime and siliceous sand with a mainly quartz formation (Q), and the relationships between the various layers. Above the rendering, partially separated by fissures (F), an irregular layer of lime (no. 2: whitewash) is visible, also with numerous fissures that make up a kind of "craquelure".

Followed by: 3) a discontinuous layer, very dark, based on lamp black, dispersed in an organic medium that is probably proteinic; 4) a greyish drawing of preparation made with a proteinic binder probably mixed with a fine gypsum filler, a little lamp black and a slight amount of jarosite [$KFe_3(SO_4)_2(OH)_6$] and/or natrojarosite [$NaFe_3(SO_4)_2(OH)_6$]; 5) an ochre-orange pictorial layer based on jarosite (and/or natrojarosite) dispersed in a proteinic type of organic medium. The proteinic nature of the surface layers (numbers 3, 4 and 5) was deduced by the results of the histochemical tests ([5]).

The function of the black layer seems to be the 'base coat' over which the various polychromies were applied (see the pictures of the sampling area).

[5] Histochemical tests were carried out, on each of the sections analysed, with: Fuchsine, Naphthol Blue Black and Sudan Black; on the same sections the microchemical test was also made to identify the saponifiable substances.

Sample n. 3

Sampling area

South 'Dom', area above the arch, left pendentive, from the yellow background between the angel's body and tunic, up to the belt. The sample, collected by bistoury, included several dozens of milligrams of dust, removed selectively only from the yellow pictorial layer.

Infrared spectrophotometric analysis (FT-IR)

Results

The study of the IR spectrum obtained by the analysis (see next page) has made it possible to define the sample as essentially composed by the following components (listed in order of relative abundance):

- *Jarosite* [$KFe_3(SO_4)_2(OH)_6$], *Natro-jarosite* [$NaFe_3(SO_4)_2(OH)_6$];

- *calcium oxalate bihydrate* (weddellite: $CaC_2CO_4.2H_2O$);

- *calcite* ($CaCO_3$);

- *mineral silicates (i.e. quartz, feldspars);*

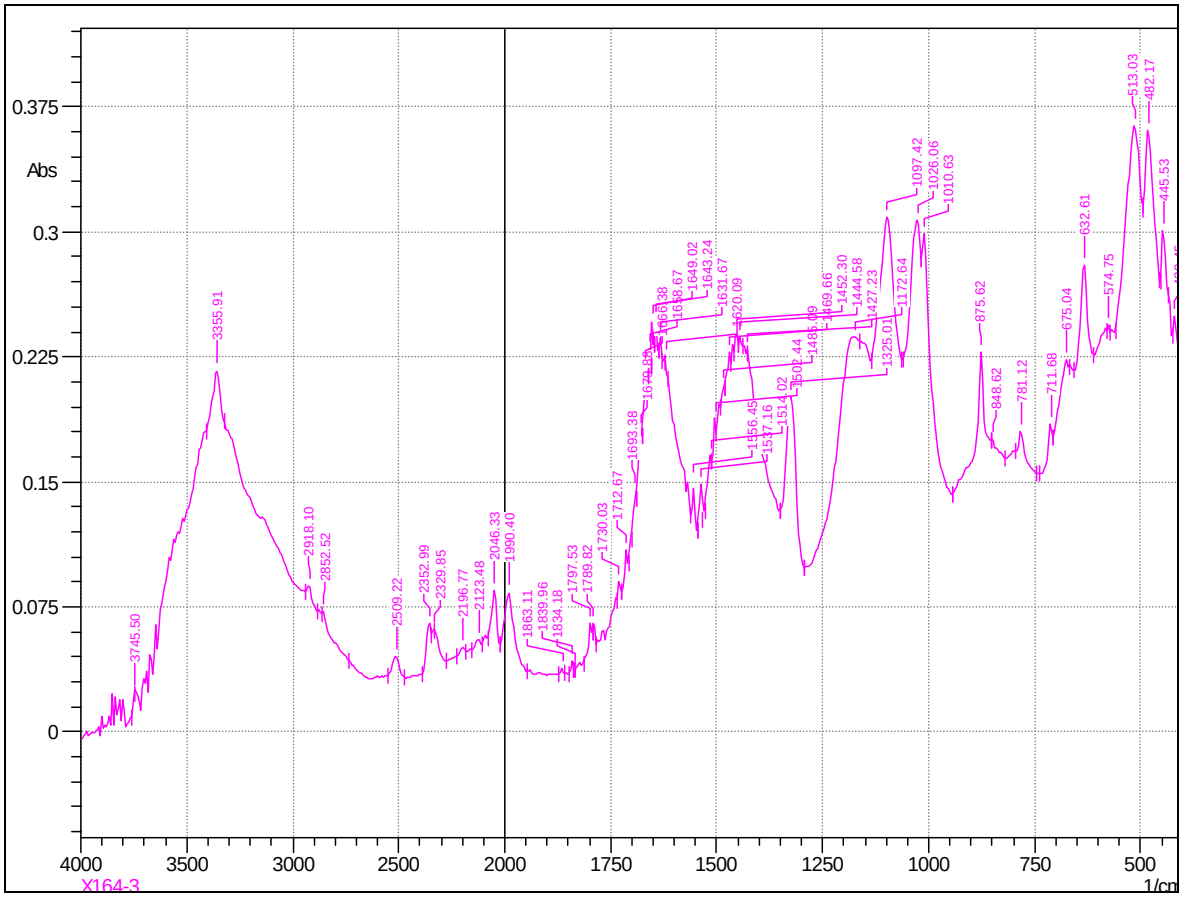
- *proteic substances*: substances not well identifiable due to the strong interference of the absorption bands of other inorganic substances present in greater quantities. Only the absorptions of the CH bands are present with certainty in the spectrum.

Remarks and interpretation of analytical results

Jarosite and/or natro–jarosite represent the yellow pigment used for the pictorial layer preparation. The layered silicates and the silicates are minerals associated with the "jarosite", a natural substance obtained by the use of grounds relatively diffuse in Egypt.

The calcite derives mainly from the white preparation layer, removed during the collecting together with the overlying yellow pictorial layer; The calcite may be in the pictorial layer for instance as Bianco S. Giovanni.

The calcium oxalates are probably to be attributed to the mineralization of the pictorial layer binder.

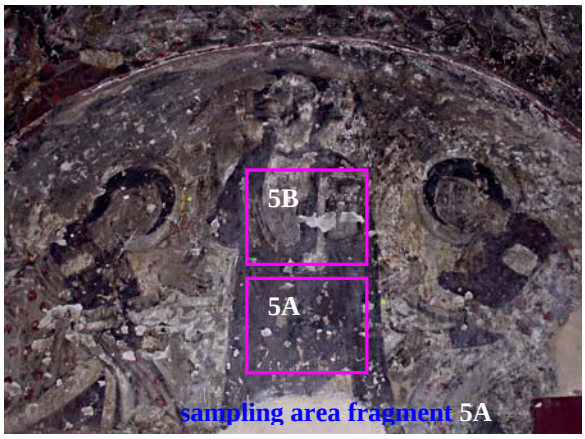


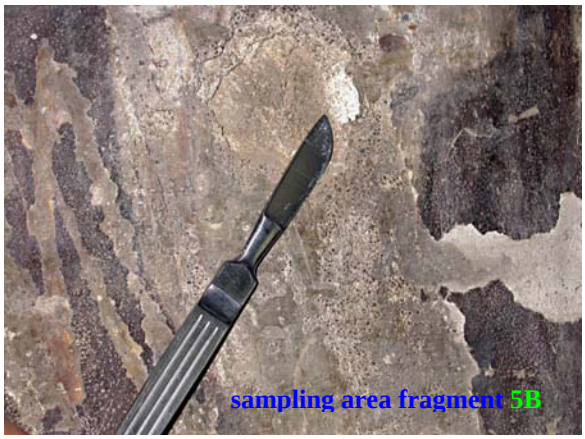
FT-IR spectrum

Samples n. 5A and 5B

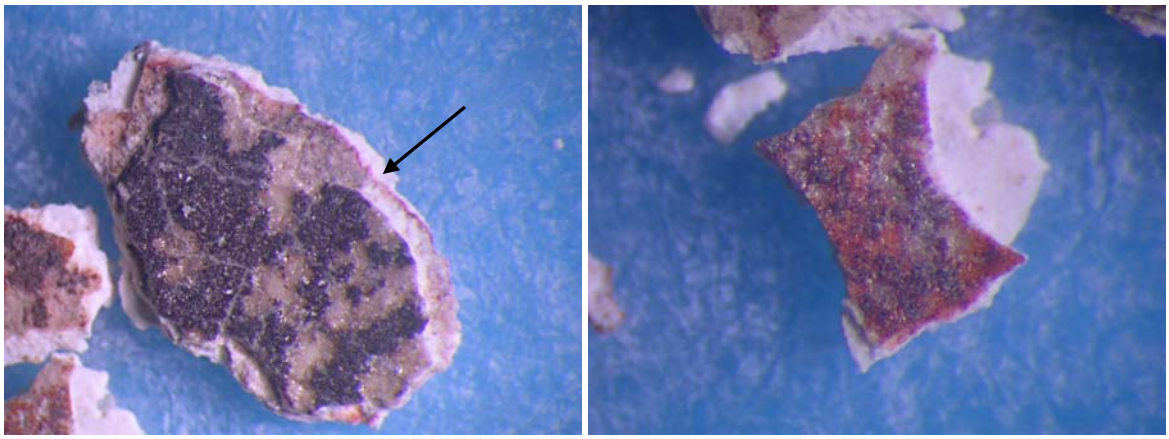
Sampling area

Repository, south wall, lunette. Two samples were taken: the first, 5A, from the Christ's brown-violet garment, inclusive of preparation and pictorial film made up of several layers, among them, presumably, a painting reintegration.
The second sample was taken from the edge of the decimetric loss on Christ's chest. It includes the support rendering and the strips of red pictorial layer.





