This technical report is an excerpt taken from the PhD dissertation by Elizabeth Woolley (awarded June 2019):

COMMERCIAL DOMINATION OF ENGLISH ECCLESIASTICAL MURAL PAINTING 1860-1910: DEMAND, SUPPLY, TECHNOLOGY AND SIGNIFICANCE

The whole thesis can be read at the Courtauld Institute of Art, University of London.

A note on the report

The data presented in this excerpt supports the technical conclusions drawn throughout the dissertation, especially Chapter 7. It is one of nine case studies. The analytical method is described in Appendix 4 of the full dissertation. The full citation for works cited here as in-line (Author Date) citations can be found in the main dissertation bibliography.

The excerpt begins with a short description of the site, followed by a description of the scheme, on site observations and results of on-site and laboratory analysis.

The FTIR reference spectra are taken from IRUG and RUFF databases, and are taken in ATR mode, whereas non-invasive on-site analysis was done in reflectance mode. There is therefore a difference in peak shape and ratio between the two modes, and sometimes a small shift in wavenumber. Nevertheless, the ATR standards can be used to identify key functional groups of common compounds. FTIR-reflectance spectra were captured 400-5000 wavenumbers, and FTIR-ATR 400-4000. The axis is scaled to reflect this. FTIR reflectance analysis draws heavily on (Miliani 2012) for identification of sulfates and carbonates by their combination bands around ~1900-2500 and ~2400-2500 respectively.

XRF spectra are presented with identified elements in a table. The table lists only the alpha lines, not the corresponding beta lines or other secondary energy lines, but these are present in the spectra, and have been considered in the analysis. Peaks below 3.3 KeV are generally not identified as interpreting this area can be ambiguous due to the overlap of K, L and M shell lines from many elements in this region (Thompson 2009). The locations which each XRF spectrum are taken from are indicated on photograph of the area, typically by colour-coded circles, and if this is unclear, with additional numbering.

Disclaimer

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

GENERAL INFORMATION

Exterior view of the Church of St. Peter.

Internal view from nave looking east into chancel

DESCRIPTION OF CHURCH

Date of church: 1864

Architect: Woodyer

Extent of painting: Chancel and nave survive almost completely. Transept painted out - see letter from CCC to Vicar 1940s.

Named firm/artist: Hardman. J. A. Pippet signed the screen, and also some nave stencils still kept by the church.

Comparable schemes: Hardman painted narrative scenes at Caterham and Greenham. Not seen anything like the stencilled Peter's Net scheme.

Archive / reports / bibliography:

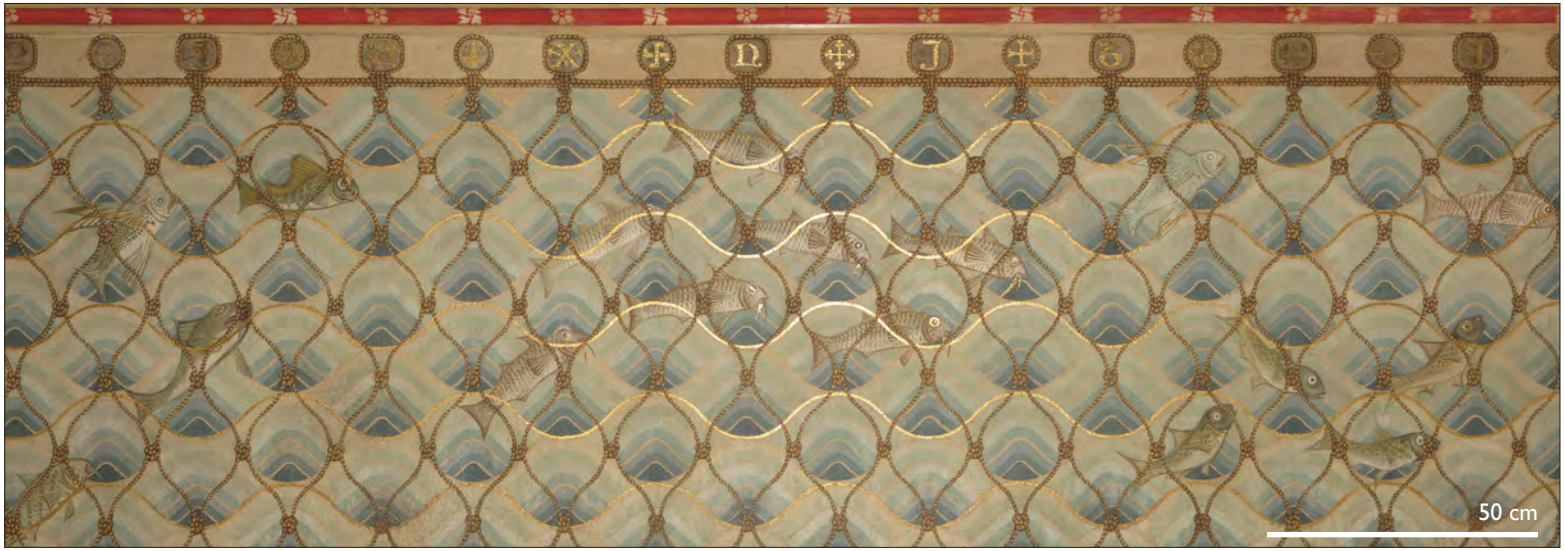
Perry Lithgow Partnership 1989. *Report on the conservation.*

Bott 2006. *A Guide to the Parish Churches of Dunsfold and Hascombe, Surrey*

Reid 2000. *Henry Woodyer and the church of St. Peter, Hascombe*, Ecclesiologist Today.

HAS/10 files at Woking Records Office.

Reredos, also by Hardman



Stencilled scheme referred to by Hardman as 'Peter's net', around the nave dado. Ends in Miraculous Draught of Fishes scene on chancel arch.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

GENERAL INFORMATION

DESCRIPTION OF SCHEME

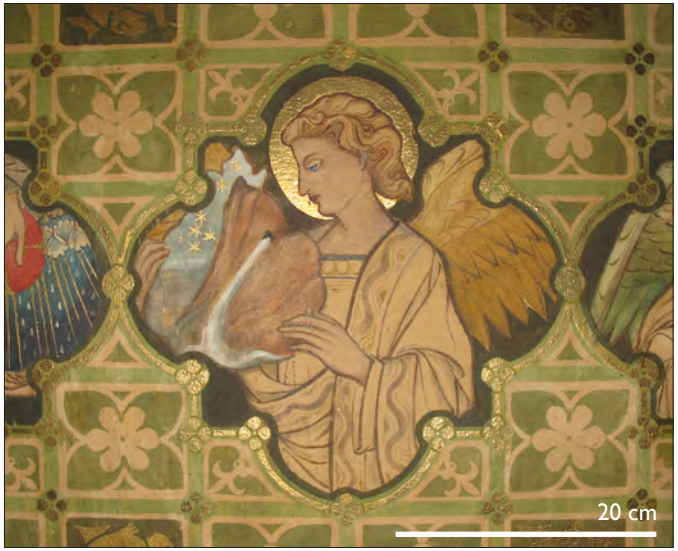
Subject matter:Various biblical scenes in the chancel, with scenes between the window openings, and further scenes in the window splays, related to the stained glass. Lower walls have angels in quatrefoils against fictive tile filler. Christ in Majesty on nave side of the chancel arch, within a mandorla with trumpeting angels and the apostles arranged around. Stencilled 'Peter's Net' motif runs all round the nave dado. Memorial to the vicars of Hascombe in SW corner of nave.

Palette: Unrestricted palette. Extensive use made of buff ground colour in figurative scenes, but quatrefoils are on a fully painted green fictive tile background, and Peter's Net almost covers the ground. Quite a lot of gold to pick out details - waves in nave dado, halos of figures. Some raised and gilded details.

Restored/repainted?: Limited repaint from 1989 conservation campaign. Reasonably easy to distinguish, so confident all analysis is of original.

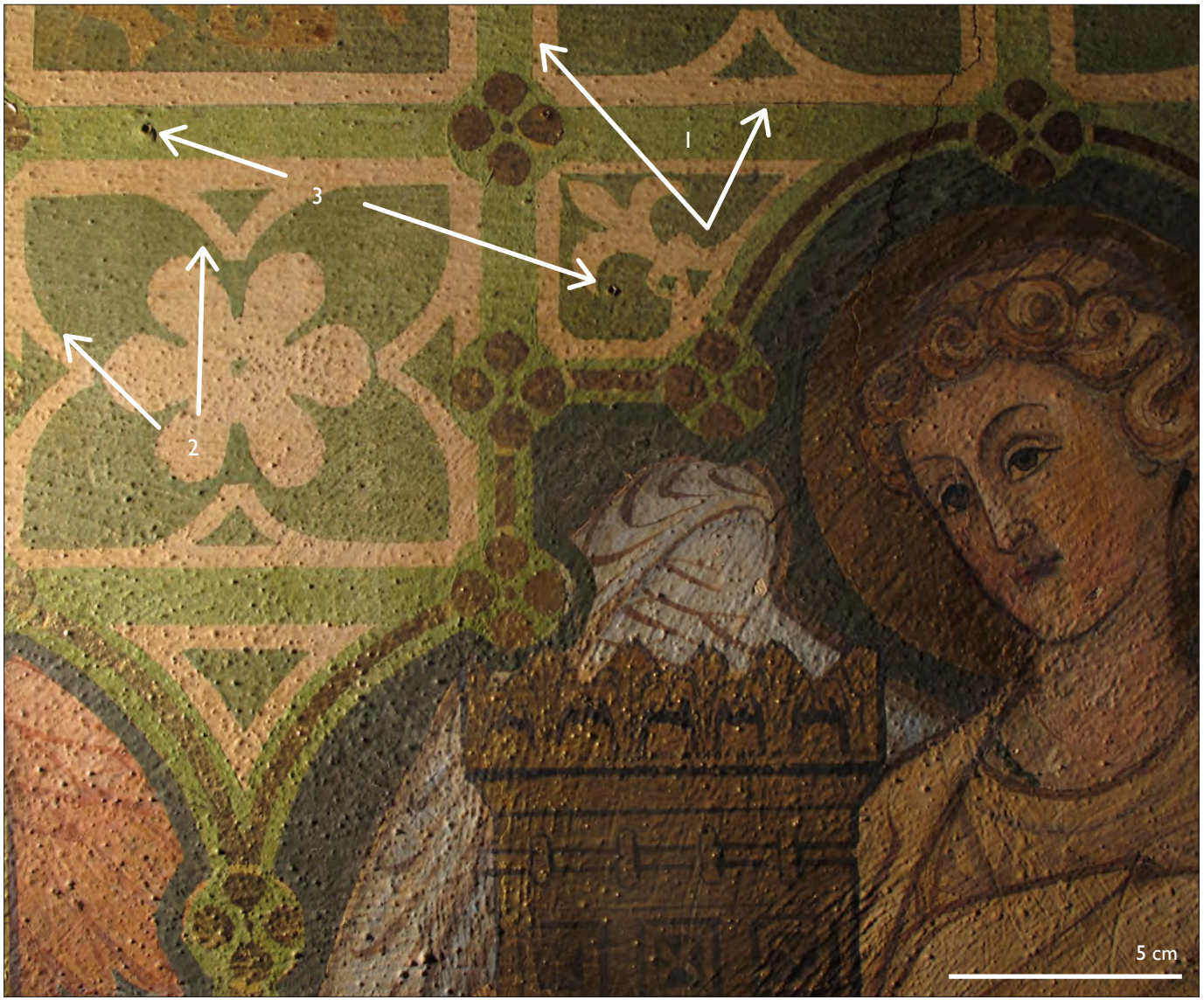
A figurative scene from the chancel apse

Christ in Majesty on the chancel arch



Angels in quatrefoils at dado level in the chancel.

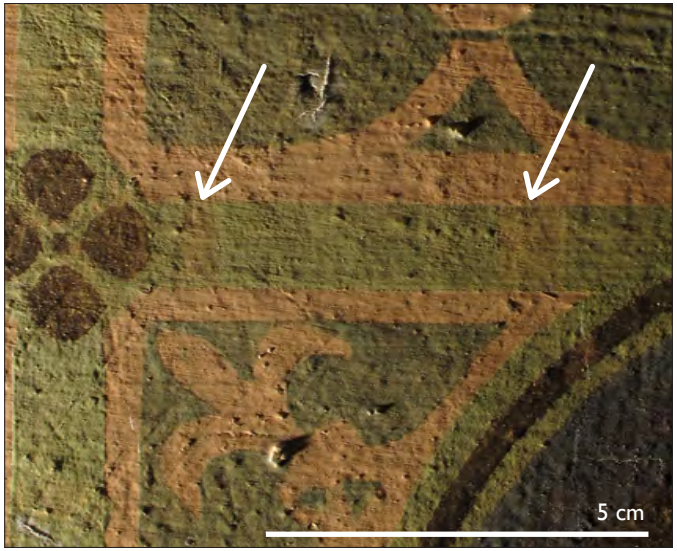
Apostles on the lower chancel arch wall, pulling in the net.



Several methods of setting out used on the chancel dado: Green grid painted first, using stencils and pencil lines (1). Squares filled in with stencils, as shown by lips of paint where stencil was lifted off (2). Tack marks through tile paint (3) suggests figurative quatrefoils were painted after tiles. Indicates quatrefoils transferred from full scale drawings.

Support: dressed masonry, plastered with rather coarse finish: grains of sand evident in raking light. Excellent condition precluded examination of layer(s) build up.
Preparatory layer evident in broad brush marks which do not correspond to composition. Ground can be incised into, e.g. compasses.
Setting out: Grid-and-stencil evident in green 'tile' motif of chancel dado. Tack marks into this suggest cartoons may have been used to part set out quatrefoil figures - finished with pencil drawing for faces and draperies. No evidence of pouncing. Squaring out used on chancel arch [see p. 9]. Compasses used for halos.
Under drawing: grey drawing pencil for setting out architecture and figures. Very few pentimenti.

Binder and pigments analysis presented on following pages, with a summary of findings on Page 34.



Painted out stencil bridges complete the line.

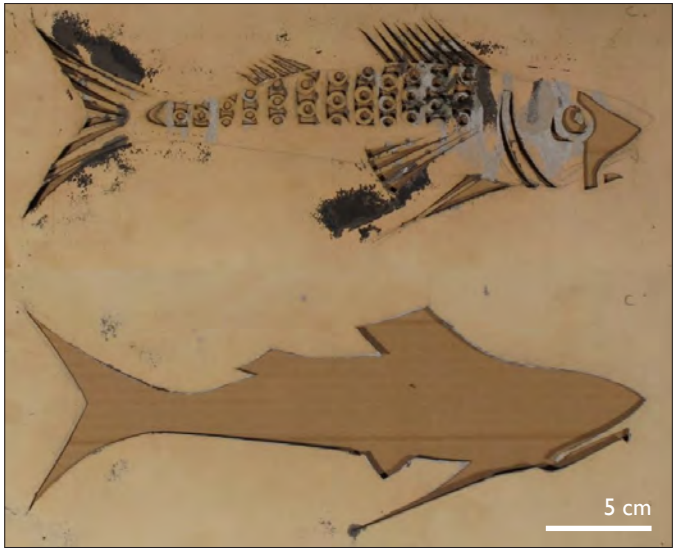
ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

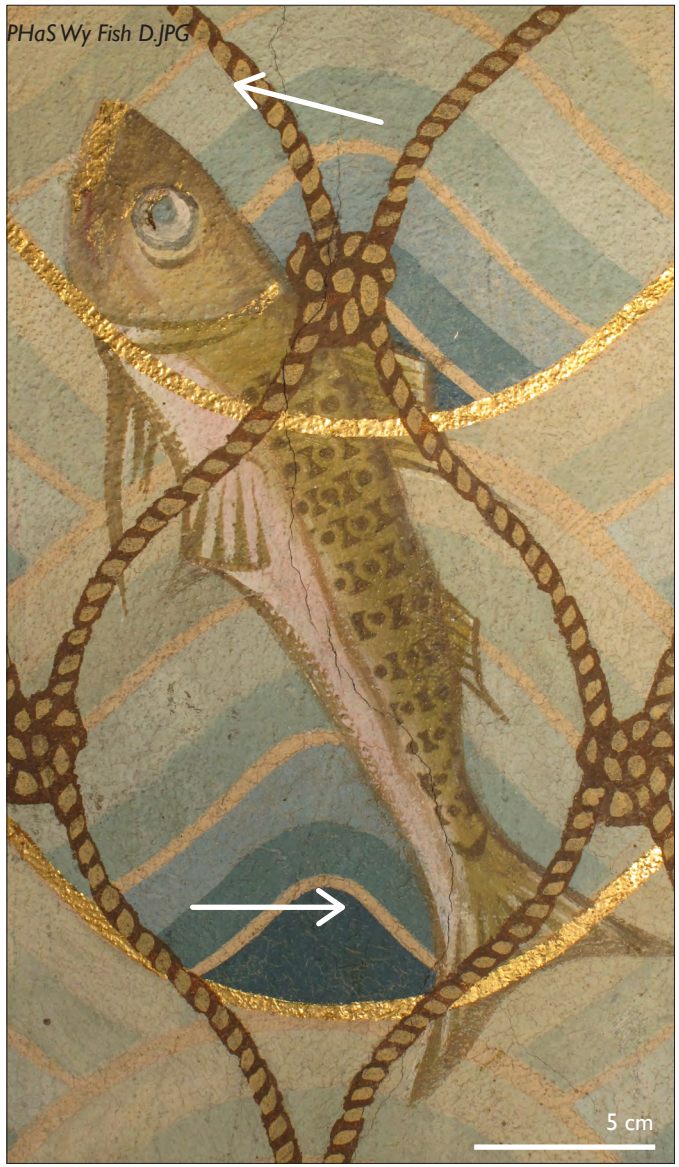
SITE IDENTIFIER: SHaP

DRAWING, STENCILS AND COMPASSES

Pencil drawing lines visible in the hair and face.

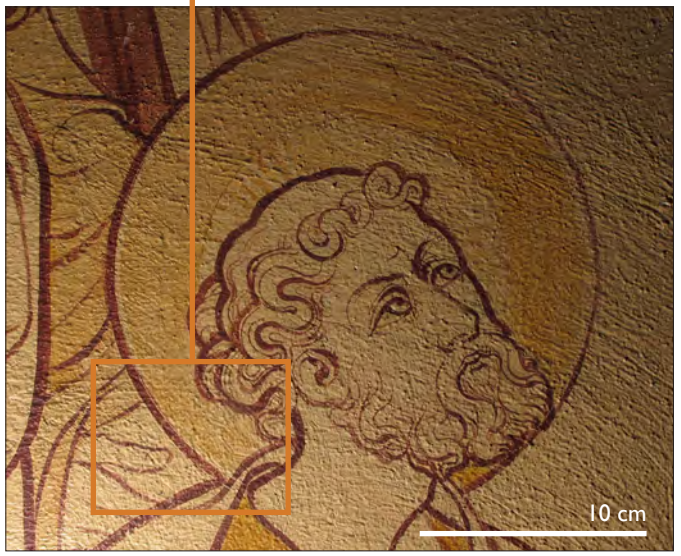


Original stencils still in church. The fish motif in the nave is achieved with ten pairs of stencils, as above.



Fish produced with stencils, shown bottom left. Fish body stencilled in after waves and before nets.

Detail of incised line from halo, below.



Compass point at centre of halo. Both pencil and incised lines were observed.

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HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

PAINT HANDLING

Flat gilded halo with gilded twine forming a raised edge.

Some impasto passages, mainly on flowers, always white.

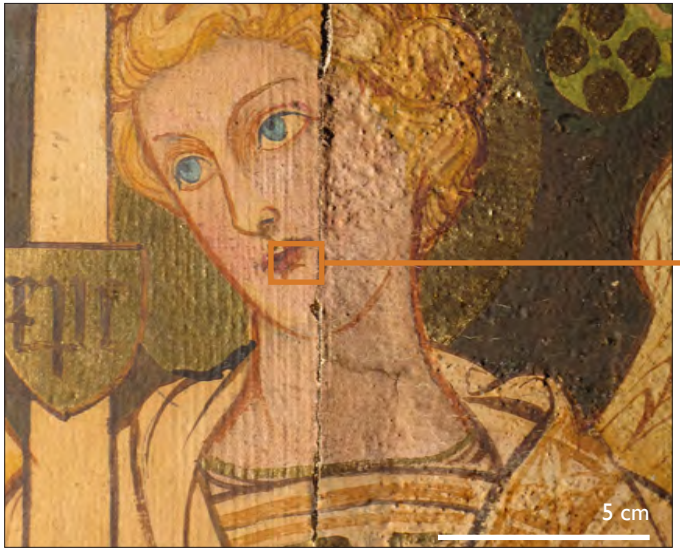
Paint handling:

Some paint mixing seen in draperies and flesh tones. Generally thin paint layer - drawing can be seen through.

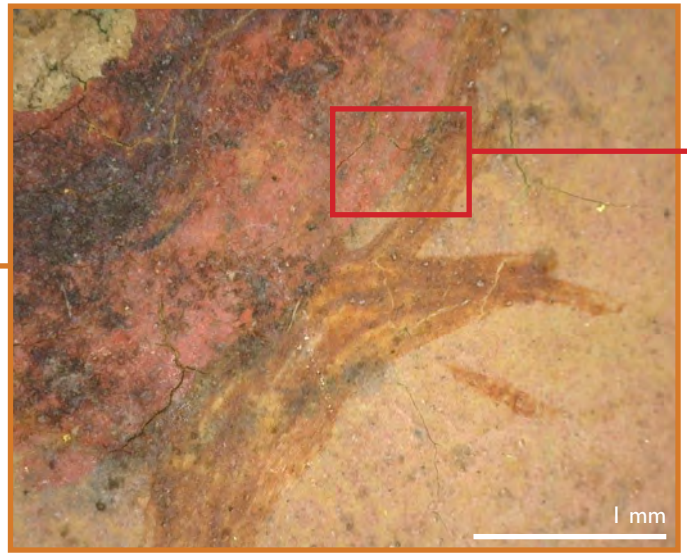
Layering of paint evident in stencilled areas, but generally looks like single, translucent layers of paint, making use of pale ground showing through.

Stencils used extensively in non-figurative parts of the scheme. Figurative scenes done freehand, both drawing and painting.

Some impasto paint, but only white, used on flowers, etc. This may be the same bulking material as for the raised gold details, described below.



Multiple thin paint layers to model flesh, pencil still visible.



Detail of angel's mouth, brown outlining over red paint.

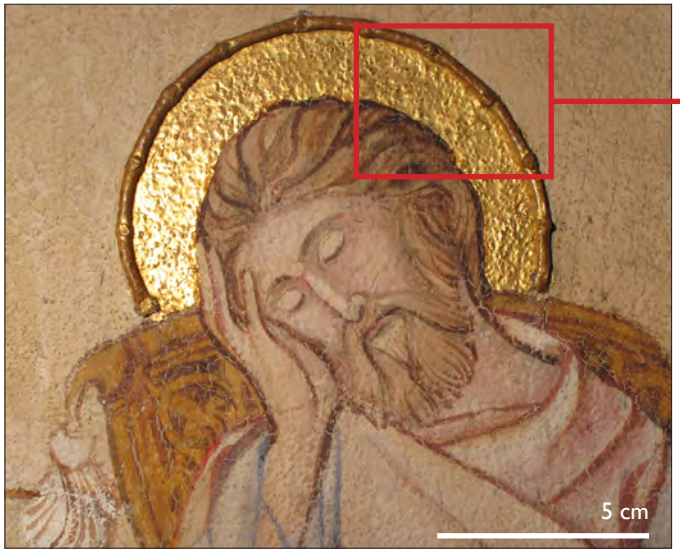
Outlining done before paint dry - red swept into brown line.

Applications:

Gold is applied both flat and raised.

- Flat gold on halos, details, tile embellishments, etc.
- Raised gold, over impasto white - see coins and stars, for example.
- Use of nailed string or similar to form halo outlines - as at St. Botolph's, Cambridge, by Leach & Sons.

The gold appears to be applied as a leaf over mordant - see Samples SHaP01 and SHaP04.



Flat gilded halo with raised edge, formed by tacked string.

Detail of string-and-tack halo edge construction.

Medallion detail. White mass applied and then gilded.

Mass brushed on, then gilded (ungilded parts at edges)

Flat gilded detail on fictive tiling.

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HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

PHOTOGRAMMETRY

Chancel arch showing squaring grid marked with dotted yellow lines. Inset detail shows how faint the lines are: they were detected by close examination of a high-resolution photomerge.

ST. PETER, HASCOMBE, SURREY

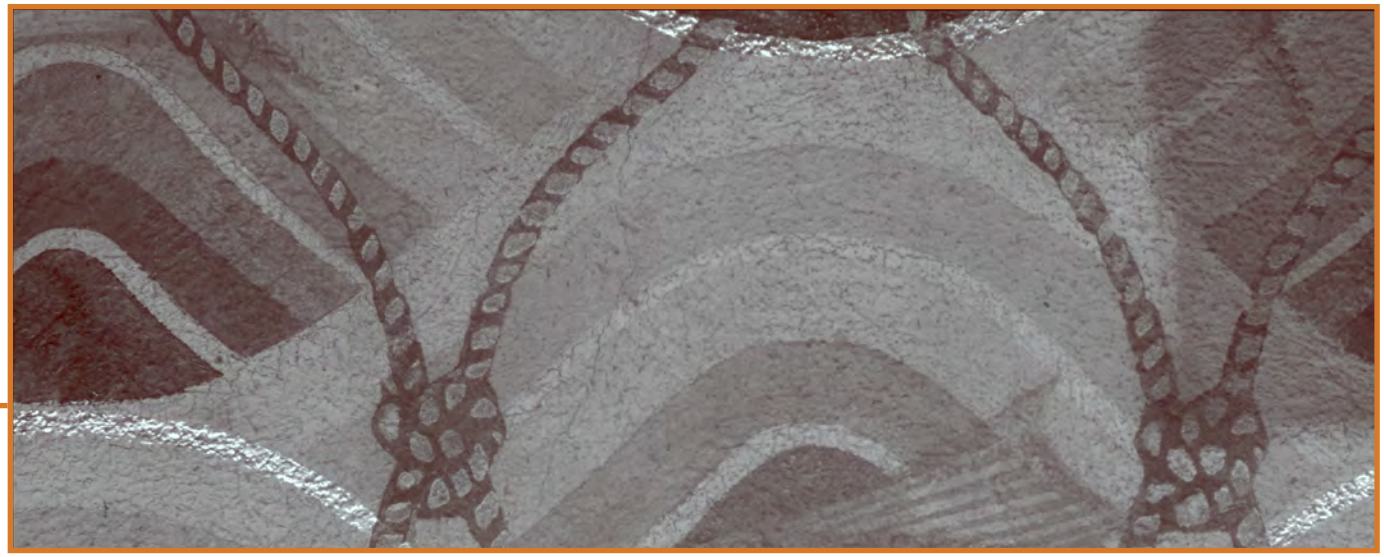
HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

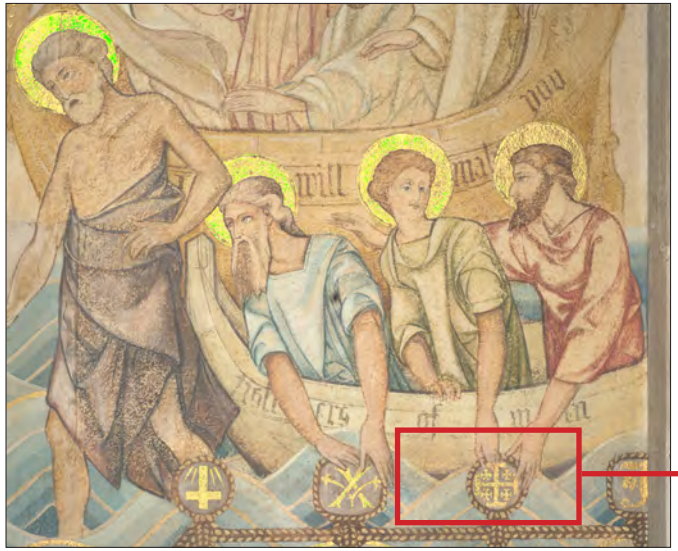
MULTISPECTRAL IMAGING

IR images can reveal underdrawing because infrared radiation is usually highly penetrative and many materials, such as organic binders and colorants, are generally transparent to infrared wavelengths (Dyer et al 2013).
IR imaging of Peter's Net motif round the nave dado revealed no obvious pencils lines. *Executed entirely with stencils?*
The Miraculous Draught of Fishes on the chancel arch has a similar motif. Unlike the rest of the dado, however, IR clearly reveals this was set out with pencil and then painted in.

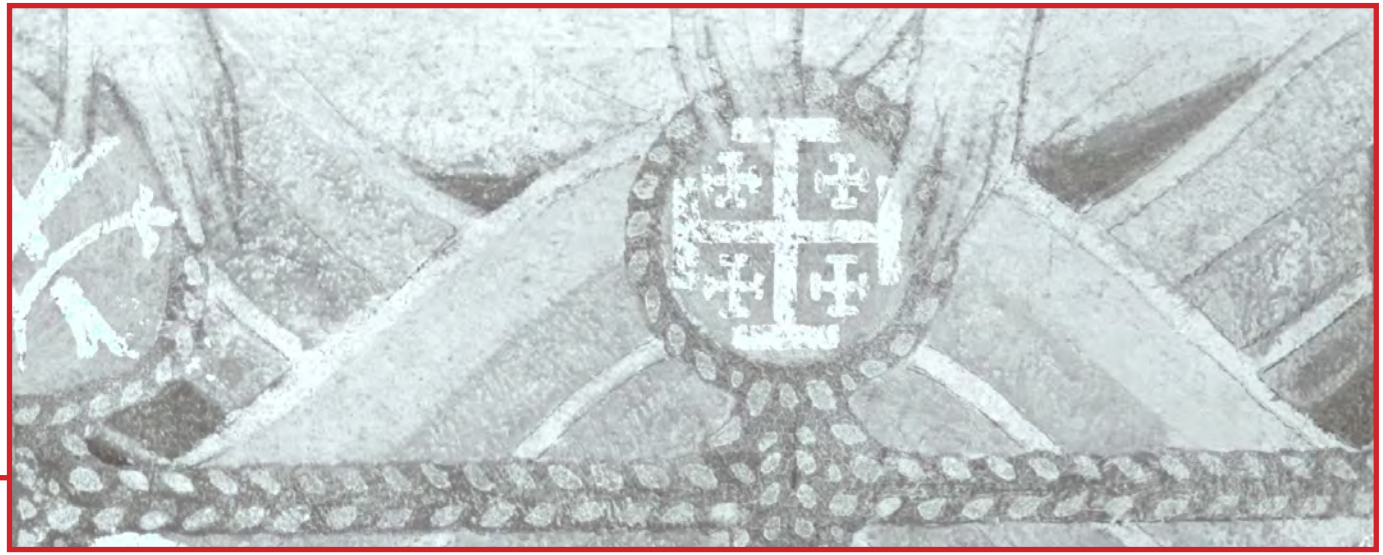
Context of nave dado fish-and-net motif, IR detail right.



IR image of fish-in-net motif on nave dado shows no pencils lines.



Context view of Apostles scene, IR detail right.