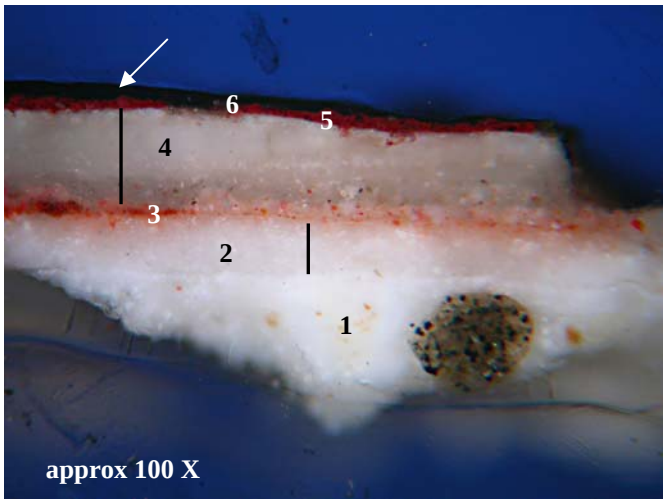
Preliminary stereo-microscopic examination

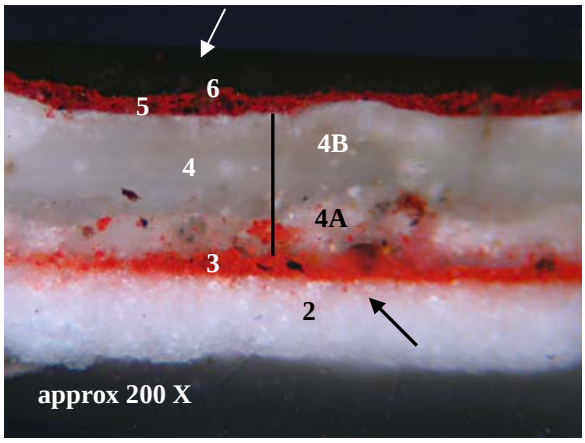


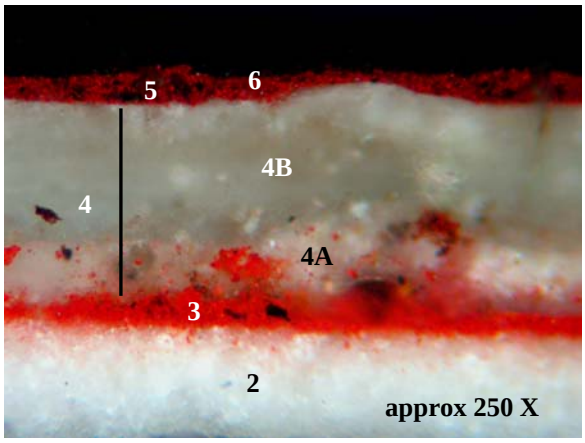
***5-A**. Stereomicroscope, reflected light, approx. 24 (photo on the left) and 40 X enlargement, respectively*

The two images show the aspect of the surface of two of the small scales taken. The one on the left, including various superimposed layers, was used for preparing the cross section described in the following pages. The arrow shows the presence of a red drawing, visible underneath a greyish-white layer of preparation and at the superficial blackish layer.
The white segment on one of the scales approximately shows the cutting line of the cross section prepared for the microstratigraphic study.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
Analytical sheet written according to the Doc Normal 12/83



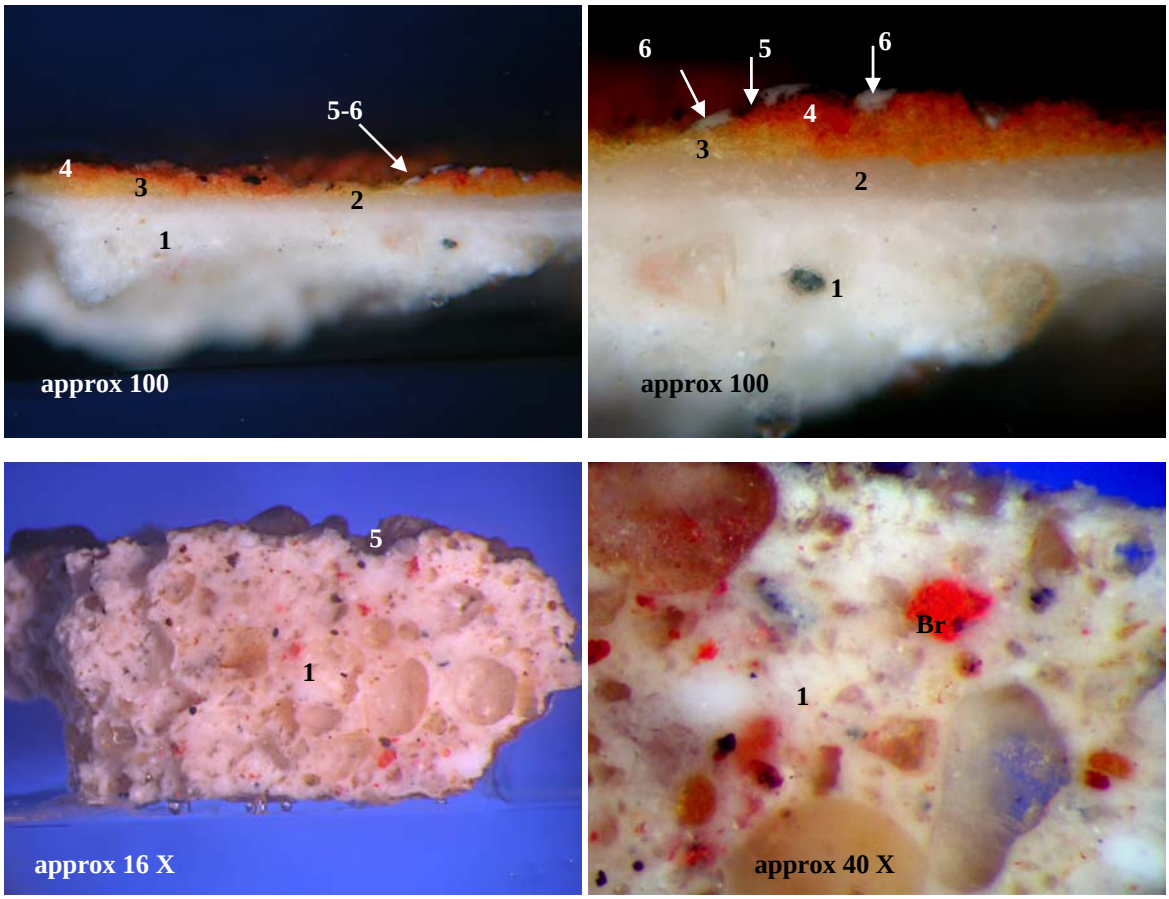




***5A**. Cross section, reflected light*

The three images, at different enlargements, show the various aspects of the cross section. Starting from the inside layer, we observe: 1) a strip of prevalently siliceous sand and lime rendering; 2) lime-based white layer; 3) red pictorial layer made with red ochre – haematite (Fe_2O_3 - $Fe_2O_3.H_2O$), applied on the still wet layer underneath (*a fresco* application); 4) a dense gypsum based layer made with two applications (4A and 4B), the lower one incorporating numerous particles and fragments of the partially disintegrated underlying pictorial layer; 5) dark red painting reintegration with violet tones based on haematite – red (Fe_2O_3, maybe mixed with Fe_3O_4), probably dispersed in a proteic medium. The superficial layer (no. 6), composed of a thin level of particulate and soot (thickness always less than 0.005 mm), is not visible in the images since it can be mistaken for the resin used for the pre-consolidation of the sample (blackish level shown by the white arrows).
The *a fresco* application of no. 3 over the underlying lime preparation (no. 2) can be deduced by the fact that the two layers tend to blend together. The black arrow (on the lower left) shows the presence of several particles of red pigment in the whitewash preparation.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
Analytical sheet written according to the Doc Normal 12/83



***5B**. Cross section, reflected light*

The four images were arranged to artificially reconstruct the stratigraphy of the sampling area (see the images shown previously). Due to the slight adhesion of the pictorial film and, in general, the surface layers, it was impossible to take a representative sample that included all the layers. Therefore two fragments were taken in succession, one of the rendering and the other including the overlying layers. The two images below describe the structure of the support rendering (no. 1) made with lime, prevalently siliceous sand and very little fine brick powder (Br). The two upper images show the overlying layers. A whitish lime-based layer (no. 2, preparation) is visible on top of a thin strip of rendering (no. 1), torn from the support during sampling, it was applied to at the same time as the yellow jarosite-based layer (no. 3 [6]) that in the upper part gradually becomes a red layer, very discontinuous, composed of red ochre – haematite (no. 4). On the upper part a thin layer of soot (no. 5) is barely visible.

The histochemical tests performed (Fuchsine, Naphthol Blue Black and Sudan Black) gave negative results in all instances.

The stratigraphic succession is closed by thin whitish strips (no. 6) referable to traces of protective substances applied during maintenance treatment.