IR image of similar motif on chancel arch shows pencil outlines to the waves.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

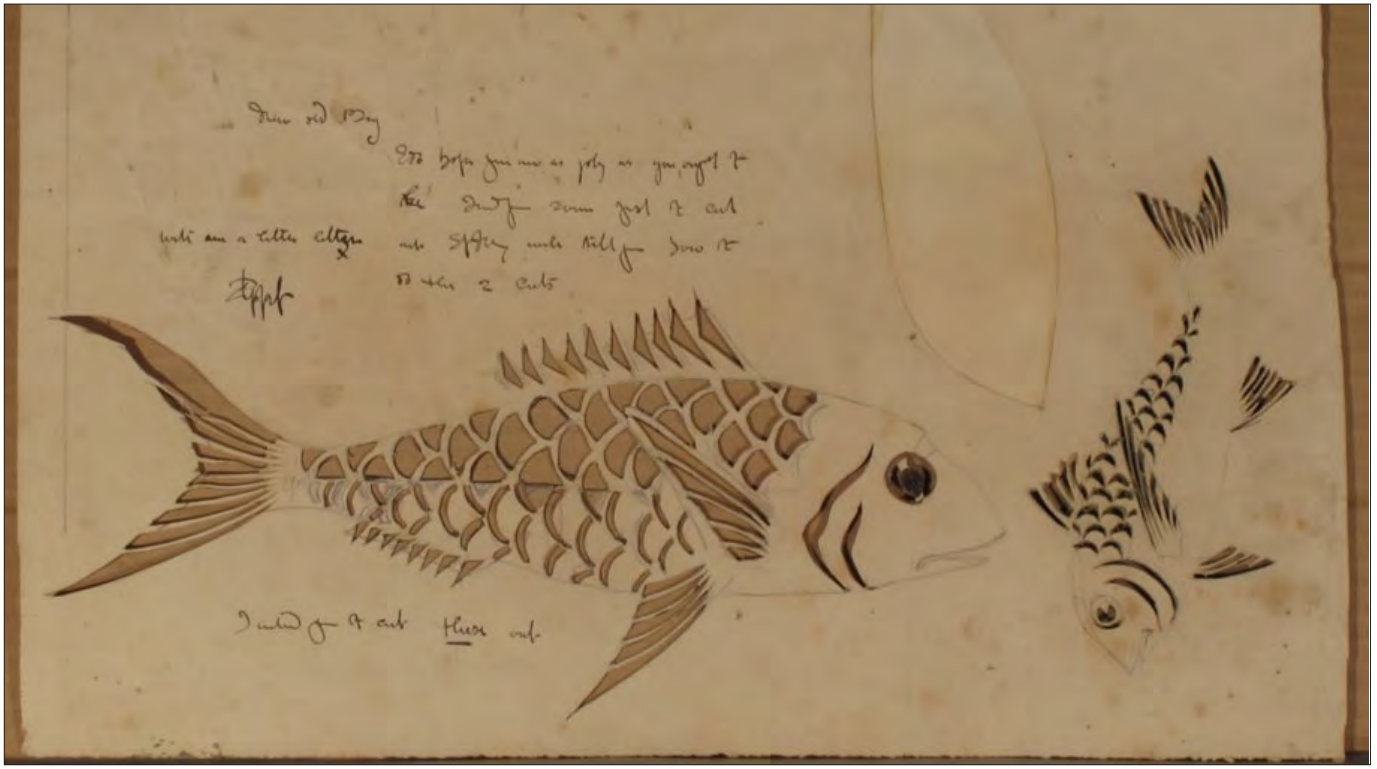
STENCIL INSTRUCTIONS

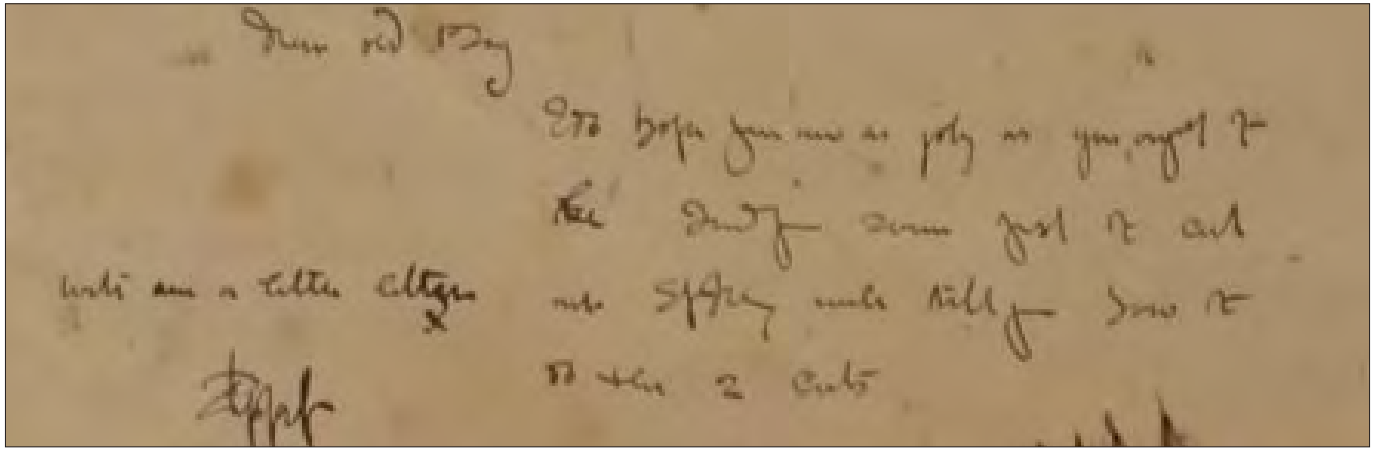
The parish has retained many of the original stencils used by the Hardman team to execute the scheme between 1883-6. This includes several fish motifs, alongside the 'Pater' analysed opposite.

Of particular interest is an annotated fish stencil, smaller than any featuring in the scheme. The handwriting belongs to J. A. Pippet, chief painter for the firm, and he appears to be issuing instructions for the work in his absence - perhaps the workmen arrived on site before the manager, or he was away on another job for part of the time of the preparations. The writing has been deciphered as:

'Dear old Boy,
I do hope you are as joly as you ought to be. I send you some just to cut out. Spo----y [name?] will tell you how to do the 2 cuts
with a letter cutter.
Pippet

I intend you to cut <u>these</u> out





Above: Instructions by Pippet, kept with the actual stencils by the church.
Left: zoomed detail of the writing.

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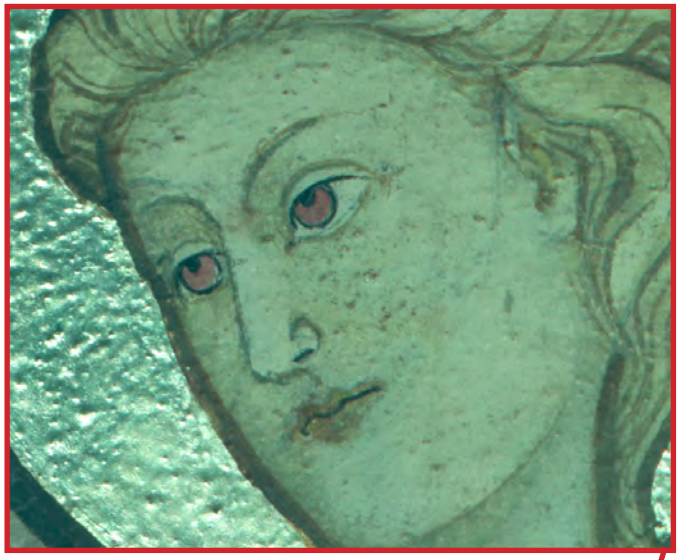
ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

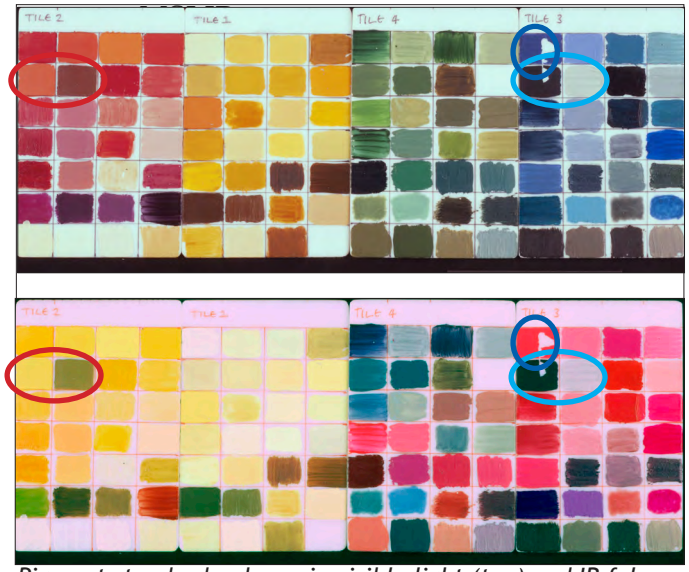
SITE IDENTIFIER: SHaP

MULTISPECTRAL IMAGING

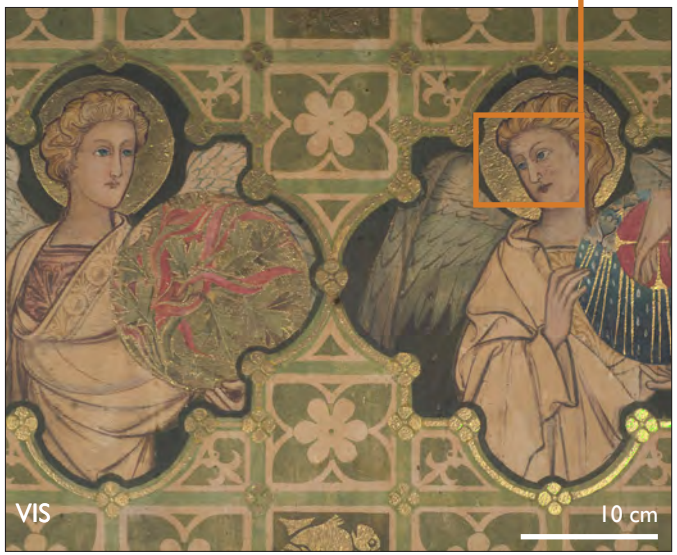
Detail of right hand angel in visible light.



IR false colour detail. Pink eye colour may be indicative of cobalt blue (among others), confirmed by XRF.



Pigment standards, shown in visible light (top) and IR false colour (bottom).



Visible light image of two angels in chancel.

IR false colour image of same gives hints as to pigments used.

Comparing the visible and IR-false colour images generated from the wall painting with known lab standards may aid the characterisation or differentiation of pigments (Aldrovandi 2005). Known standards were imaged under the same lighting conditions as on site and are shown above. Those standards which match the findings from site are circled.

Areas of interest and pigments indicated:

- right angel's blue wing and sphere are a different pigment to its blue eyes; the first two agree with Prussian blue, and the eyes with cobalt blue (see blue circles, above); *cobalt blue confirmed by XRF, see below..*
- green tiles do not bear close resemblance to any of the standards, and may be a mixture of blue and yellow not represented in the standards. See SHaP01 for more on green pigments.
- reds of left angel's sphere are bright yellow in false colour, suggesting vermilion (see red circle, above).

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HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

MULTISPECTRAL IMAGING

Visible image of scene from chancel south east window splay.

Vase and sleeve same in false colour. Angel robe different.

The IR false colour image also shows two blues used in the Dream of Joseph scene shown.

- The blue of the vase, throne and sleeves is pink in the false colour manipulation - *cobalt blue, confirmed by XRF*
- The blue drapery of the angel figure behind is a dull purple colour, *possibly a mix of Prussian blue and another pigment.*

Access limitations made further analysis of draperies and throne impossible.

Drawing lines in drapery composition visible in IR image.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

MULTISPECTRAL IMAGING

MSI of the waves suggests they are the same pigment blend, modified with a white pigment to adjust hue. Prussian blue is unusual among the blue pigments for giving a bluish IR false colour - many other pigments are pinkish. However, as can be seen from the standards (top right), the false colour generated from the waves is not quite like Prussian blue, but rather more purple. This may suggest an admixture - inclusions of ultramarine were found in the layer corresponding to a blue wave in SHaP02 by EDS analysis (see below).

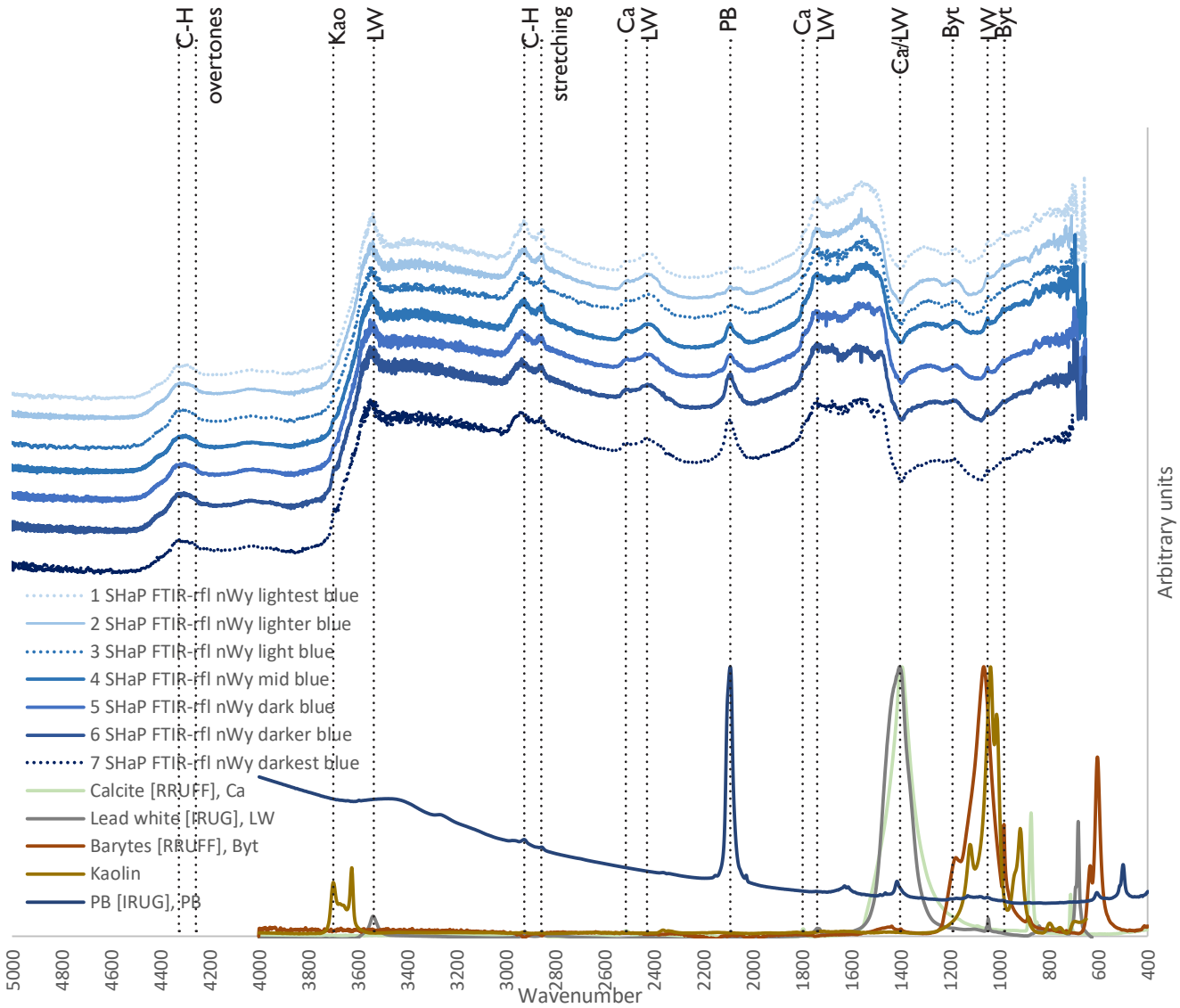
Prussian blue standards, circled, in visible light (left) and IR false colour (right).

The stencilled wave pattern has seven graded shades of blue. The seven shades were analysed by FTIR-reflectance spectroscopy, giving seven very similar spectra, containing:

- Prussian blue (signal at ~2100 is faint in the palest blues),
- lead white,
- calcite,
- kaolin,
- *possibly baryte.*

Other pigments cannot be ruled out of the blue paints - ultramarine was found in SHaP02, corresponds to Spot 7. The IR-FC image (facing page) suggests a mixture of blues.

Seven different shade of blue, used to stencil nave scheme.