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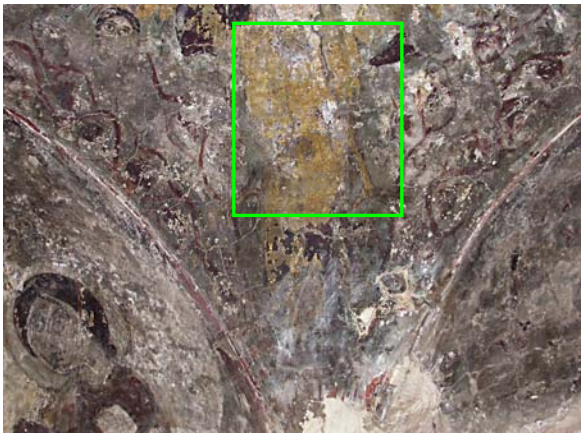
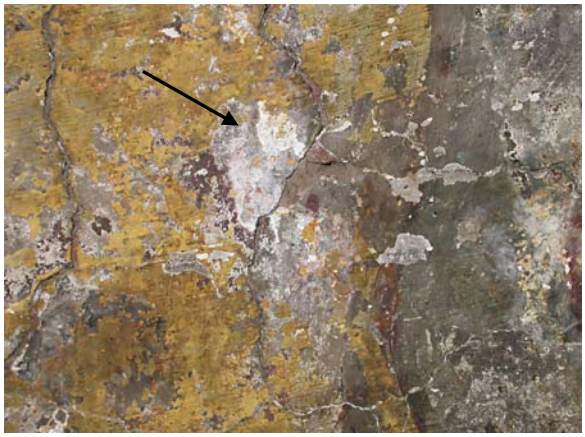
[6] $[KFe_3(SO_4)_2(OH)_6]$ or natrojarosite $[NaFe_3(SO_4)_2(OH)_6]$.

Sample n. 6

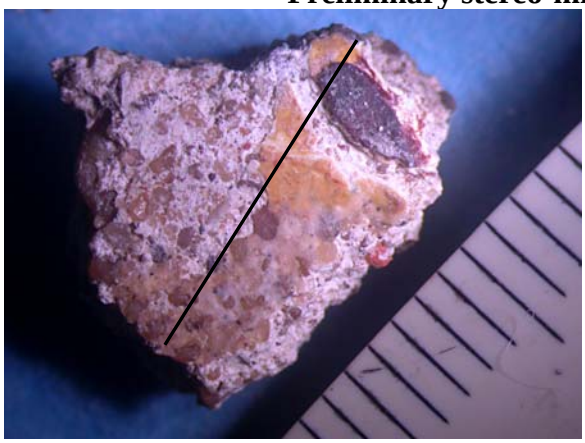
Sampling area

Repository, “gabled” ceiling, gable on the southwest side, from the edge of a crack. The sample, taken by bistoury, includes the support plaster and all the layers on top of it. The earth found in the crack was also taken.





Preliminary stereo-microscopic examination

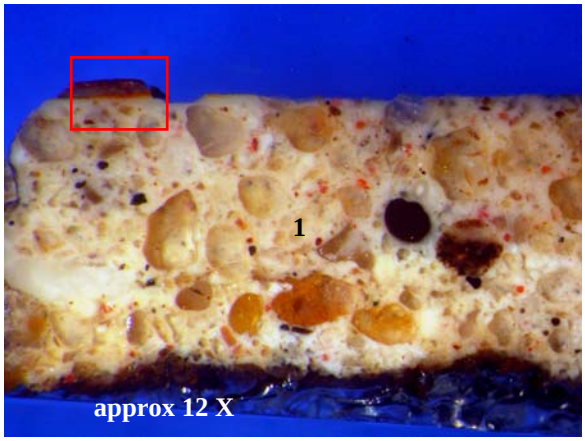


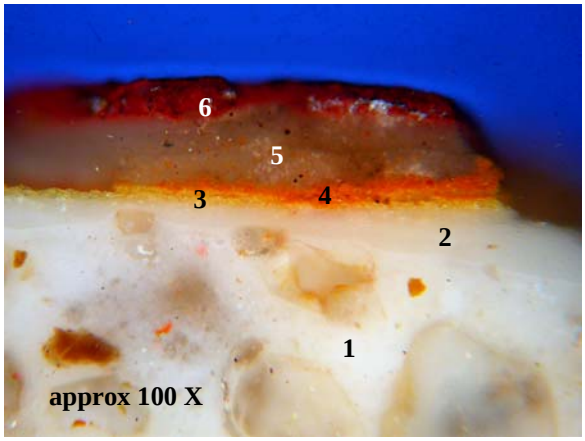
Stereomicroscope, reflected light, approx. 7 (photo on the left) and 18 X enlargement, respectively

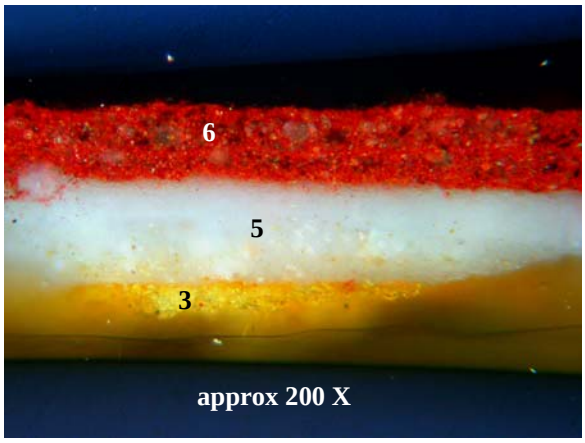
The two images show the scales that were taken. The one described in the left image shows the rendering and the first overlying yellow drawing. Visible in the image is also a small strip of a pictorial layer of dark red over the yellow layer. The image on the right shows the presence of a whitish drawing between the yellow and dark red layers.

The black segment approximately shows the cutting line of the cross section prepared for the microstratigraphic study and described in the following pages.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
Analytical sheet written according to the Doc Normal 12/83







Cross section, reflected light

The image on the upper left shows the structure of the support rendering (no. 1) made with lime, prevalently siliceous sand and very little fine red brick dust. The red inset shows the portion of the section that includes also the pictorial layers The image on the upper right shows the enlargement of the red inset. Over the rendering we note: 2) a lime-based white layer (preparation); 3) a jarosite-based yellow pictorial layer with longitudinal cracks, probably applied "*a fresco*"; 4) a thin hematite-based red layer applied at the same time as the preceding one and, presumably, with the same technique; 5) a thick layer of gypsum-based preparation; 6) a red pictorial layer based on haematite – dark red and Bianco S. Giovanni, applied "*a secco*" with a proteic medium.
The image below describes another detail of the pictorial layers, enlarged, retrieved in an area without rendering and layers (no. 4), with a lot of loss.

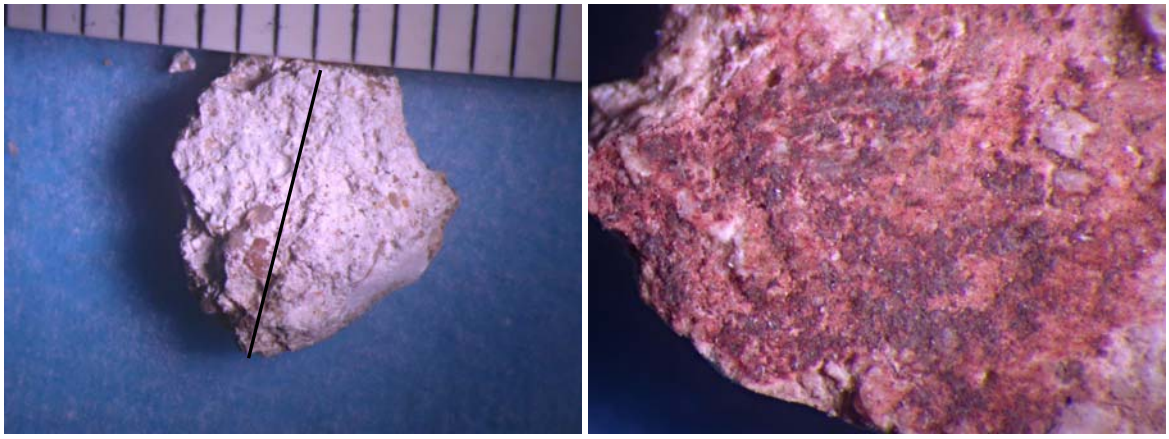
The histochemical tests performed (Fuchsine, Naphthol Blue Black and Sudan Black) gave negative results in all instances.

Sample n. 7

Sampling area

Ground floor, north 'conco', column to the left of the repository entrance. The sample was taken from the red 'background' behind the column, alongside the first white rhombus which is about 35 cm from below. The millimetric sample included the stucco and the overlying red pictorial film.