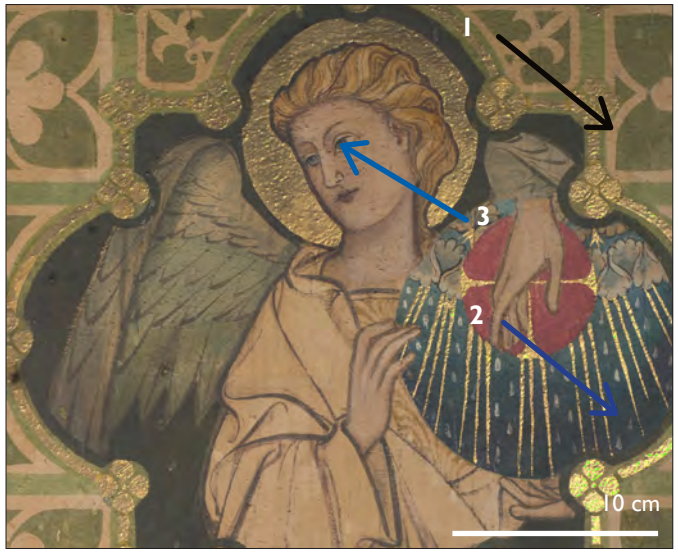


ST. PETER, HASCOMBE, SURREY

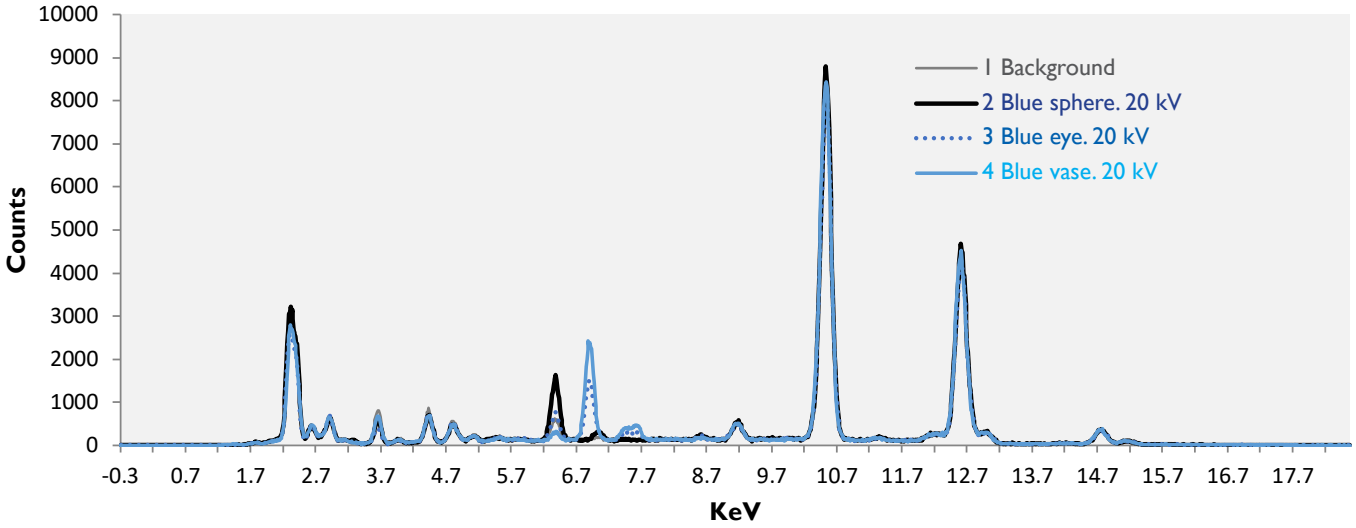
HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

BLUE PAINT ANALYSIS - XRF



Context image of two XRF sample spots, numbered and marked in blue.



Spectra of background and three areas of blue paint. Chart shown on linear scale.

Context image of XRF sample spot, numbered and marked in blue.

	Ca ($K\alpha_1$ 3.692)	Ba ($L\alpha_1$ 4.466)	Cr ($K\alpha_1$ 5.414)	Mn ($K\alpha_1$ 5.898)	Fe ($K\alpha_1$ 6.404)	Co ($K\alpha_1$ 6.930)	Cu ($K\alpha_1$ 8.048)	Zn ($L\alpha_1$ 8.638)	Au ($L\alpha_1$ 9.713)	Hg ($L\alpha_1$ 9.989)	Pb ($L\alpha_1$ 10.552)	Comments
1 Background	x	x			x						x	Pb, Fe, Ca and Ba signals.
2 Blue sphere. 20 kV	x	x			x						x	As background, with elevated Fe peak.
3 Blue eye. 20 kV	x	x			x	x					x	As background, with additional Co signal.
4 Blue vase. 20 kV	x	x				x					x	As background, with additional Co signal.

In spectrum 2, there is a high peak for Fe. This is a spot which is quite a dark blue hue, so may have a high Prussian blue concentration in it.

In spectra 3 and 4, there is a Co signal, but no Sn peaks (~3.44 or ~25.27), which suggests this is cobalt blue ($CoAl_2O_4$) not cerulean blue ($CoO \cdot n\ SnO_2$), which confirms MSI findings.

FTIR-REFLECTANCE

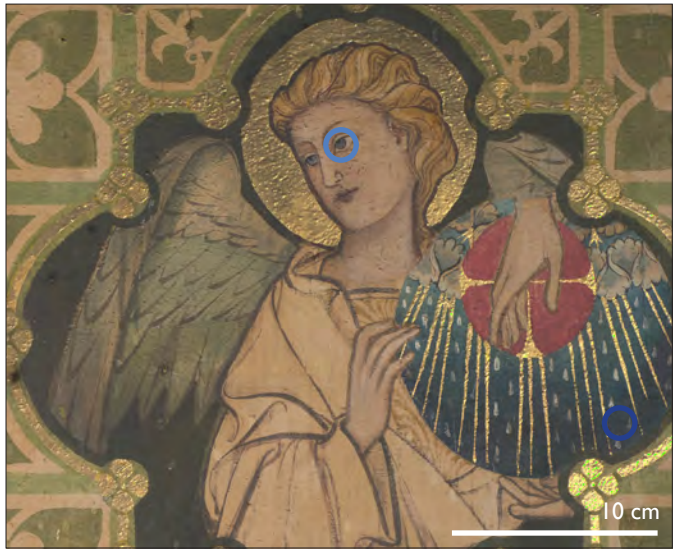
Two spots comparable with 2 Blue sphere 20 kV and 3 Blue eye 20 kV were analysed by FTIR-reflectance. In both cases the following were detected:

- lead white,
- barytes
- calcite
- an organic material (doublets at ~2900 and ~4300)
- *possibly kaolin (signal at ~3700)*

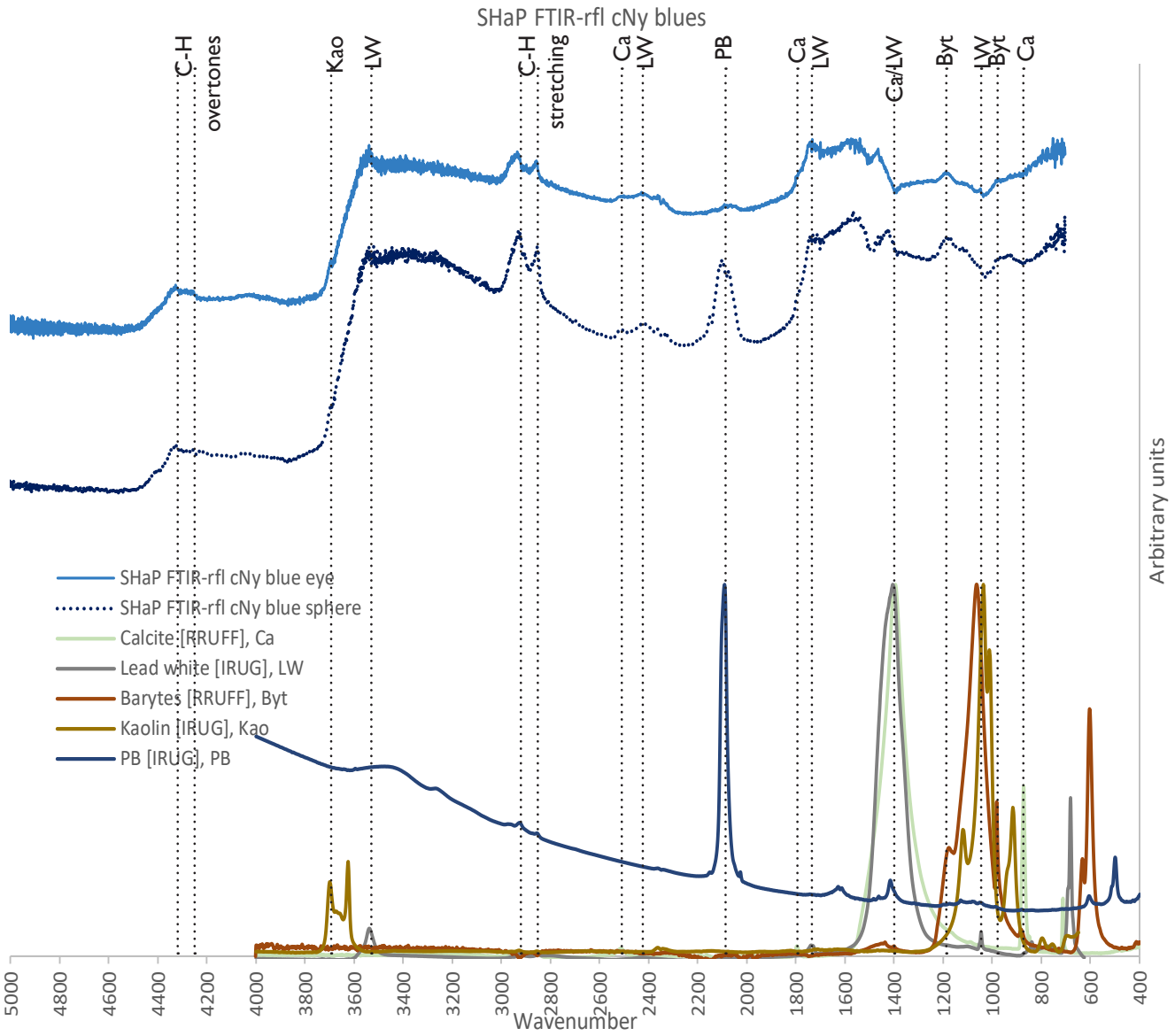
The spectrum from the sphere also contains Prussian blue, which confirms the MSI and XRF findings, above.

The inclusion of ultramarine cannot be confirmed or rejected on the basis of these analyses as the silicate peak at ~1000 cannot be distinguished.

The presence of kaolin is interesting - it may be an extender, although it is also used as raw material for French ultramarine (Eastaugh 2008: 215).



Context image of two FTIR sample spots, circled in blue.



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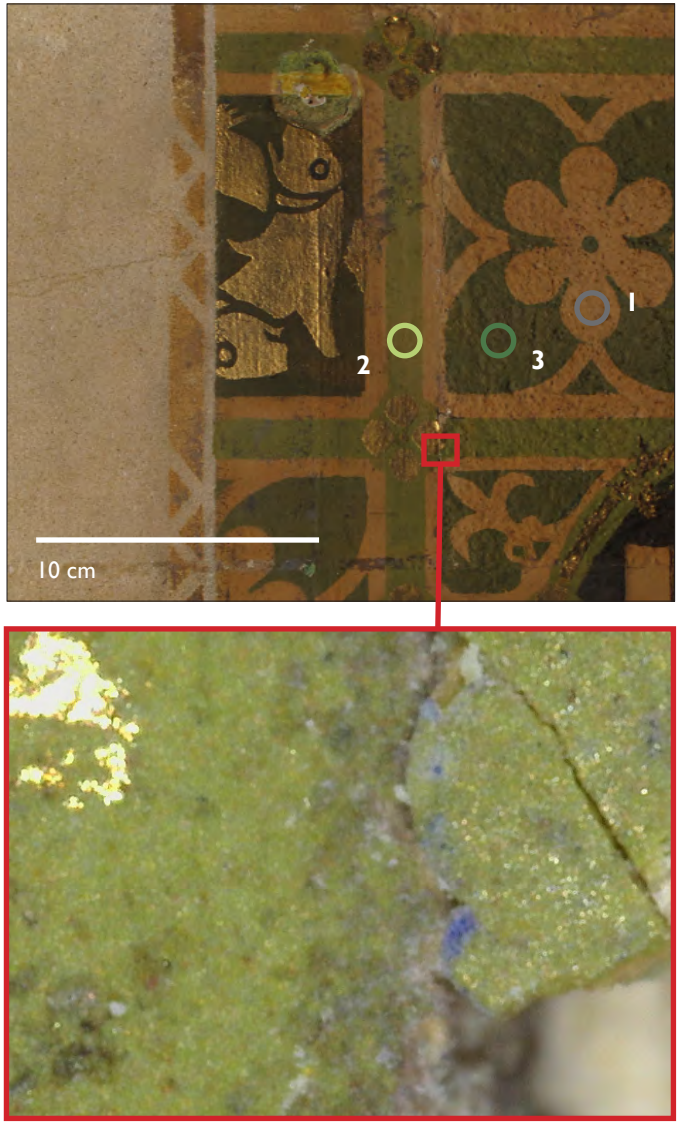
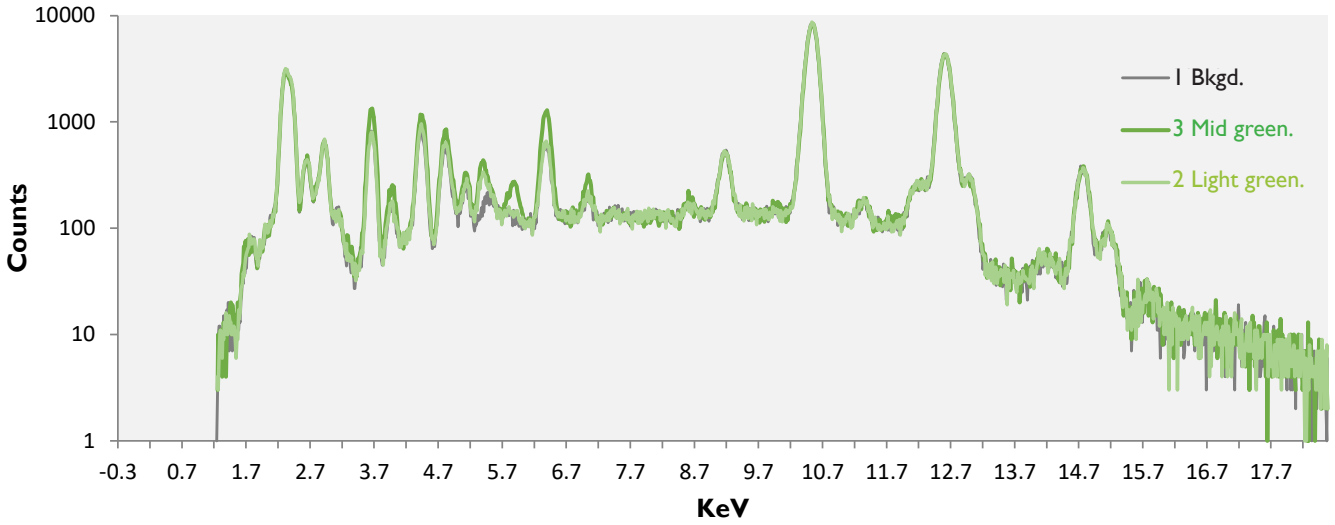
HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

GREEN PAINT ANALYSIS - XRF



Context image of three XRF sample spots, numbered. The inset shows an area magnified x200, with visible blue particles, suggesting a mix.



	Ca ($K\alpha_1$ 3.692)	Ba ($L\alpha_1$ 4.466)	Cr ($K\alpha_1$ 5.414)	Fe ($K\alpha_1$ 6.404)	Mn ($K\alpha_1$ 5.898)	Co ($K\alpha_1$ 6.930)	Cu ($K\alpha_1$ 8.048)	Zn ($L\alpha_1$ 8.638)	Au ($L\alpha_1$ 9.713)	Hg ($L\alpha_1$ 9.989)	Pb ($L\alpha_1$ 10.552)	Comments
1 Bkgd. 20 kV	x	x		x							x	Pb, Ca, Ba and Fe peaks
2 Light green. 20 kV	x	x	x	x							x	As background, elevated Fe signal.
3 Mid green. 20 kV	x	x	x	x	x						x	As background, elevated Fe signal. Cr and Mn present

Cr present in both greens, which could be a blue mixed with chrome yellow, or a chrome green pigment such as viridian. On site microscopy images (see bottom left) of the light green paint suggests a blue/yellow mixture. The large royal blue particles may be ultramarine.