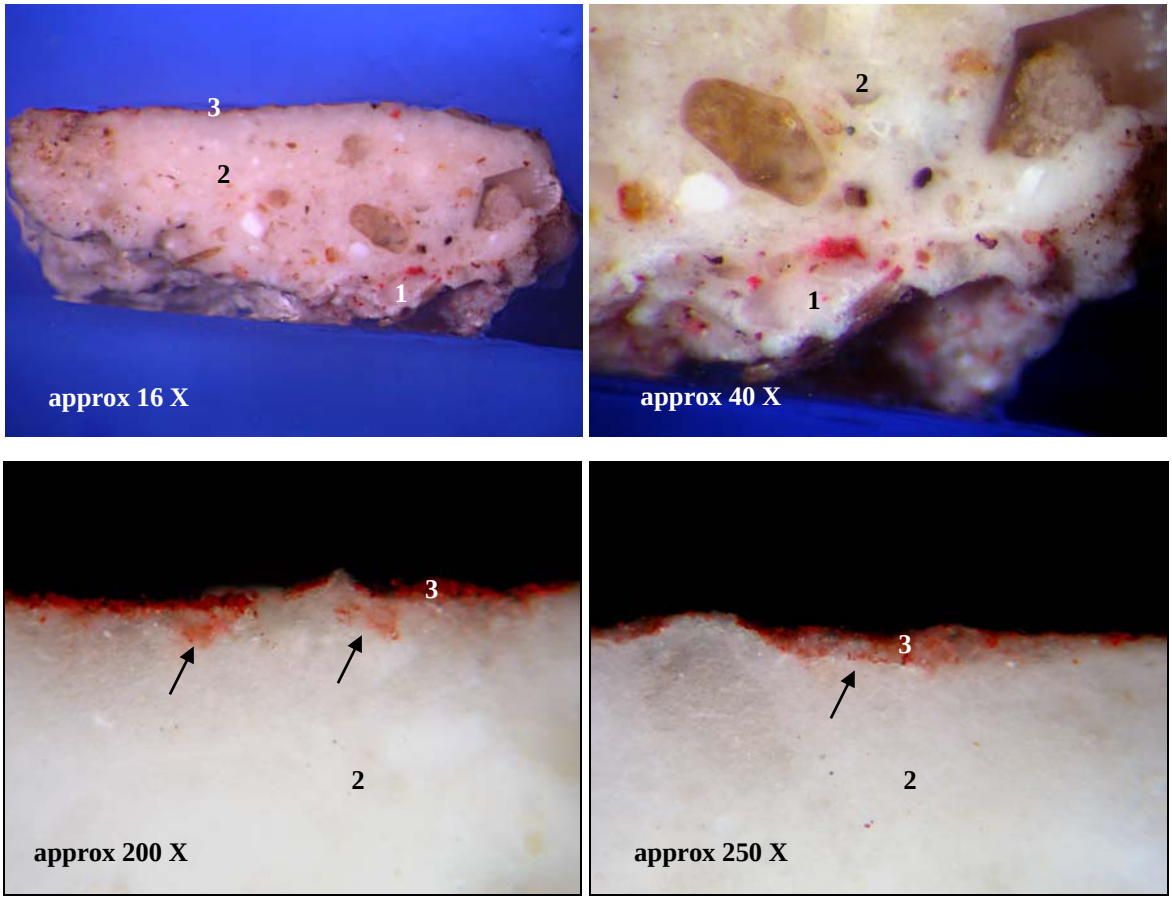
Preliminary stereo-microscopic examination



Stereomicroscope, reflected light, approx. 10 (photo on the left) and 18 X enlargement, respectively

The two images show the innner face and the superficial face, respectively, of the fragment taken.
The black segment approximately shows the cutting line of the cross section prepared for the microstratigraphic study and described in the following pages.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
Analytical sheet written according to the Doc Normal 12/83



Cross section, reflected light

The upper left image, at low enlargement, describes the whole surface of the cross section that includes, starting from below: 1) a strip of lime-based rendering, siliceous sand and minute fragments of red brick; 2) light rendering made with lime, a small amount of sand and limestone dust; 3) a thin red pictorial "*a fresco*" drawing, realized dispersing haematite in water or limewater. The upper right image shows the base portion of the section where we can see the strip of the background rendering (no. 1) and the overlying light rendering (no. 2).

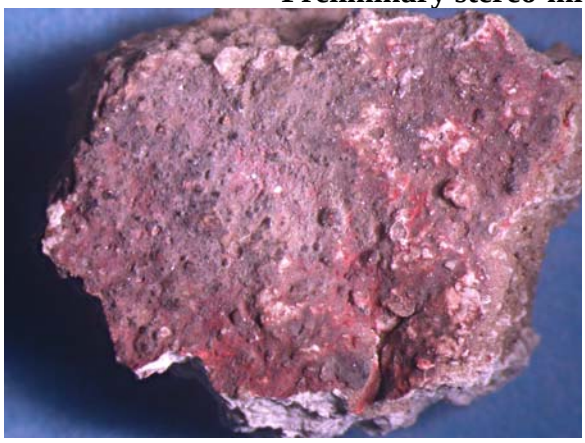
The two lower images, greatly enlarged, show the structure of the thin red pictorial drawing (no. 3), based on red ochre – haematite ($Fe_2O_3.nH_2O$ - Fe_2O_3), spread on the still wet surface light rendering. The two layers tend to merge together (arrows).

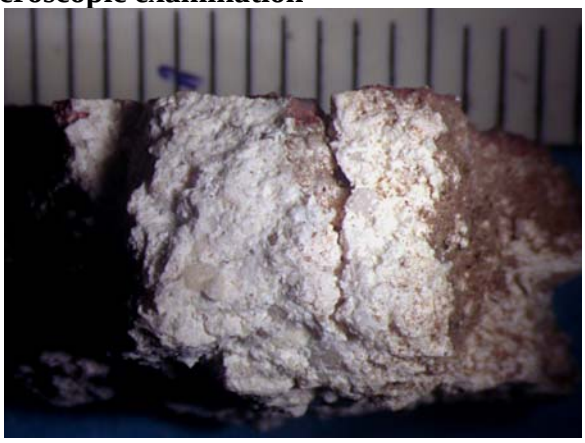
Sample n. 9

Sampling area

Ground floor, north 'conco', 1st niche from the left, column in Assuan red granite. The millimetric sample was taken by bistoury from the edge of the loss behind the column.

Preliminary stereo-microscopic examination

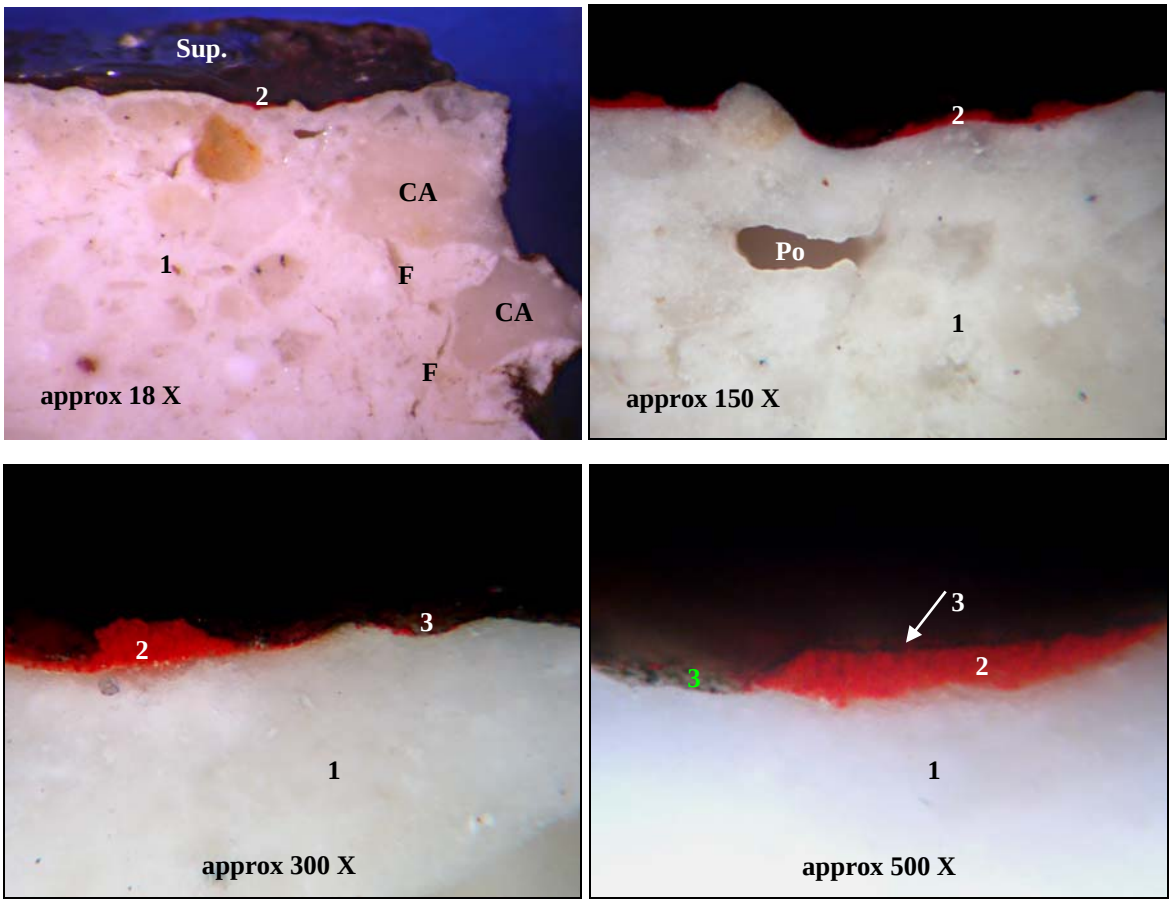




Stereomicroscope, reflected light, approx. 6,5 X enlargement (both images)

The two images show, respectively, the surface (on the left) and the cross section of the fragment that was taken. This includes a white light rendering (or stucco), composed of lime and fragments of limestone, and a thin red pictorial layer. In the two images, and above all in the right hand one, we can also see an earthy brown deposit (arrow).
The black segment approximately shows the cutting line of the cross section prepared for the microstratigraphic study and described in the following pages.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
Analytical sheet written according to the Doc Normal 12/83



Cross section, reflected light

The image on the upper left, with a relatively low enlargement, basically describes the structure of the light rendering made with lime and limestone 'dust' (CA). Higher up we can barely see the thin red pictorial layer based on red ochre – haematite ($Fe_2O_3.nH_2O$ - Fe_2O_3) applied on the still-wet surface rendering. The other enlarged images show the red pictorial layer (no. 2) and its relationship with the underlying light rendering. In the two lower images we can see the thin superficial translucent layer (no. 3) made up of wax, with soot fixed on it.
The light rendering, relatively compact (inside there are few cracks from desiccation, F, and even fewer globular pores; Po), was made with the intention of obtaining a white surface, similar to the one that characterises the Roman stuccoes made of lime and marble dust or limestone.

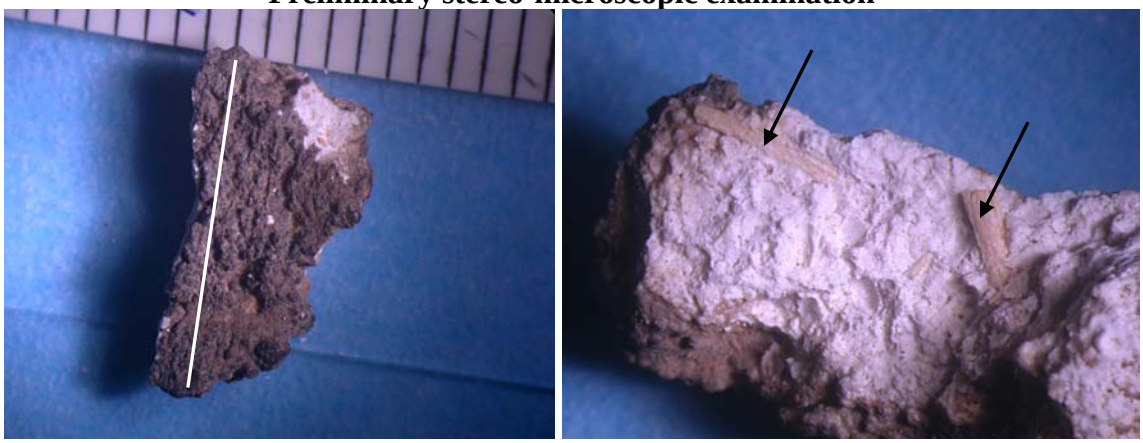
In the upper left image, due to the depth of field, even the surface of the sample is visible (Sup).

Sample n. 10

Sampling area

Ground floor, north ‘conco’, right niche, column in Assuan red granite. The millimetric sample was taken by bistoury from the edge of the rendering, near the right side of the column, at the capital

Preliminary stereo-microscopic examination



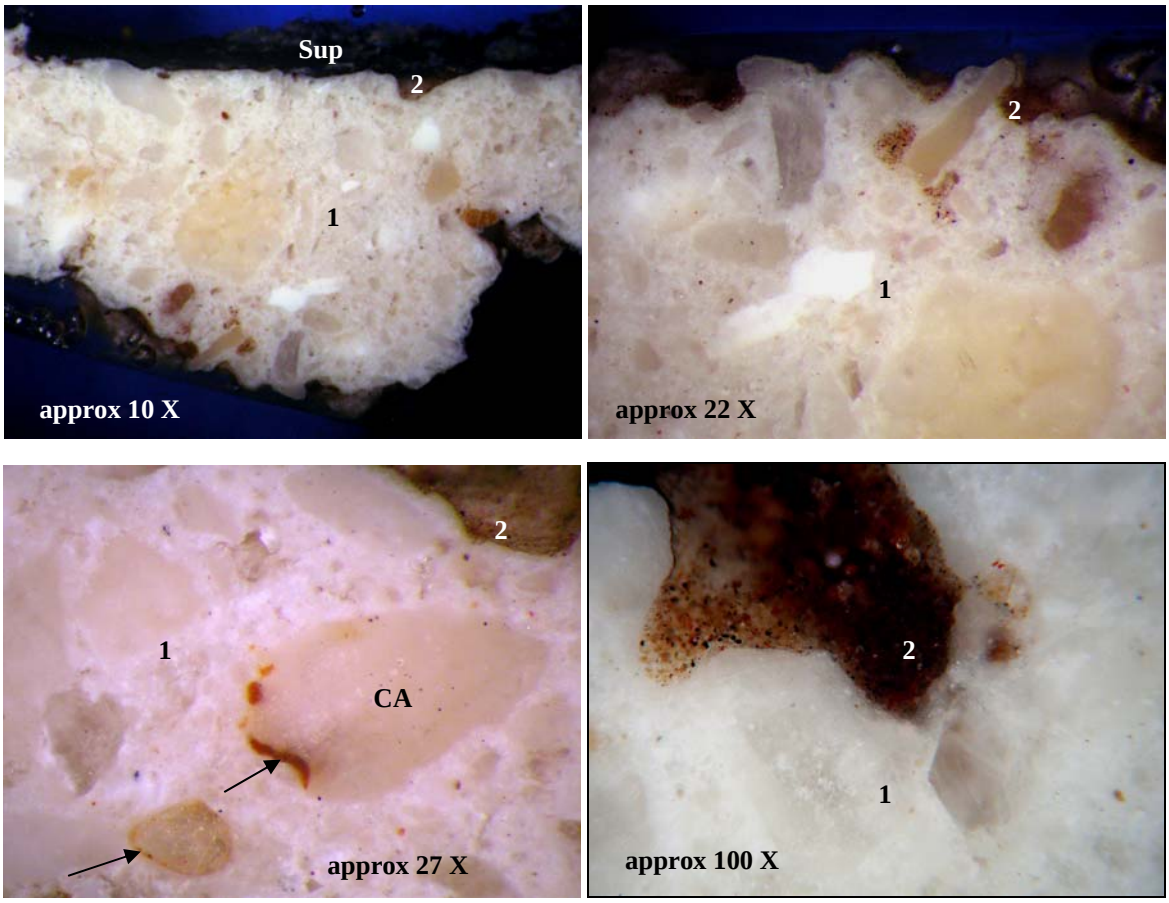
Stereomicroscope, reflected light, approx. 8 X enlargement (both images)

The two images show, respectively, the surface (on the left) and a transverse section of the fragment that was taken. This includes:

- a light coloured rendering, made up of lime, fragments of limestone and a few vegetable fibres (arrows);
- a thin brown layer referable to a deposit of earth.

On the following page the characteristics of each layer are described in detail.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
Analytical sheet written according to the Doc Normal 12/83



Cross section, reflected light

The images show various aspects of the cross section that well illustrate the structure of the light rendering (or stucco: no. 1) made with lime, limestone dust (CA) and a few vegetable fibres (not visible in the images, but documented by the photos taken with the stereo microscope). The sub-rounded morphology of some of the limestone granules and the presence, though slight, of reddish rings of iron oxide at the edges (arrows), show that the limestone aggregate was obtained, at least partially, by selecting and fragmenting a type of limestone sand (or fine gravel). Regarding the degree of evolution of the granules, it could be a sand that was formed by the erosion of limestone rocks and by their sedimentation after a brief move (for example, by temporary, transient torrents that flow in the "uadi"). This type of limestone and, hence, the sands formed near it, are found in various areas near the Nile in mid–north Egypt ([7]). Above all in the two lower images we can see the thin earthy deposit (no. 2), made up of silicates, oxides and also carbonaceous particles.

In the upper left image, due to the depth of field, even the surface of the sample is visible (Sup).

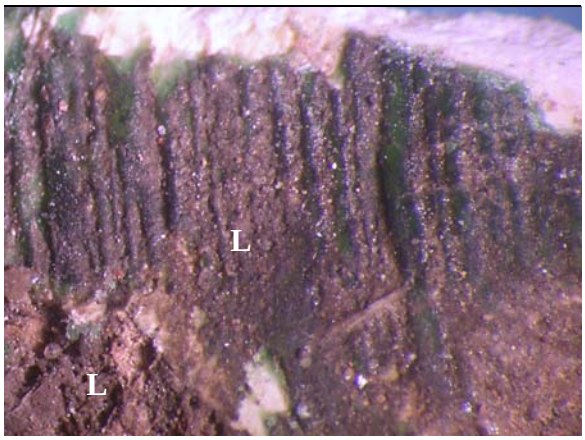
[7] www.eeescience.utoledo.edu/Faculty/Harrel/Egypt/Quarries/Softst_Quar.html

Sample n. 11

Sampling area

South 'Dom', ground floor, left niche, cornice near the apex, from the edge of a loss. A fragment of stucco was taken with a green "wax" pictorial layer.

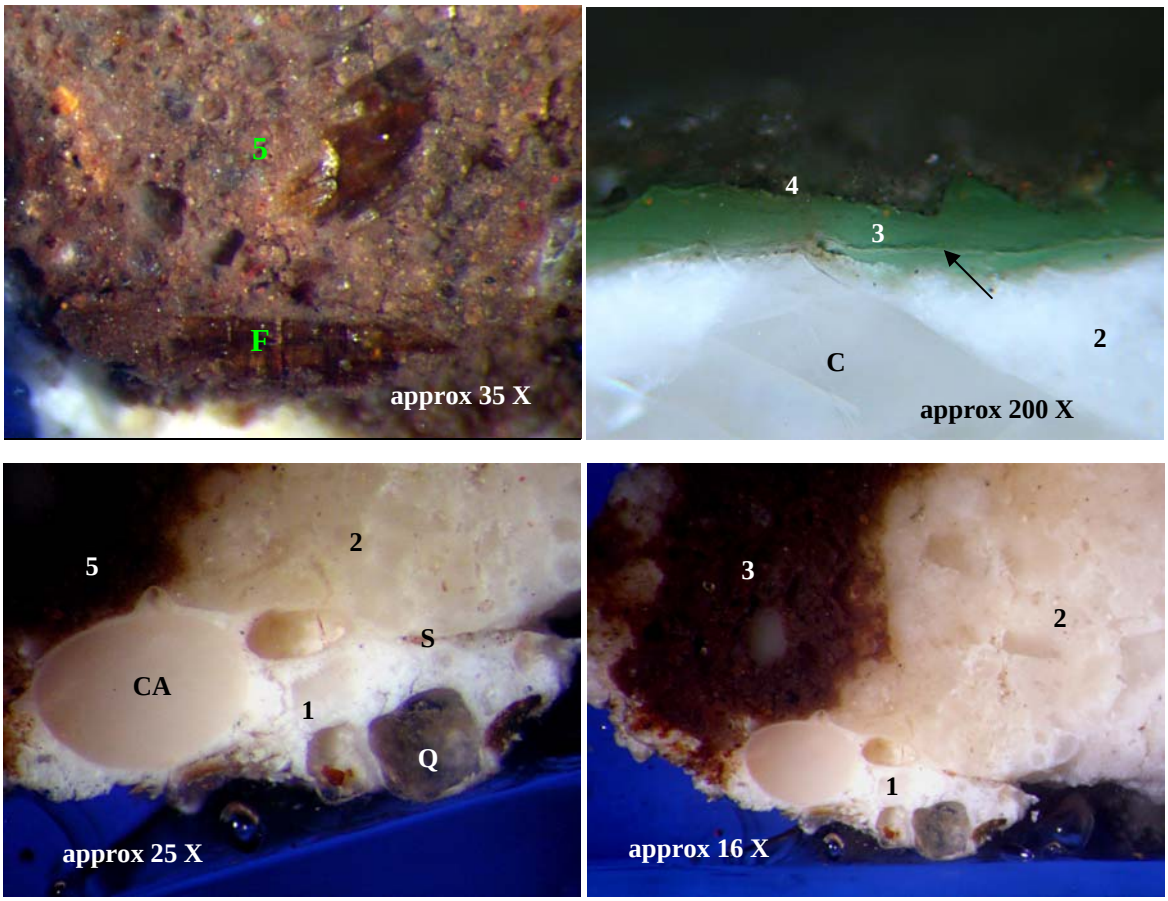
Preliminary stereo-microscopic examination