As the iron signal is not elevated above background levels in 2 Light green XRF spectrum, yellow iron oxide is unlikely to be the yellow pigment in the admixture.

The peak in the mid green spectrum at ~5.9 in 3 Mid green is higher than expected for Cr K-beta (Thompson 2009). Suspect instead presence of Mn, and the elevated Fe signal to be from umber.

FTIR-REFLECTANCE

Three spots comparable with 1 Bkgd, 3 Mid green and 2 Light green were analysed by FTIR-reflectance. Both greens have a similar spectrum, containing

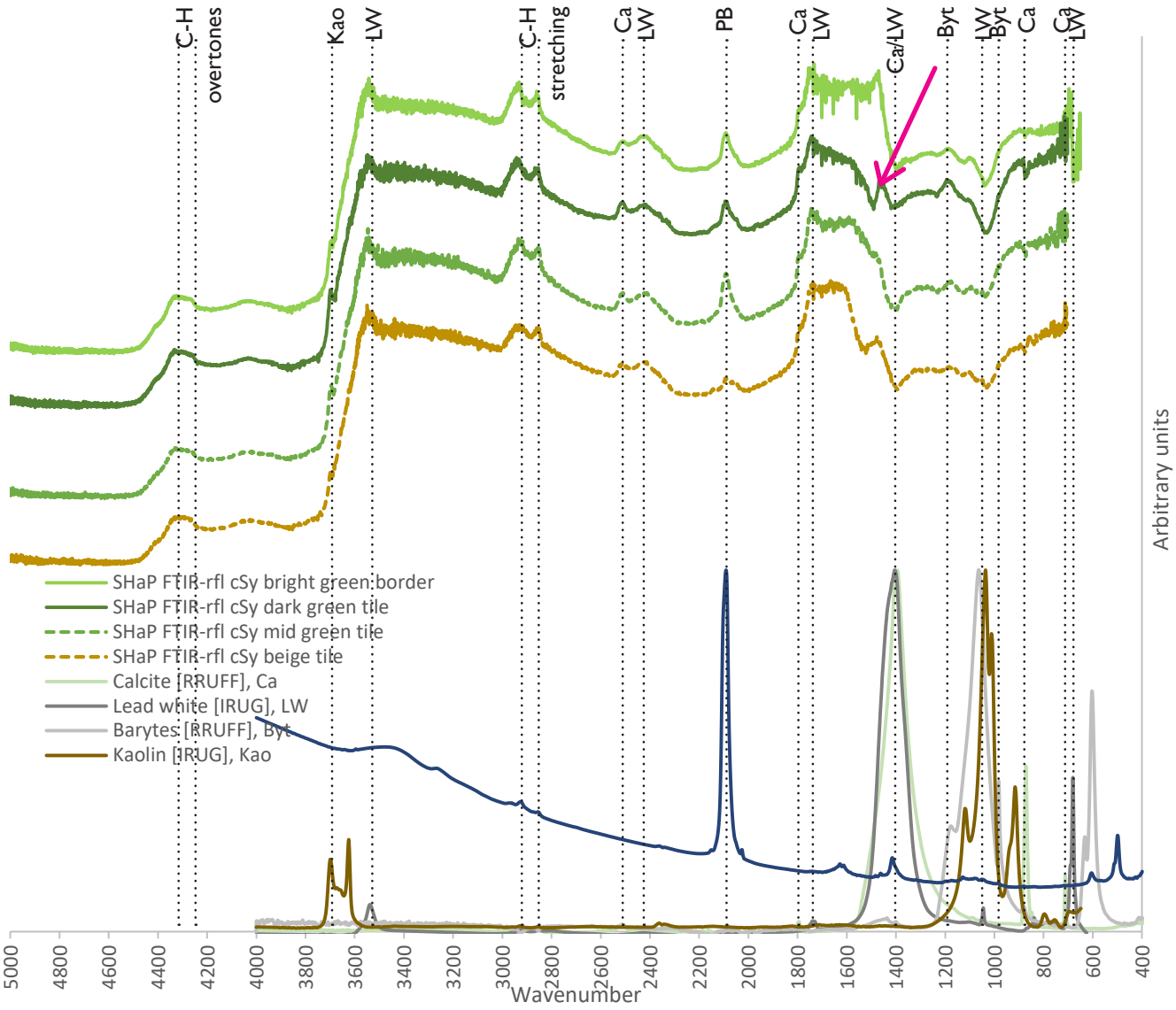
- lead white,
- kaolin
- Prussian blue.

The presence of Prussian blue is confirmed by FTIR, but it is not very apparent in cross-section of SHaP01. Its high tinting strength may mean it is present in low quantities not readily detected by XRF, opposite.

EDS analysis of sample SHaP02, and visual analysis of SHaP01 (corresponding to 'bright green') showed the presence of ultramarine. It cannot be excluded by the analysis presented here as the silicate peak at ~1000 cannot be distinguished.

Suggested pigment combinations based on both XRF and FTIR results:

- Light green: lead white, Prussian blue, chrome yellow, ultramarine [?].
- Mid green: lead white, Prussian blue, chrome yellow, ultramarine [?] and umber.

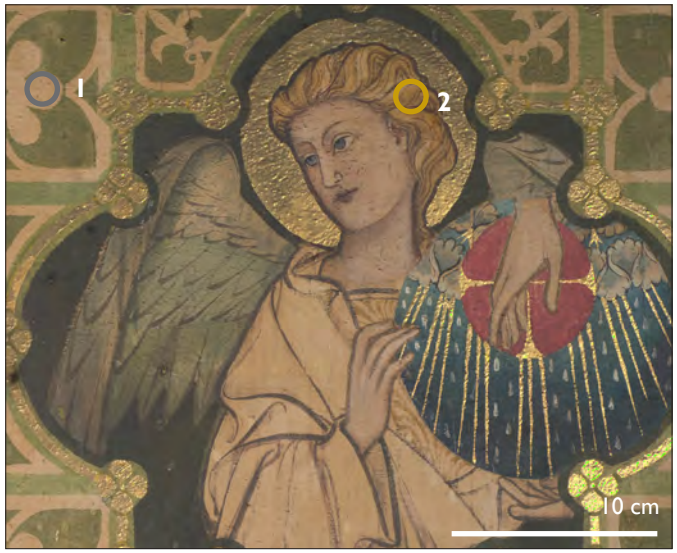


ST. PETER, HASCOMBE, SURREY

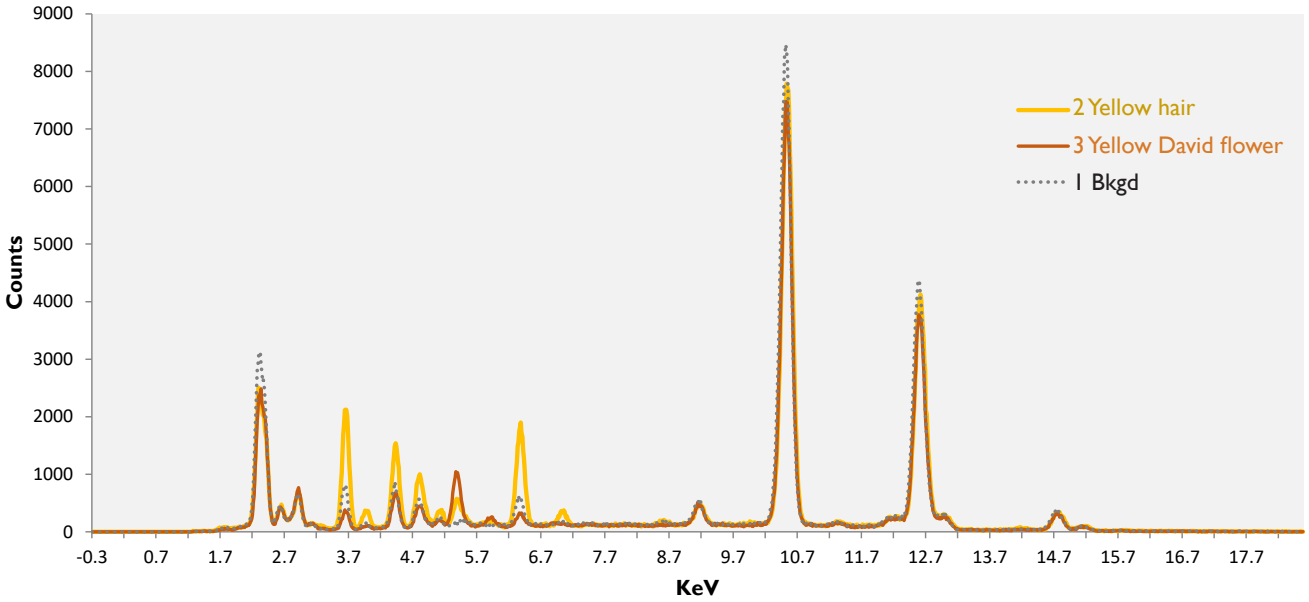
HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

YELLOW PAINT ANALYSIS - XRF



Context image of two XRF sample spots in hair and bkgd, numbered and circled.



Yellow flower XRF sample spot, numbered and circled.

	Ca ($K\alpha_1$ 3.692)	Ba ($L\alpha_1$ 4.466)	Cr ($K\alpha_1$ 5.414)	Fe ($K\alpha_1$ 6.404)	Mn ($K\alpha_1$ 5.898)	Co ($K\alpha_1$ 6.930)	Cu ($K\alpha_1$ 8.048)	Zn ($L\alpha_1$ 8.638)	Au ($L\alpha_1$ 9.713)	Hg ($L\alpha_1$ 9.989)	Pb ($L\alpha_1$ 10.552)	Comments
1 Bkgd. 20 kV	x	x		x							x	Standard background elements of Pb, Ca, Ba and Fe.
2 Yellow hair 20 kV	x	x	x	x							x	Strong Fe signal - *yellow iron oxide?* Cr also present, as well as Ba and Ca.
3 Yellow David flower. 20 kV		x	x	x							x	Strong Cr signal - *lead chromate?* Small Fe signal, as well as ..

Pb, Fe and Cr detected in all both yellow samples, but 3 Yellow David flower. 20 kV has a stronger Cr signal and a very weak Fe signal, and 2 Yellow hair 20 kV is inverse. This suggests two different yellow pigments were - yellow iron oxide and a chrome yellow - and mixed varyingly.

Ba was detected, so barium chromate, a yellow pigment, cannot be ruled out. However, as the Ba signal is stronger in the hair spectrum, where iron oxide is suspected as the main yellow pigment, this Ba signal may be from a baryte extender, rather than a yellow barium pigment. Given the abundance of barium sulfate found at Hascombe (identified with EDS, below), lead chromate with barium extenders may be more likely.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

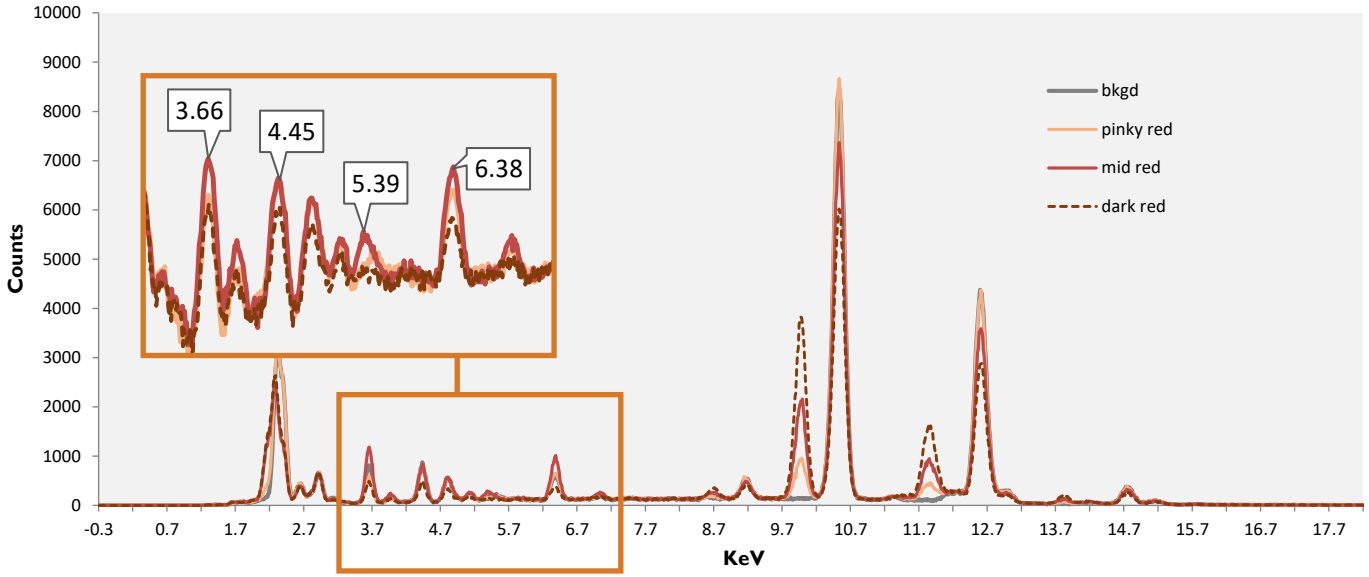
SITE IDENTIFIER: SHaP

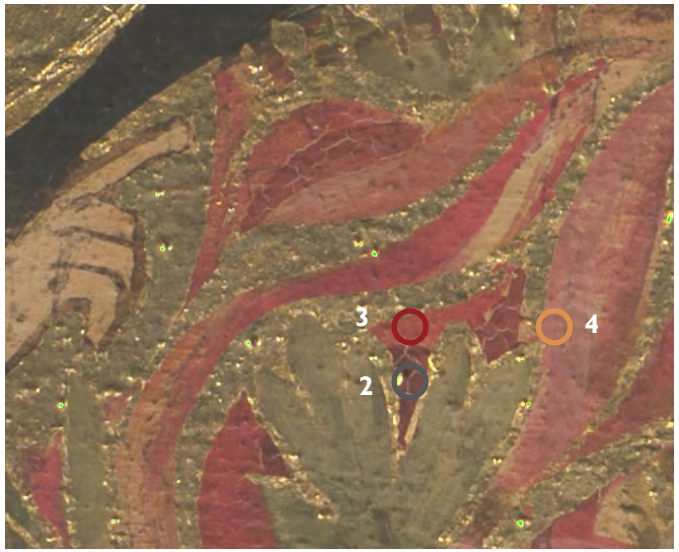
RED PAINT ANALYSIS - XRF

Fe and Hg were detected in all three red tones analysed, along with Ca, Ba and Pb (~8.72 is a minor Hg L1 x-ray emission, not Zn). There is a possible signal for Cr in the mid-red spectrum, The logarithmic scale shows this more clearly (see inset chart).

All three shades have similar elements, in different ratios. The lighter red has more lead white (as expected), and the darkest red has a stronger mercury signal. Although XRF spectra from such heterogenous materials and surfaces cannot be quantitative (MacGlinchey 2012), these results, combined with the visual appearance of the paint handling, suggest a mixing of different tones on the palette.

Au was not detected in any spectra, which confirms visual observation that the gilding was done *after* painting was complete.





Context image of XRF sample spots, numbered and circled.

	Ca ($K\alpha_1$ 3.692)	Ba ($L\alpha_1$ 4.466)	Cr ($K\alpha_1$ 5.414)	Fe ($K\alpha_1$ 6.404)	Mn ($K\alpha_1$ 5.898)	Co ($K\alpha_1$ 6.930)	Cu ($K\alpha_1$ 8.048)	Zn ($L\alpha_1$ 8.638)	Au ($L\alpha_1$ 9.713)	Hg ($L\alpha_1$ 9.989)	Pb ($L\alpha_1$ 10.552)	Comments
Bkgd [same area as facing page]. 20 kV	x	x		x							x	Ca, Ba, Fe and Pb - ground thought to be same across chancel scheme.
2 Dark red 20 kV	x	x		x						x	x	Fe peak lower than for background. Hg = *vermilion*.
3 Mid red 20 kV	x	x	x	x						x	x	Fe peak higher than for background. Hg present. *Mix of red iron oxide and vermilion, possibly chrome orange too..*
4 Pinky red 20 kV	x	x		x						x	x	Fe and Pb intensities similar to background. Hg = *vermilion.*

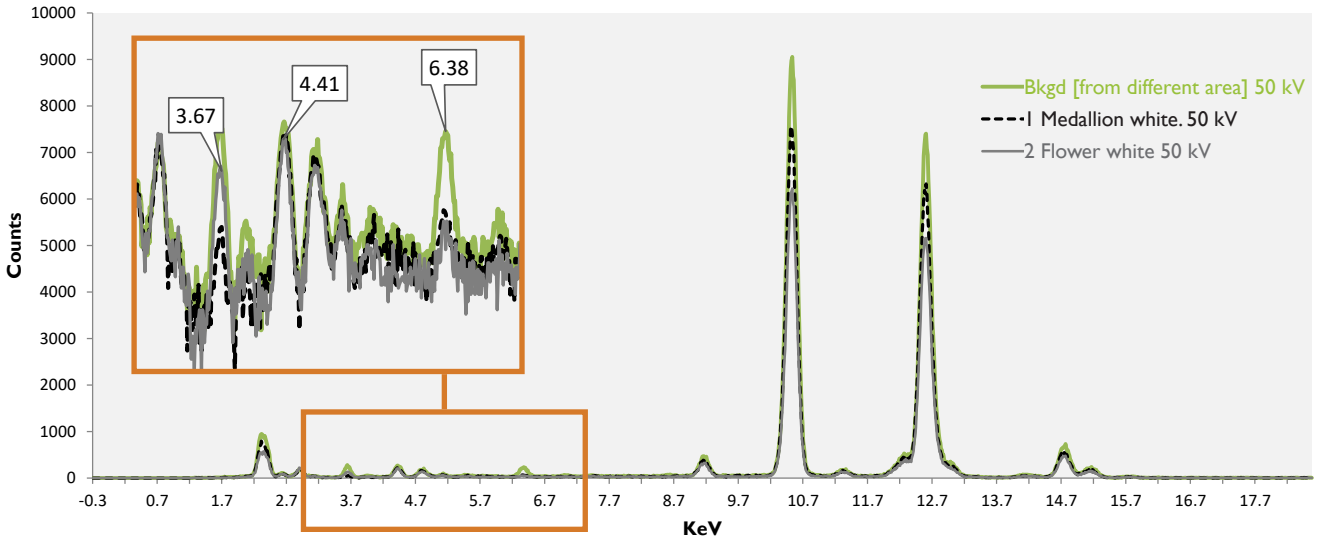
ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

WHITE PAINT ANALYSIS - XRF

Area of impasto analysed: white bulk, subsequently gilded.



Spectra of white paint and white bulk material. Main chart shown with linear scale, inset with logarithmic.

Area of impasto analysed: white flower petal.

	Ca ($K\alpha_1$ 3.692)	Ba ($L\alpha_1$ 4.466)	Cr ($K\alpha_1$ 5.414)	Fe ($K\alpha_1$ 6.404)	Mn ($K\alpha_1$ 5.898)	Co ($K\alpha_1$ 6.930)	Cu ($K\alpha_1$ 8.048)	Zn ($L\alpha_1$ 8.638)	Au ($L\alpha_1$ 9.713)	Hg ($L\alpha_1$ 9.989)	Pb ($L\alpha_1$ 10.552)	Comments
Bkgd [from different area]. 50 kV	x	x		x							x	Standard background elements of Pb, Ca, Ba and Fe.
1 Medallion white. 50 kV	x	x									x	Fe signal missing in bulk whites. Pb signal strong, also Ca and Ba.
2 Flower white 50 kV	x	x									x	Fe signal missing in bulk whites. Pb signal strong, also Ca and Ba.

The scheme makes use of white impasto, sometimes left white, sometimes mixed with yellow pigment, and sometimes gilded. XRF analysis of the unpainted white from a flower and the white gilded bulk (same area as sample SHaP03) indicates this is the same material - a lead white with a calcium and barium component.

The Fe component, used to tint the background, is missing [see inset detail]: a pure white seems to have been sought.

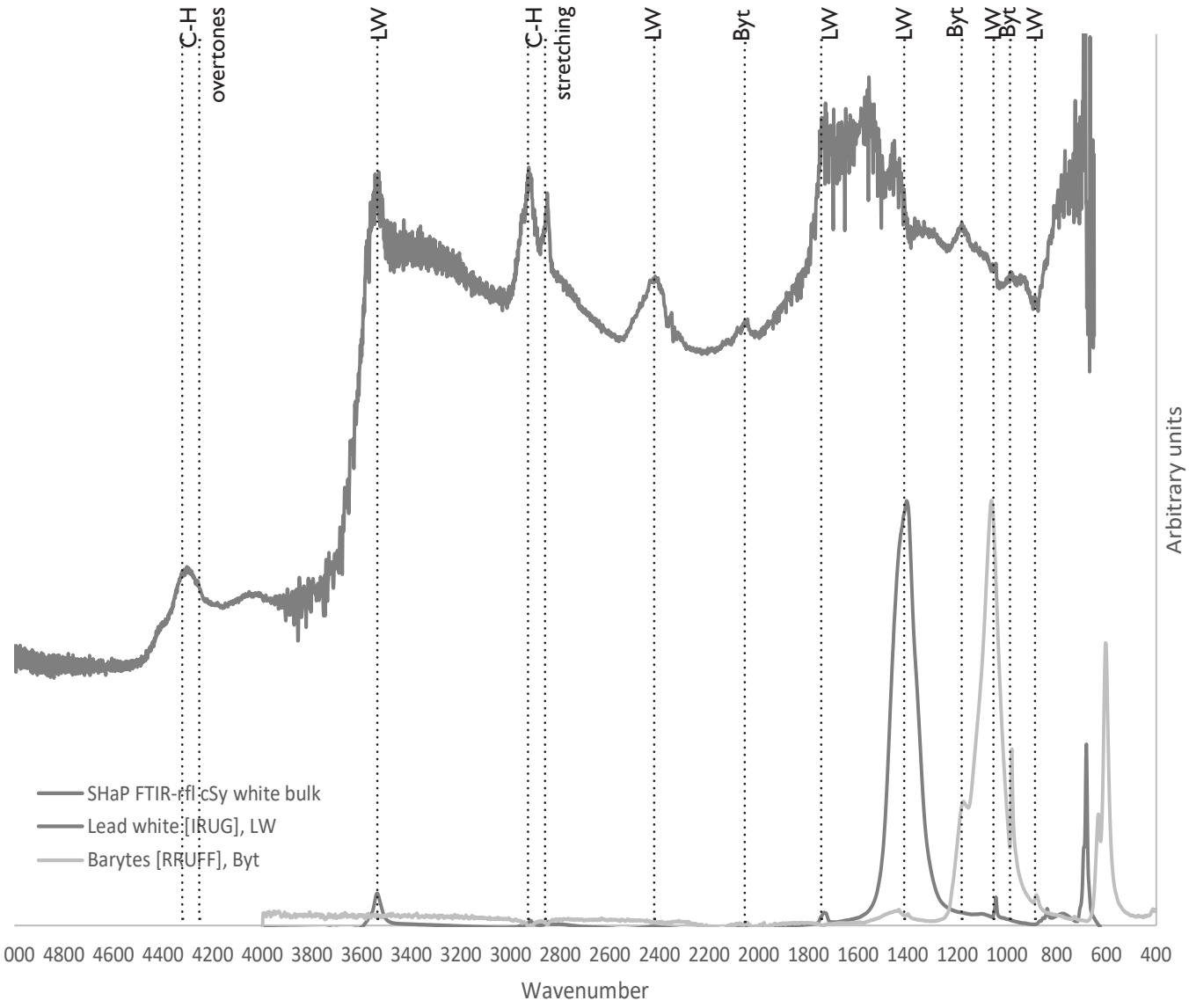
FTIR-REFLECTANCE

An area equivalent to 1 Medallion white 50 kV was analysed by FTIR-reflectance. The spectrum from the bulk material is noisy, but seems to contain:

- lead white
- baryte.

Carbonate combination band at ~2400 is indicative of lead white rather than calcite (Miliani et al 2012]) The position of the sulfate combination band at ~2100 is indicative of baryte.

Area of impasto analysed: white bulk, subsequently gilded.



ST. PETER, HASCOMBE, SURREY

SITE IDENTIFIER: SHaP

HARDMAN - *c. 1883-6*

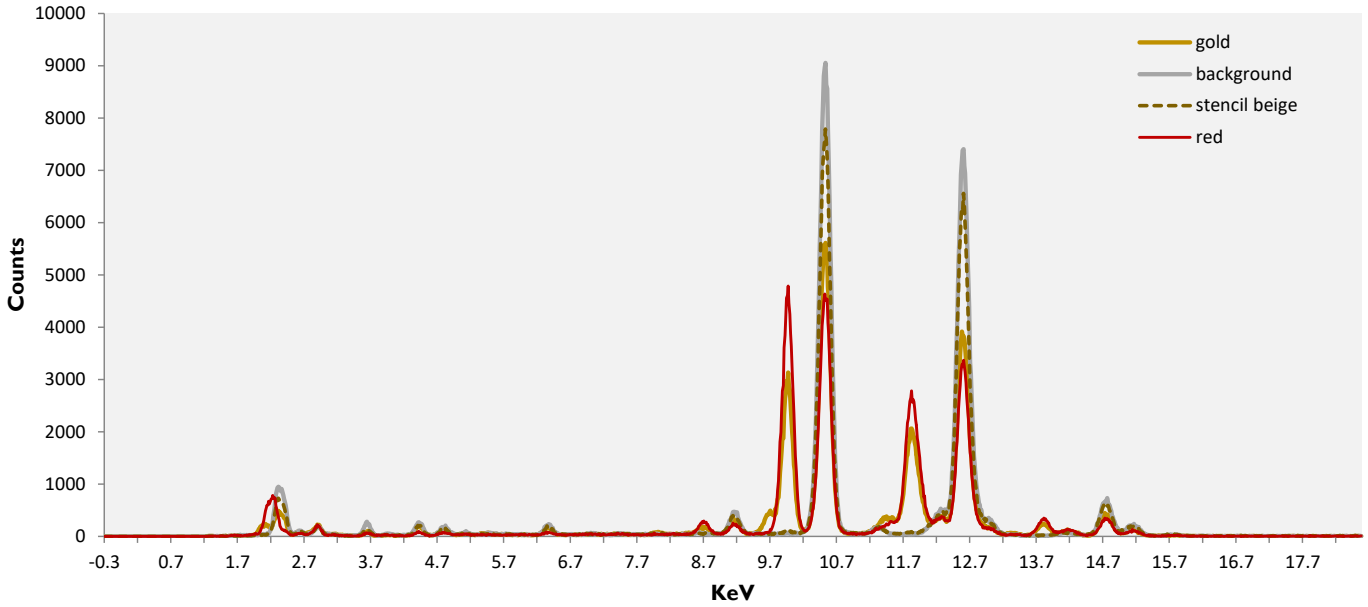
GOLD ANALYSIS - XRF

Paints on the original stencil used for this area of gilding were analysed. Results suggested a similar material to the ground was used to stencil in the word 'Pater', presumably acting as the mordant. The elements detected were Pb, Ba, Ca and Fe.

These elements were also present in the gold spectrum, as signal from the mordant could be detected through the very thin gold. The metal appears to be pure Au, which in combination with the stencil evidence suggests a mordant and gold leaf technique.

The red paint adjacent to the gold writing was determined to be vermilion due to Hg signal. This signal is present in areas of gilding, but the thickness and density of the mordant and gold layers together attenuates the Hg signal: note the diminished ratio between the L-alpha and L-beta peaks in gold spectrum.

The red paint has a strong Pb peak too, which may be red lead or lead white - XRF cannot distinguish between the two.



Areas analysed by XRF - numbered and circled.

	Ca ($K\alpha_1$ 3.692)	Ba ($L\alpha_1$ 4.466)	Cr ($K\alpha_1$ 5.414)	Fe ($K\alpha_1$ 6.404)	Mn ($K\alpha_1$ 5.898)	Co ($K\alpha_1$ 6.930)	Cu ($K\alpha_1$ 8.048)	Zn ($L\alpha_1$ 8.638)	Au ($L\alpha_1$ 9.713)	Hg ($L\alpha_1$ 9.989)	Pb ($L\alpha_1$ 10.552)	Comments
1 Bkgd. 50 kV	x	x		x							x	Standard background elements of Pb, Ca, Ba and Fe. Very similar to the 'Stencil paint' spectrum, below.
2 Red 50 kV										x	x	Hg signal indicates vermilion.
3 Gold 50 kV	x	x		x					x	x	x	Au signal indicates gold foil, but thinness allows signal from underlying layers to be detected. Hg is somewhat attenuated.
4 Stencil paint 50 kV	x	x		x							x	Similar to background. May function as the mordant for gold foil.

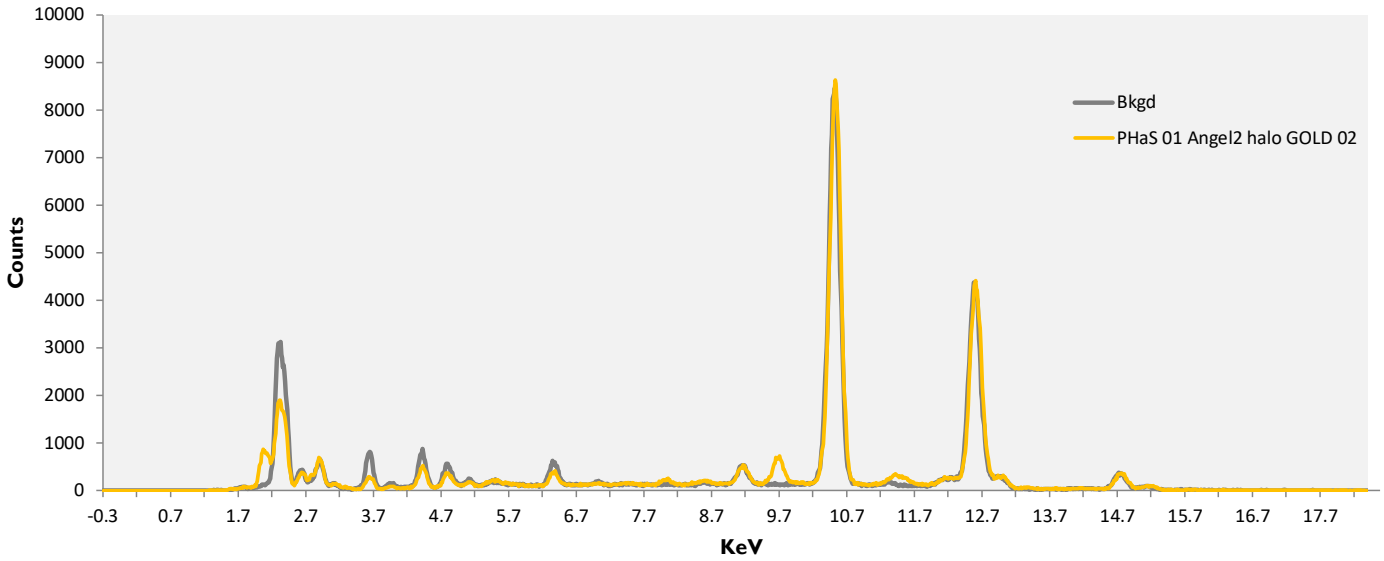
ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

GOLD ANALYSIS - XRF

Location of XRF spot analyses, numbered and circled.



	Ca ($K\alpha_1$ 3.692)	Ba ($L\alpha_1$ 4.466)	Cr ($K\alpha_1$ 5.414)	Fe ($K\alpha_1$ 6.404)	Mn ($K\alpha_1$ 5.898)	Co ($K\alpha_1$ 6.930)	Cu ($K\alpha_1$ 8.048)	Zn ($L\alpha_1$ 8.638)	Au ($L\alpha_1$ 9.713)	Hg ($L\alpha_1$ 9.989)	Pb ($L\alpha_1$ 10.552)	Comments
1 Bkgd. 20 kV	x	x		x							x	Standard background elements of Pb, Ca, Ba and Fe.
2 Gold 20 kV	x	x		x					x		x	Same as background, but with additional Au signal, indicating gold foil.