Stereomicroscope, reflected light, approx. 7(photo on the left) and 16 X enlargement, respectively

The two images show, respectively, the inside 'face' (on the left) and a portion of the surface 'face' of the fragment taken. This includes a white light rendering (or stucco), composed of lime and fragments of limestone, and a green wax-based pictorial layer that preserves the signs of the superficial brushstrokes (image on the right). Above the stucco and on the pictorial layer there is a discontinuous, irregular brown layer (L) made up of silt and vegetable fibres. This latter could come from the application of a mud mortar, applied to compensate the edges of the loss. It could also be the residue of an earthy deposit that irregularly covers the lower surfaces of some parts of the church.
The black segment on one of the scales approximately shows the cutting line of the cross section prepared for the microstratigraphic study and described in the following pages. applied before the overlying paint layer.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
Analytical sheet written according to the Doc Normal 12/83



Cross section, reflected light

The two images on the right show the entire stratigraphic succession. The two images on the left show the two details of the renderings and the layer of silt and vegetable fibres (F). In particular, starting from below we see:
1) a strip of rendering made up of lime, mainly siliceous sand (essentially silica minerals: Q) and subordinately limestone (inside it a small perfectly round bowl made of limestone: CA);
2) a white lime-based light rendering (or stucco) and limestone dust;
3) a green pictorial layer with a wax and verdigris base;
4) a thin very dark level, made up of fine soot-based particulate;
5) an irregular, discontinuous brown layer ([8]) made up of sandy silt that includes vegetable fibres (see what is shown on the preceding page concerning the theories about the origin of the layer). The letter S has marked a solution of continuity between the two renderings (1 and 2).

The black arrow points to a longitudinal crack that tends to separate the green pictorial layer.

[8] The layer was given number 5 of the stratigraphy, since from the preliminary examination under the stereo microscope (see the preceding page) it is superimposed on the pictorial drawing.

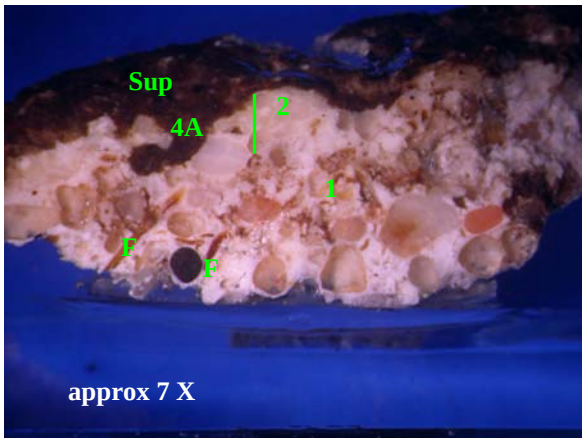
Sample n. 12

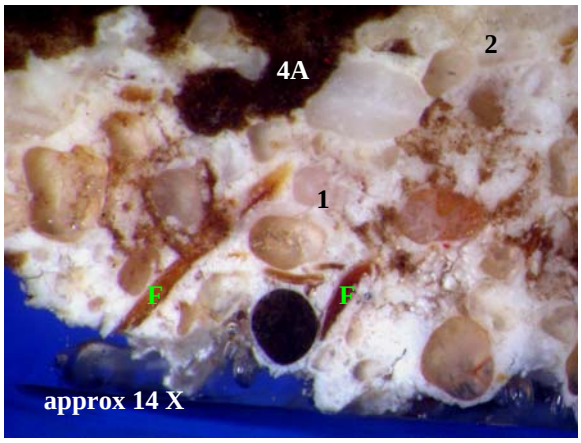
Sampling area

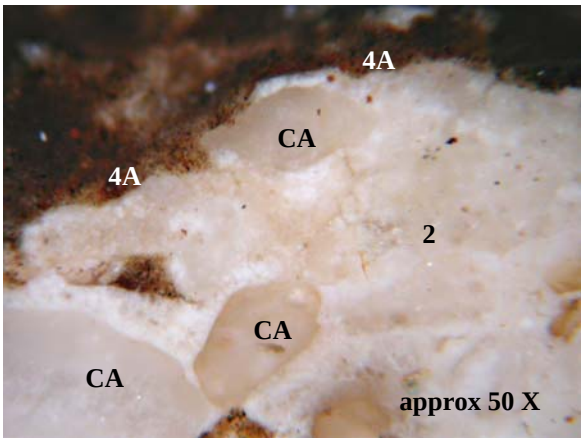
Ground floor, East 'Dom', 1st niche from the right, left baluster at approx. 25 cm from the base, near the edge of the rendering loss. A fragment of stucco was taken with a green "wax" pictorial layer and strips of a brown deposit.

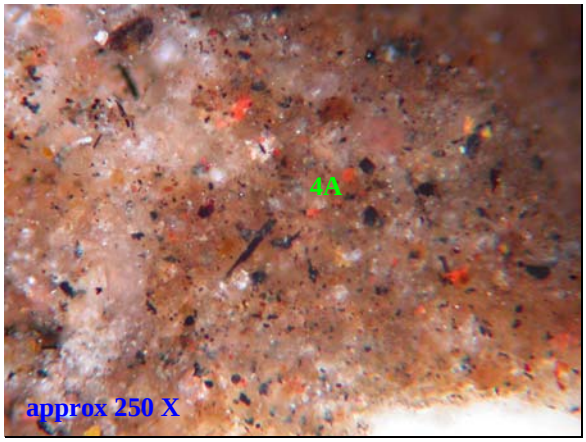
Microstratigraphyc analyses on cross section with microchemical and histochemical tests

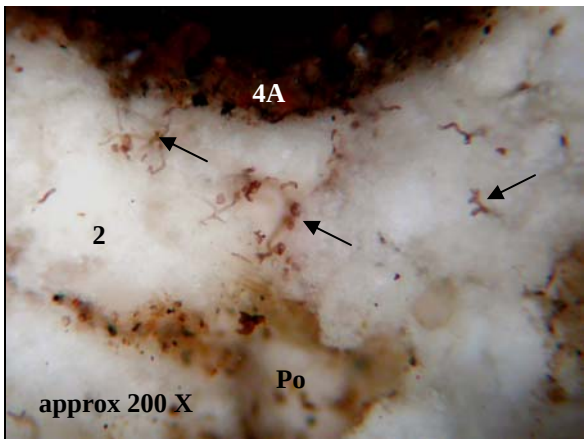
Analytical sheet written according to the Doc Normal 12/83

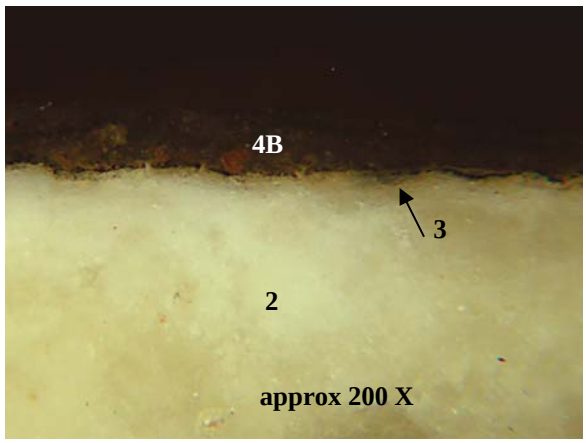












Cross section, reflected light

The two images above and the one at centre left describe the whole stratigraphy and the structure of the two layers of rendering. The first (no. 1), made with lime, sand and a few vegetable fibres (F), the second (no. 2) composed of lime and limestone dust (CA; similar to the Roman stucco). Higher up there is an irregular earthy deposit (no. 4A) with the structure well documented in the image at centre right. Inside a brown slimy clay mass, numerous black, brown, yellow and red particles can be seen, relatable to carbon granules, iron and/or manganese oxides associated to the earth and, maybe, granules of pigment eroded from the painted surfaces and incorporated in the deposit. This latter was formed

due to the depositing of particulate (essentially dust) over time and, maybe, it was also due to heavy flooding in the Nile.
The image on the lower left describes a surface portion of the white stucco concerned by relatively coarse blistered pores (Po) and, above all, by the presence of numerous brown biological structures, with a filamentary or globular form (arrows).
Regardless of the type of biodeteriogenes (autotrophy organisms, algae and/or cynabacteria, or heterophis, microfungi [9]), their presence shows that for a certain period the humidity in the materials in the sampling area was not very low.