The mordant appears to be made of very similar elements to the background. In contemporary schemes, commonly a chrome oil mordant was used, which seems not to have been the case here.

ST. PETER, HASCOMBE, SURREY

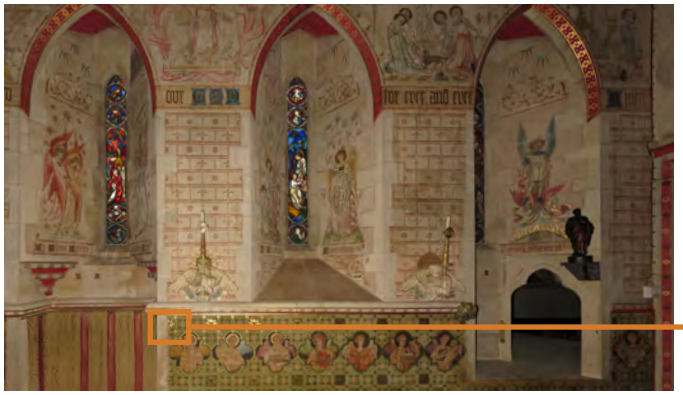
HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP01 / 5539

RATIONALE FOR SAMPLING

Taken to examine ground layers and nature of gold paint/leaf/ mordant and compare with XRF findings.



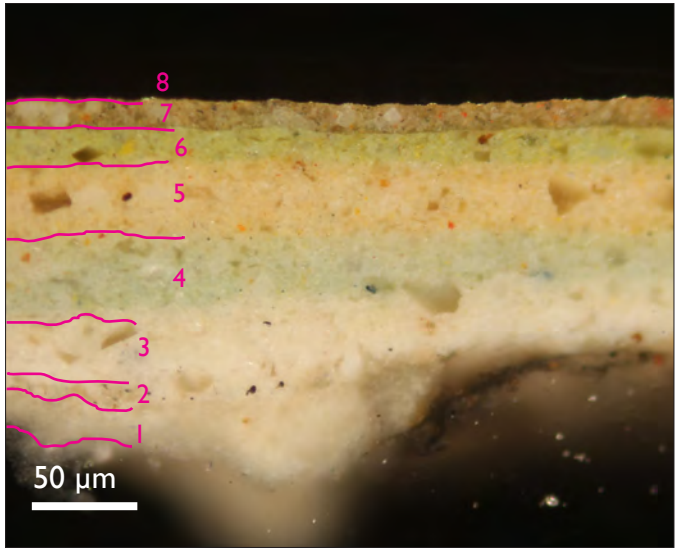
Context: Dado of chancel.

Detail: gilded detailing on fictive tiling.

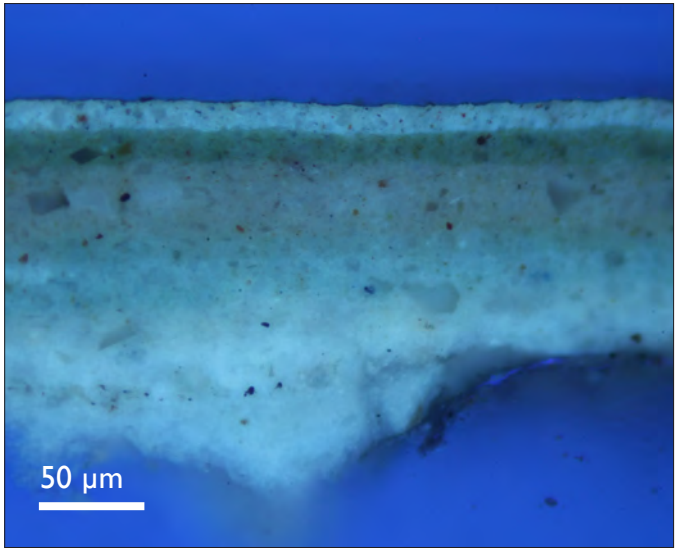
Macro: sample location. Some ungilded mordant visible.

STRATIGRAPHY

Layer 8. Extremely thin gold leaf layer, more obvious in UV.
Layer 7. Even brownish beige mordant layer with translucent particles and smaller bright red ones. Luminesces bright white in UV (20 µm).
Layer 6. Even green layer (20 µm) with bright yellow particles
Layer 5. Fourth ground: pale yellow matrix with large square translucent particles (c. 60 µm)
Layer 4. Third ground: blue-green matrix with yellow, red and black particles (50 µm)
Layer 3. Second ground: white layer with large translucent particles. Bright in UV light (50 µm) [this may be two layers?]
Layer 2. First ground: greyish-white, with tiny black and red particles, uneven thickness
Layer 1. Plaster [partial]



Pale blue-green ground not evident in nave sample, SHaP02.



Mordant luminesces bright white in UV light.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

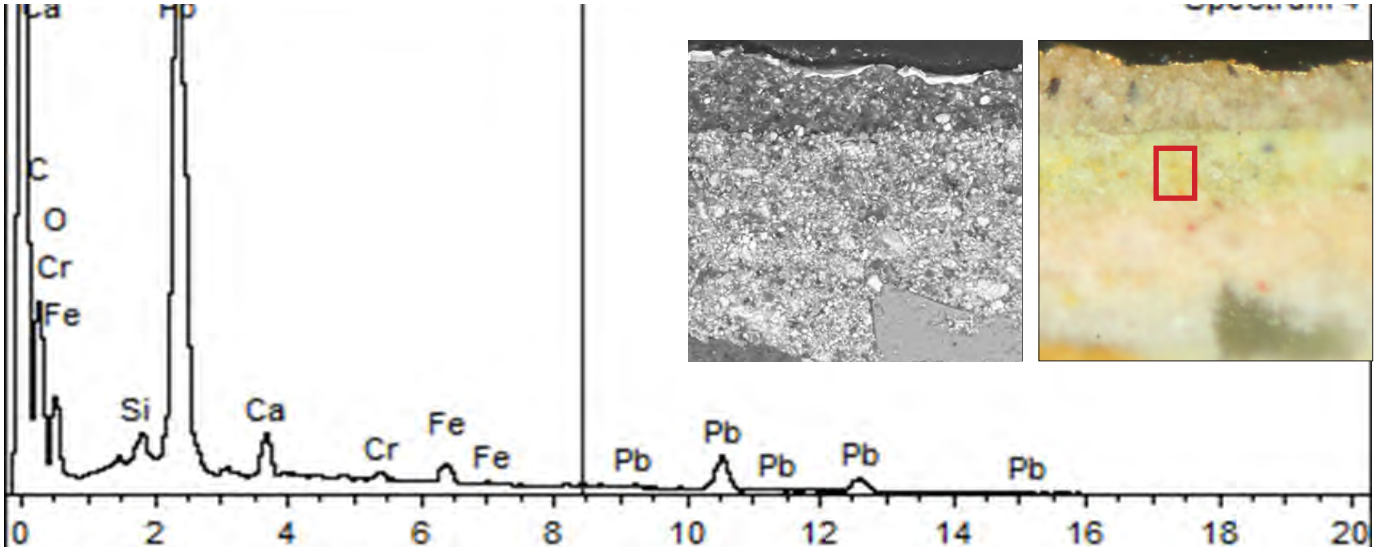
SAMPLE NUMBER: SHaP01 / 5539

EDS

Layer 6 (Green):

- No distinct green particles to sample. Suspect blue and yellow mix to make green.
- The small size of lead chromate (<2 um according to Eastaugh 2008) is smaller than the probable interaction area of the beam and sample in EDS. This make mapping for Cr problematic, and also spotting distinct Cr particles difficult.
- A clustered area of yellow gave signal for Cr and Fe.
- Suspect lead chromate and Prussian blue (from FTIR) perhaps with yellow iron oxide.

(Layer 7) Mordant:
Ca, Pb, Cr and Fe detectged. Notably less dense than the ground in EDS image (see inset image), presumably oil rich.



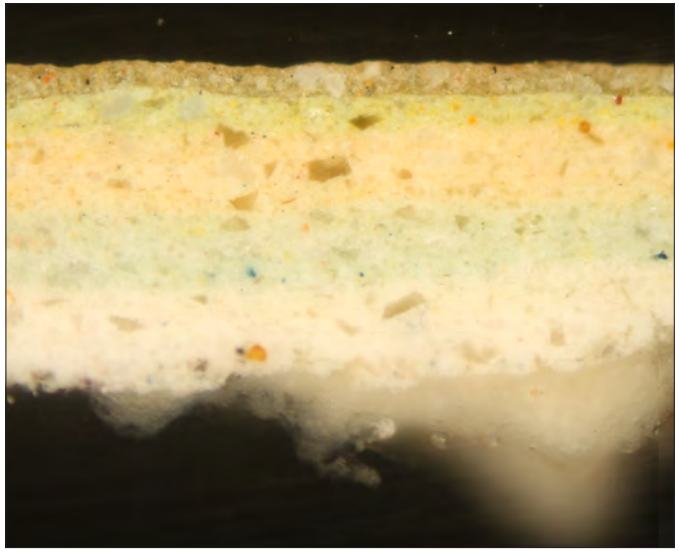
Spectrum from an area of yellow in Layer 6 (marked in red on inset image). Pb, Ca, Fe and some Cr detected.

HISTOCHEMICAL STAIN

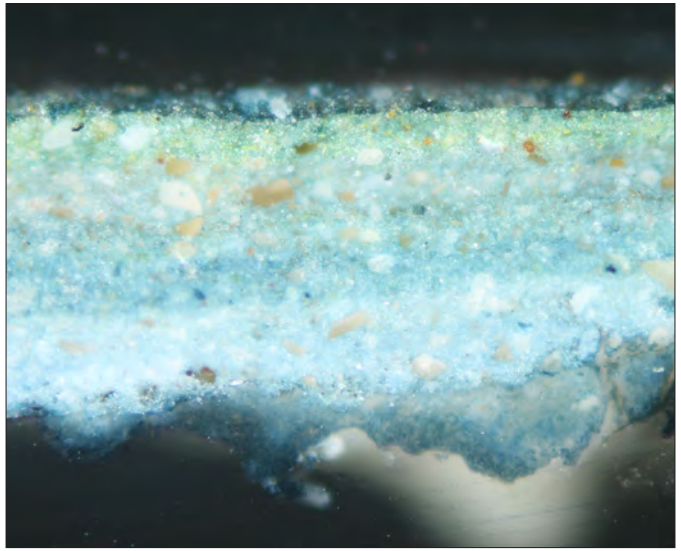
The distribution of lipids can be visualised in cross-section by staining with Sudan Black B applied as a saturated solution in 60ml alcohol : 40ml water for 30 mins and then rinsed for 30 mins.

The results of this stain test tend to be amiguous, which may be because the test is best done at 70 °C (Sandu 2012, 865).

However, the staining in this case seems logical, as the mordant layer is most heavily stained, and the SEM images from SHaP03 indicate the mordant is low density, and so possibly oil rich.



Cross section in visible light before staining.



Cross section in visible light after staining for lipids .

ST. PETER, HASCOMBE, SURREY

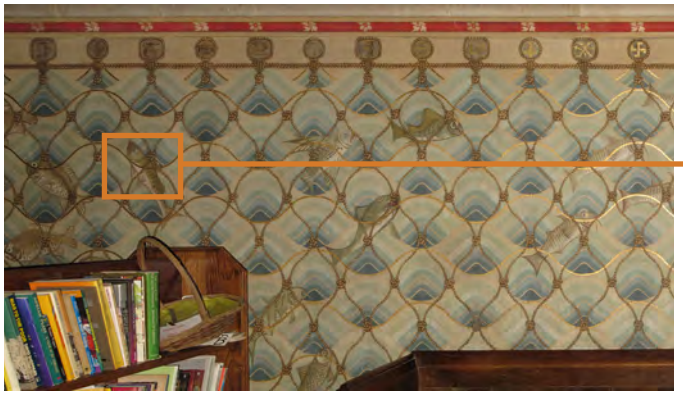
HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

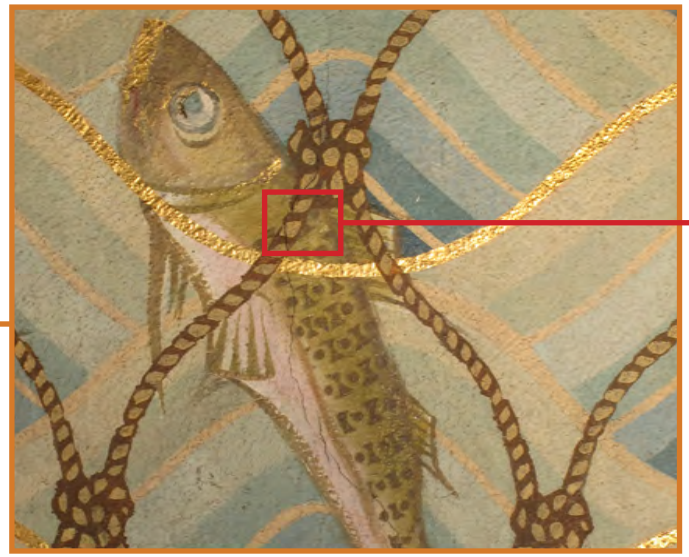
SAMPLE NUMBER: SHaP02 / 5540

RATIONALE FOR SAMPLING

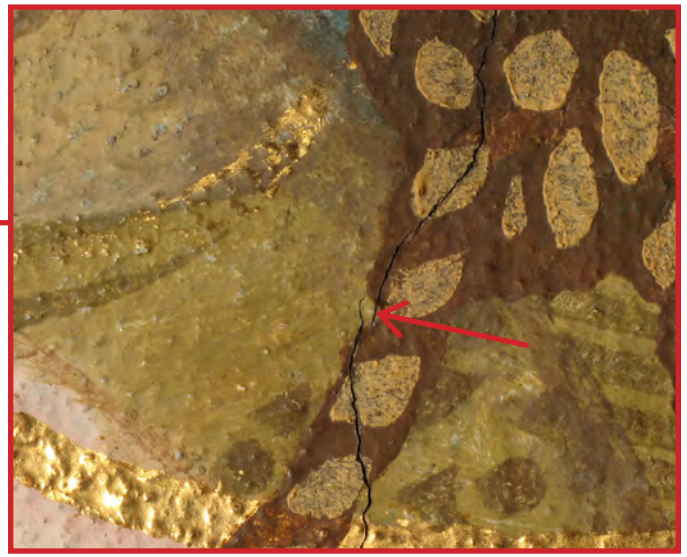
Area of superimposed stencilling layers: examine for layer thickness compared to freehand painting. Also examine ground compared to chancel scheme.



Context: fish and net scheme from nave dado.



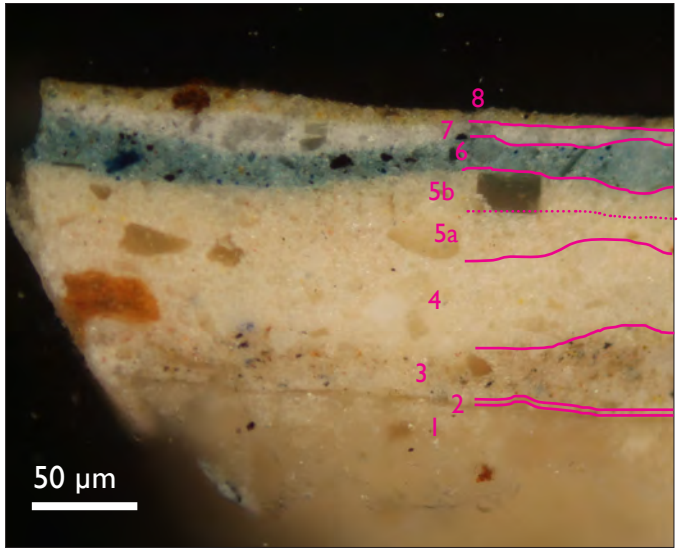
Detail: stencilled fish over stencilled waves.