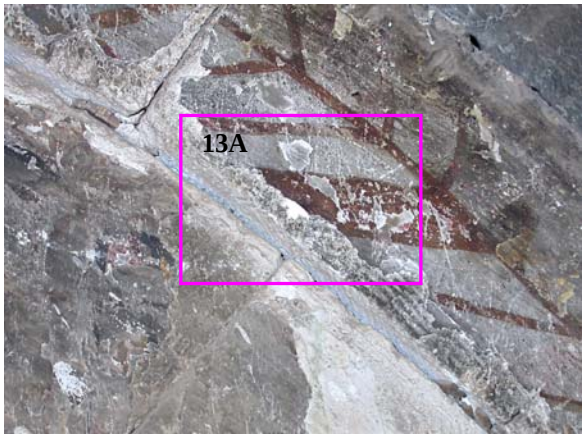
The lower right image shows a surface portion of the section where there are traces of the wax based green and verdigris pictorial layer (no. 3). Higher up is a layer composed of wax that abundantly includes soot (no. 4B).
In the upper left image, due to the depth of field, even the surface of the sample is visible (Sup).

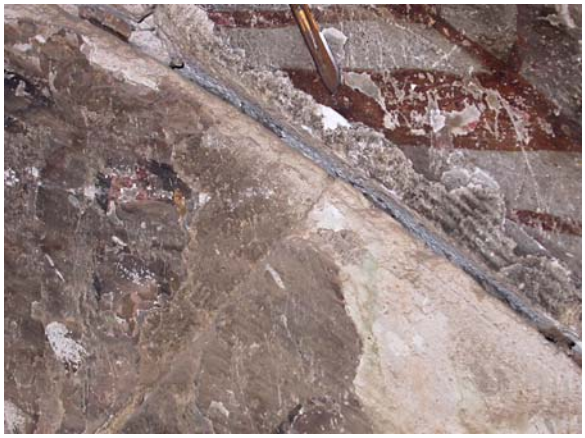
[9] The study of the section, or rather 'slides', by a biologist expert in diagnostics for cultural heritage, would enable a better classification of the biological forms observed.

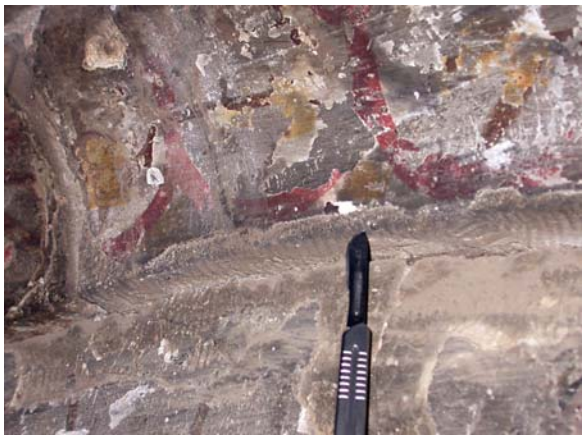
Samples n. 13A and 13B

Sampling area

External façade, left side, 1st niche from the left, from the arch cornice. Two samples were taken a few decimetres from each other that included the stone, the overlying rendering and the superimposed layers







Microstratigraphyc analyses on cross section with microchemical and histochemical tests
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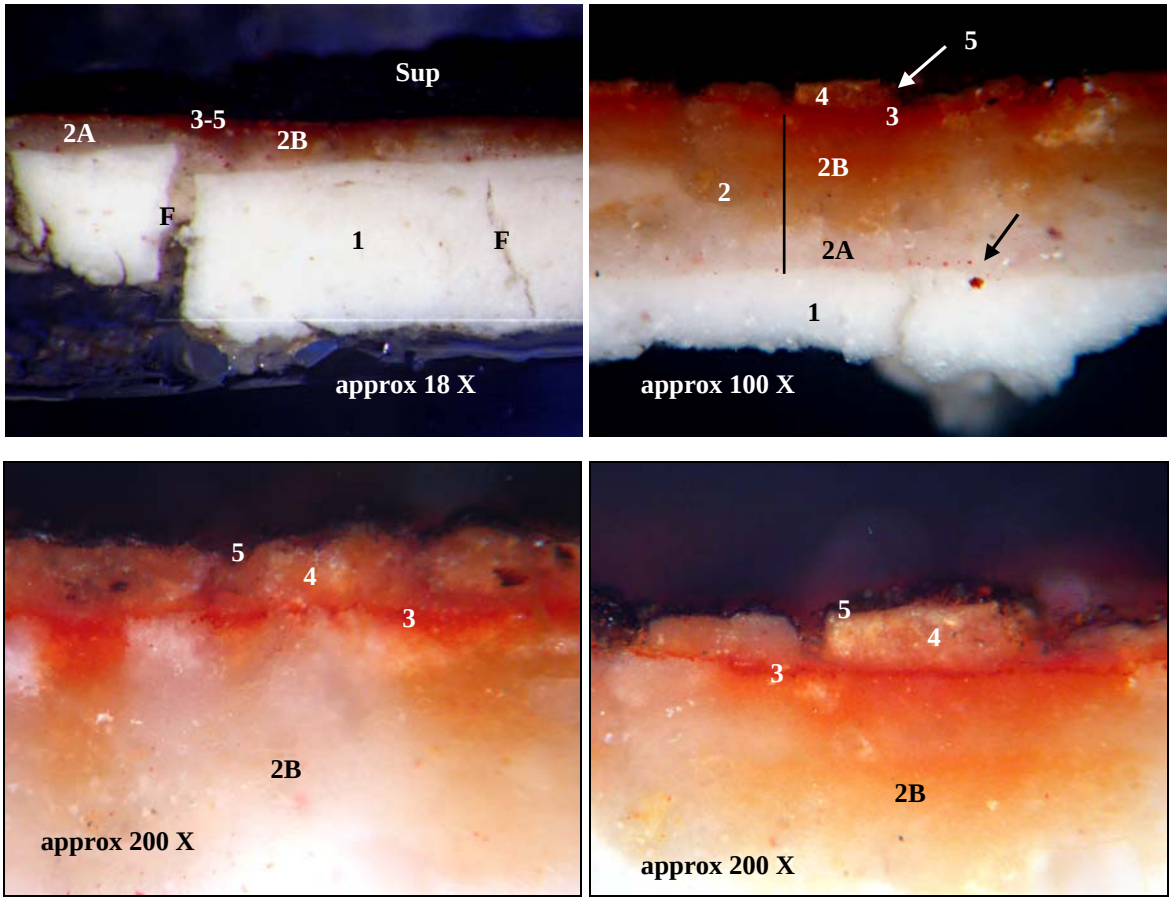


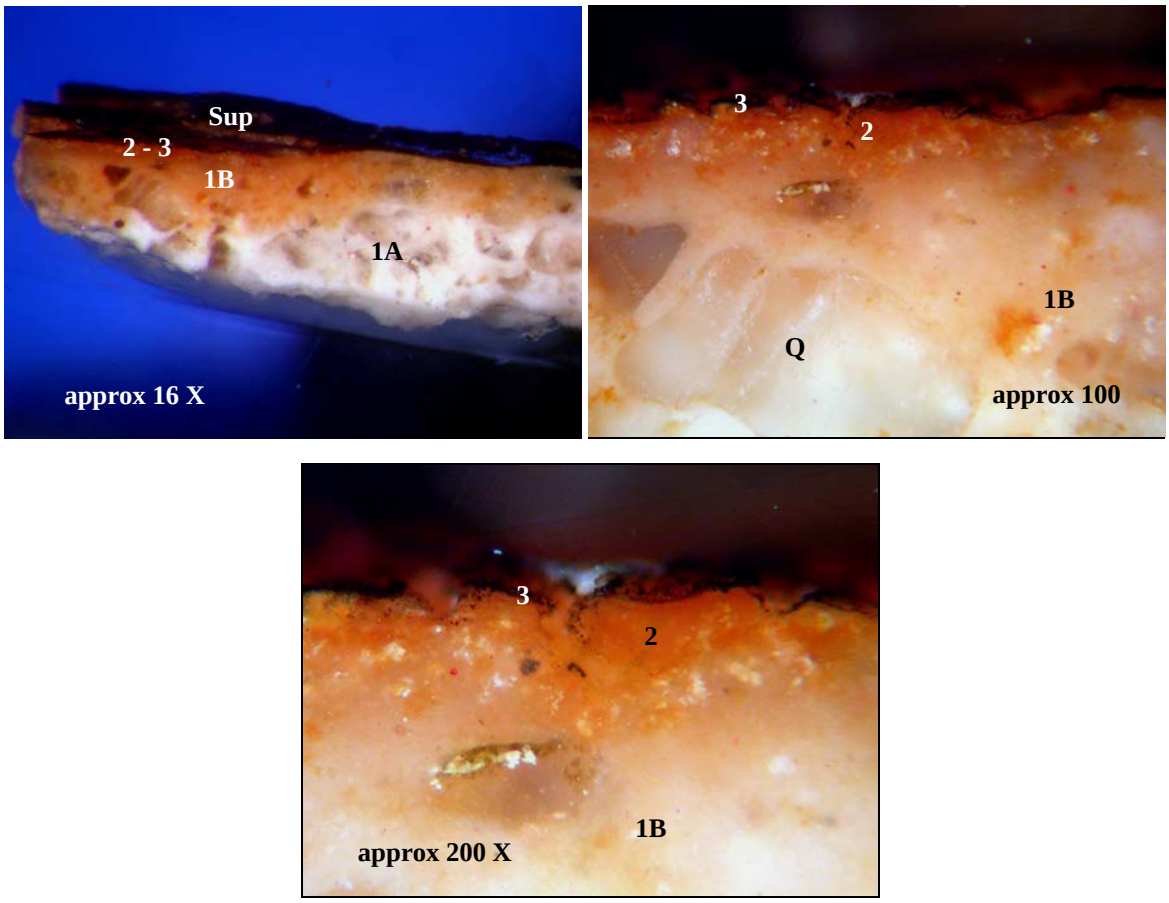
***13-A**. Cross section, reflected light*

The two upper images show the entire stratigraphic sequence. With relatively low enlargement, with which they were taken, one can still see above all the lower layers, whereas the more external ones are better described in the two highly enlarged images below. Starting from below we see:

1) dense lime-based *scialbo*, with deep cracks from desiccation (F), here and there partially filled by the material from the overlying layers;
2) dense gypsum based layer, animal glue and very little fine calcium carbonate applied in two coats, 2A and 2B. The first, a pinkish colour, contains few particles of haematite (Fe_2O_3); the second (2B) of a colour varying from yellow to reddish was pigmented with jarosite {[$KFe_3(SO_4)_2(OH)_6$]} or natrojarosite {[$NaFe_3(SO_4)_2(OH)_6$]} and with hematite;
3) thin haematite-based red layer applied at the same time as the preceding one. Even if the histochemical tests gave uncertain results, it is likely that the pictorial layer binder is proteinic in this case too;
4) discontinuous slightly translucent light yellow pictorial layer, affected by a thick 'craquelure'. E) jarosite mixtures probably dispersed in a proteinic medium, maybe egg (assumption to check with specific investigations);

5) thin level of soot deposited on the surface over time, mixed with very little wax.

In the upper left image, due to the depth of field, even the surface of the sample is visible (Sup)



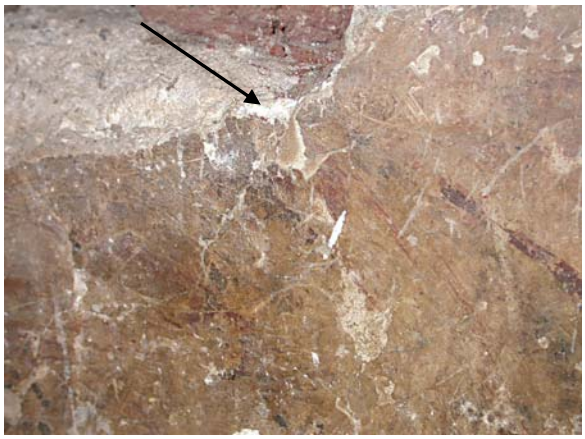
***13-B**. Cross section, reflected light*

The upper left image, taken with relatively low enlargement, describes the cross section nearly entirely. The other images show variously enlarged details of the surface. The plaster, based on lime and sand of a basically siliceous type, was applied in two layers (1A and 1B), of which the latter coloured with jarosite and/or natrojarosite. On top of the rendering, with no solutions of continuity, one can see the pictorial layer in yellow (no. 2) made '*a fresco*' dispersing minerals of the jarosite group in water (or water lime). A thin level of soot (no. 3) deposited on the surface over time closes the stratigraphic succession.
In the upper left image, due to the depth of field, even the surface of the sample is visible (Sup).

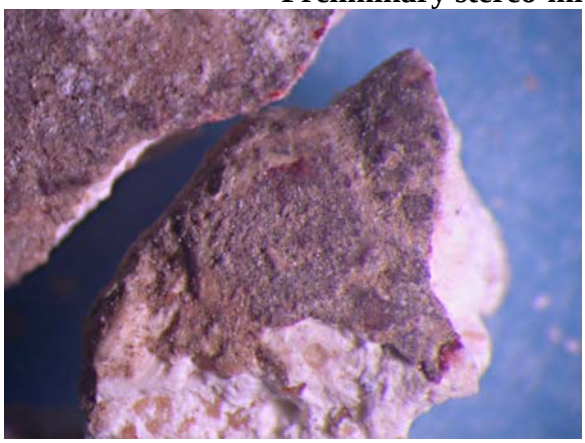
Sample n. 14

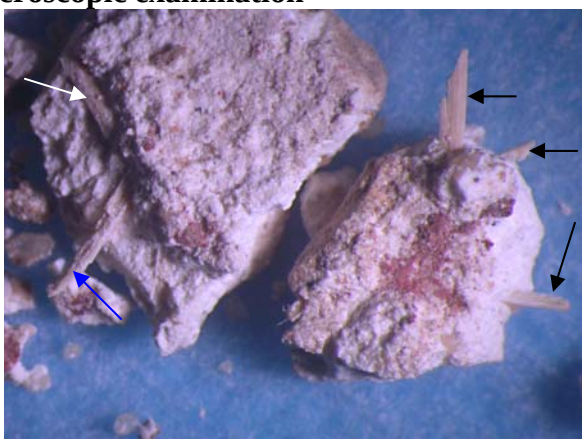
Sampling area

Left transept, north wall, 14th century knight. The sample, made up of several millimetric fragments, includes the rendering and the pictorial film.



Preliminary stereo-microscopic examination





Stereomicroscope, reflected light, approx. 18 (photo on the left) and 14 X enlargement, respectively

The two images show, respectively, the surface (on the left) and the inside 'face' of the fragments taken. These include the rendering, any preparation and the pictorial film. The image on the right shows some vegetable fibres contained in the rendering (arrows).

The white segment on one of the scales approximately shows the cutting line of the cross section prepared for the microstratigraphic study and described in the following pages.

Microstratigraphyc analyses on cross section with microchemical and histochemical tests
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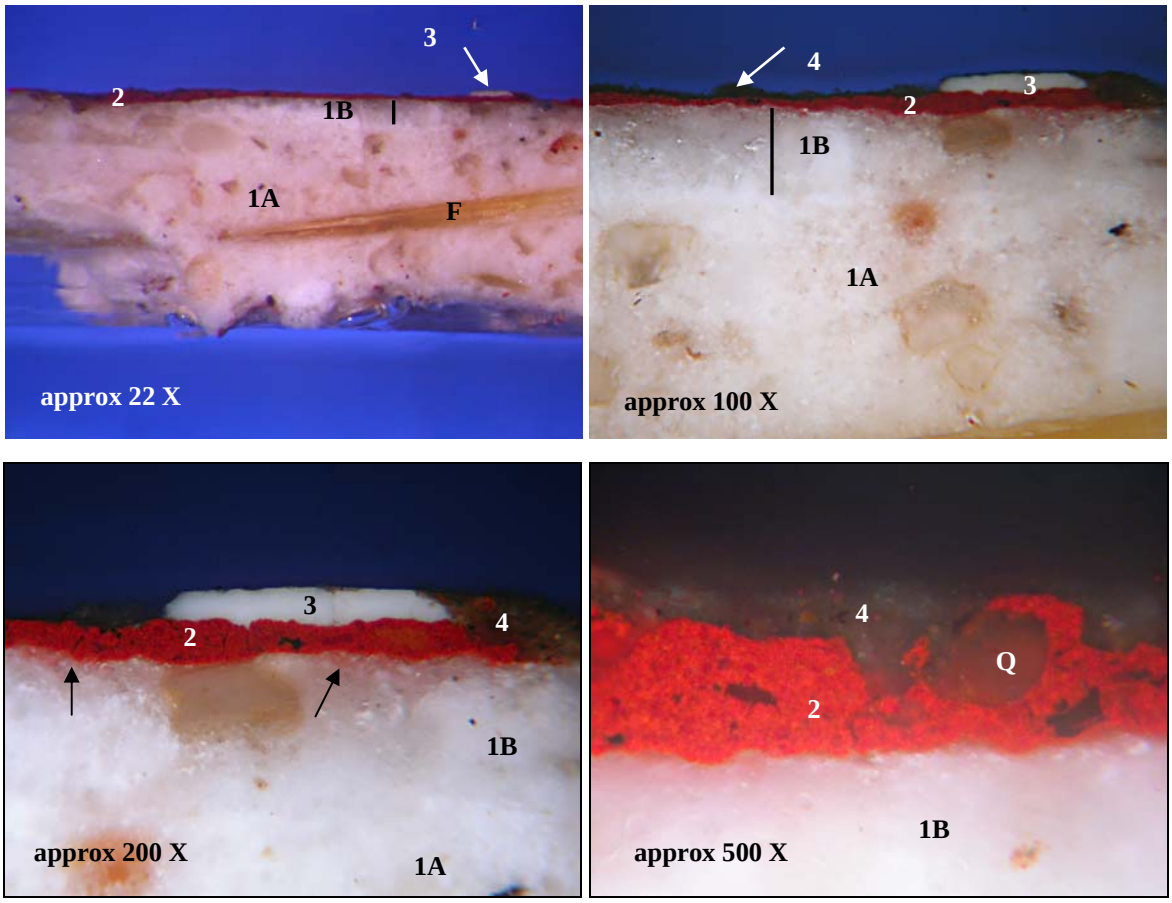

Cross section, reflected light

The four images, in various enlargements, describe various aspects of the stratigraphy. Those above show prevalently the structure of the rendering (no. 1) based on lime, vegetable fibres (F) and a essentially siliceous and, secondarily, type of limestone sand (a few granules of limestone were found inside it).
Furthermore the two images show that the rendering was applied in two layers at the same time (1A and 1B), the last one being relatively thin (approx. 0.2 mm thick) was used for preparing the overlying pictorial layer. This latter, red with purplish tones (no. 2) was prepared with haematite applied *"a fresco"* to the rendering.
Seen above the red pictorial layer is a small strip of a lime-based painting reintegration (no. 3) and an irregular brown level with a translucent aspect (no. 4) made up of wax and carbonious particulate (soot). The two images below, greatly enlarged, show the structure of the superficial layers. The letter Q indicates a siliceous type of granule, referable to quartz, present in the red pictorial layer.

The black arrows in the lower left image show how the rendering (1B) and the overlying red pictorial film tend to blend together, since they are not separated by a clear-cut solution of continuity.