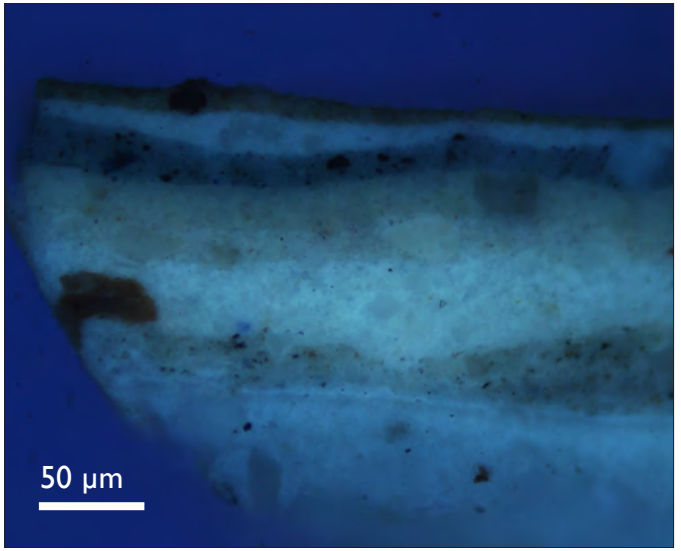


Macro: sample location - several superimposed stencils.

STRATIGRAPHY

Layer 8. Even dull green layer with bright yellow particles and very occasional, small grass green particles. (20 µm)
Layer 7. Bright white with angular translucent particles. Bright white in UV. (20 µm)
Layer 6. Blue paint layer with large black particles, tiny bright blue particles, and scattered yellow particles. (30 µm)
Layer 5. Third ground: pale beige matrix with large square translucent particles up to 30 µm. Possibly applied as two layers, marked 5a and 5b on the image, right. (20 µm)
Layer 4. Second ground: white layer with some angular translucent particles. Bright in UV light. (50 µm)
Layer 3. First ground: greyish-white layer, with tiny black and red particles and some large rounded white particles and one very large carbon black particle. (30 µm). Lead white and calcite identified by FTIR-ATR (see below)
Layer 2. Sealant layer fluoresces white in UV. (<5 µm)
Layer 1. Plaster [partial]





Pale blue-green ground, found in chancel, not evident in this sample from nave. Apparent multiple grounds more obvious in UV.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP02 / 5540

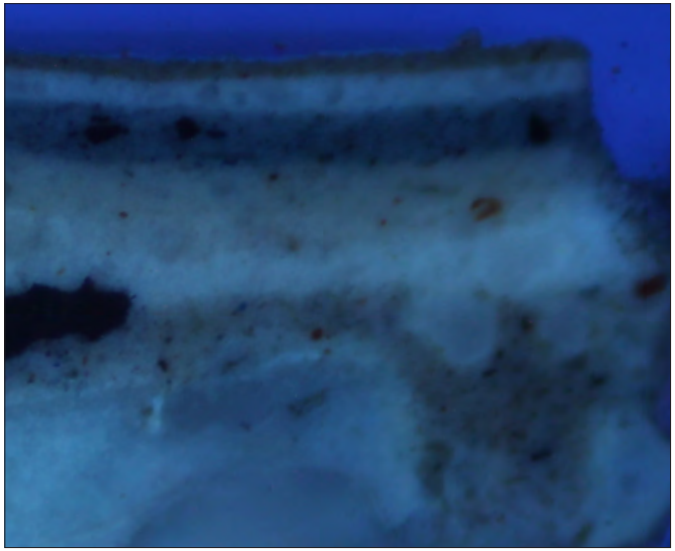
SEM-EDS

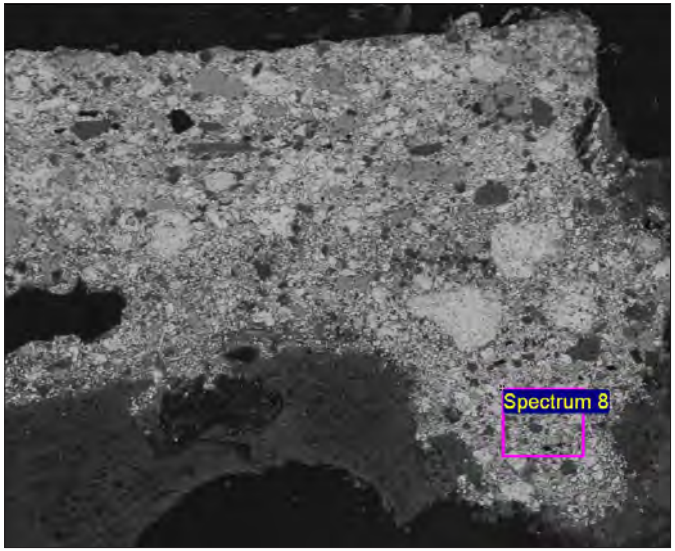
Mapping indicates that:

- Layer 8: green matrix contains Ca, Fe and Ba.
- Layer 7: white contains Ca, Pb and Ba combination, and the large squarish translucent particles are Ba-based. Some Fe detected.
- Layer 6: Pb and Ba matrix with elements consistent with ultramarine.

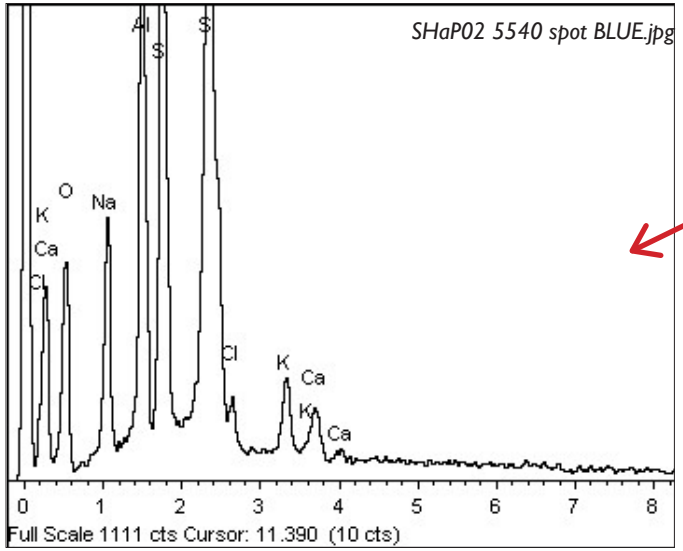
Point/area analysis indicates that:

- Layer 8: a bright green particle only showed Ba and S.
- Layer 6: large black particles contain Fe - Prussian blue? Bright blue particles - ultramarine.
- Layer 3: predominately Pb, some Ca and Fe. Large white rounded particles are Pb-based.
- Layer 1: plaster is Ca with no S detected, therefore is likely to be $CaCO_3$, not $CaSO_4$.

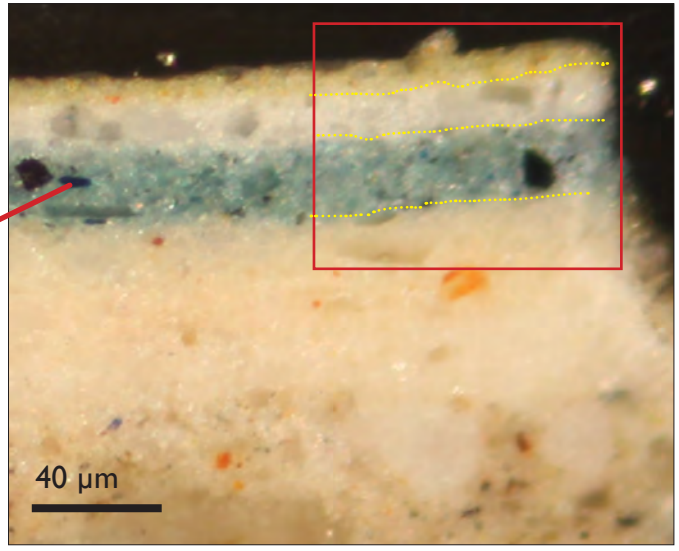


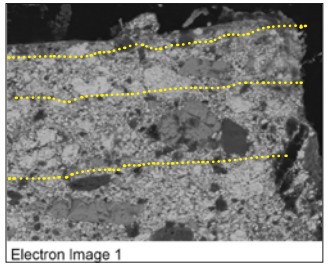


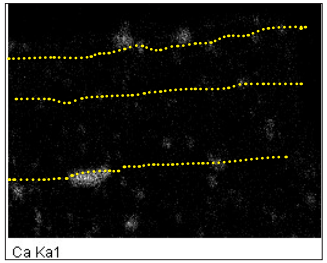
The UV image clearly shows the multilayered grounds, unlike the backscattered image where all are of a similar density, and therefore hard to distinguish.

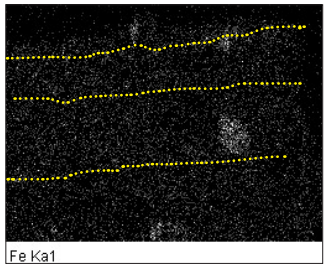


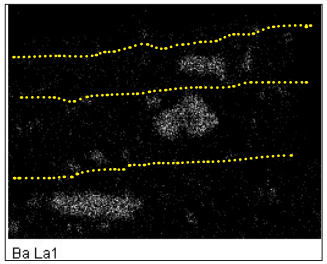
Analysis of blue particle in Layer 6, suggests ultramarine.











Green is a mix of iron yellow and calcium, white makes use of barium extenders, as shown in mapping.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP02 / 5540

FTIR-ATR

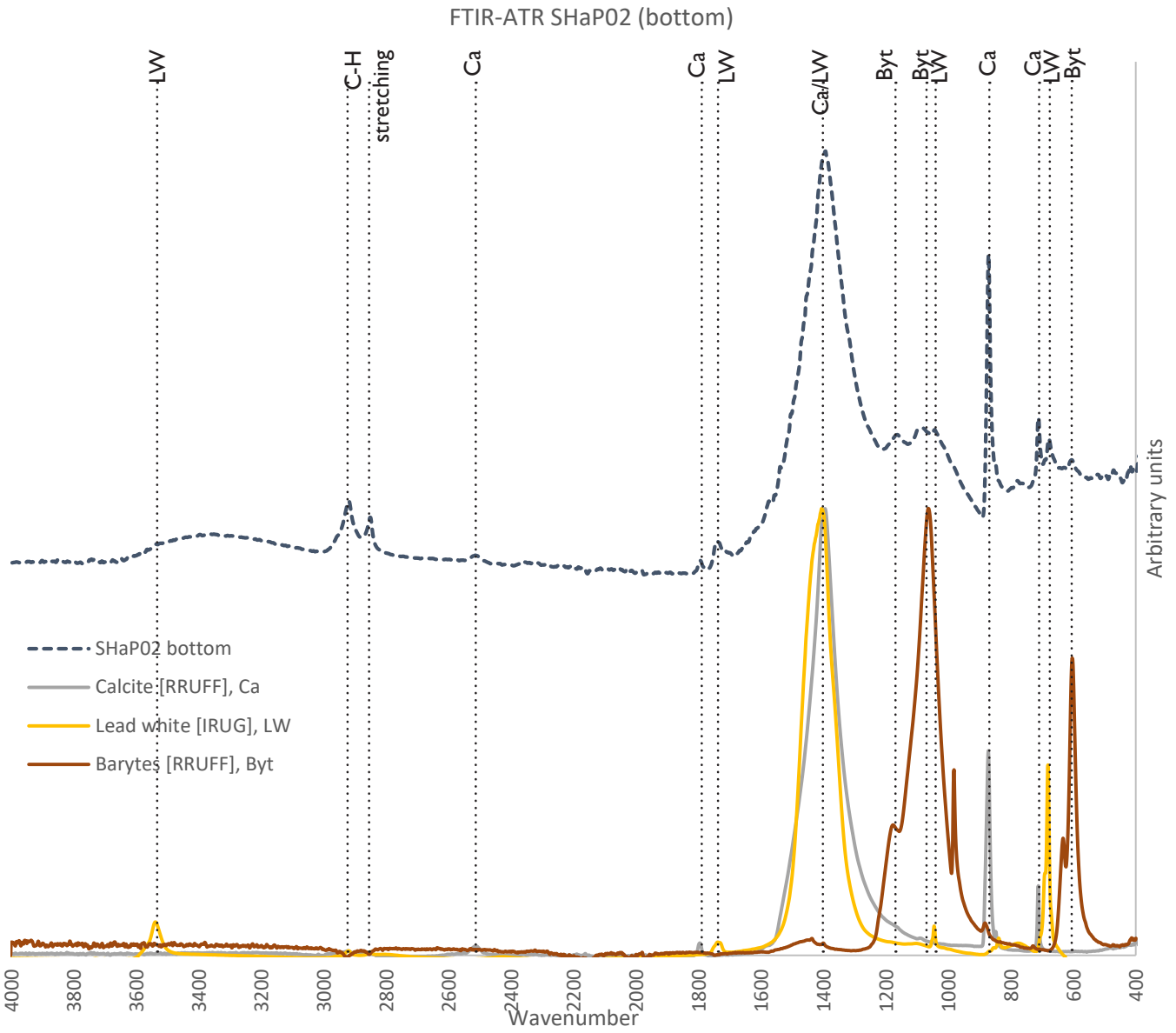
Sample placed with lower stratigraphy in contact with diamond window. Findings are thought to pertain to ground(s) more than paint layer.

Main components detected at the bottom of the cross-section are

- calcite
- lead white
- barytes.

The presence of an organic material is evident from the C-H stretching at ~2850 and 2950. No further comment on binder was possible.

Unlike SHaP04, gypsum was not clearly present in this sample, suggesting the grounds for the chancel and nave are chemically as well as visually different.



ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

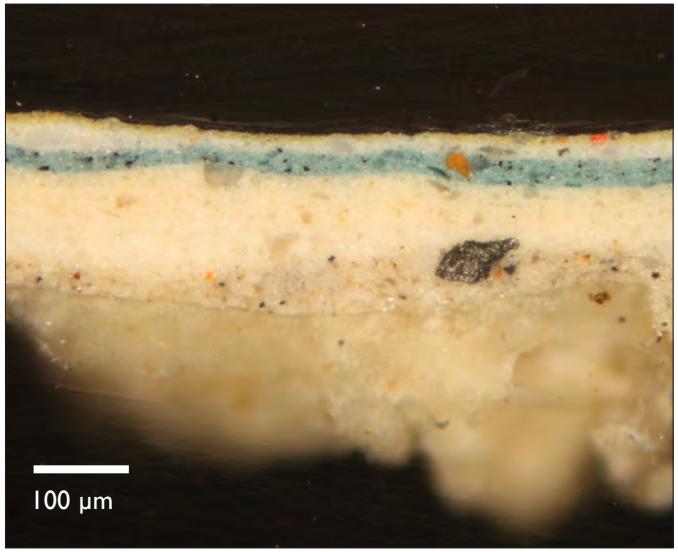
SAMPLE NUMBER: SHaP02 / 5540

CHEMICAL STAIN

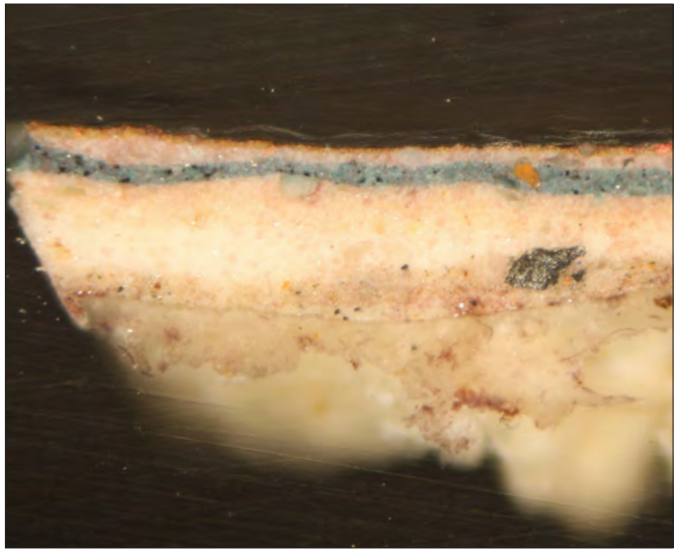
Following a protocol described by Matteini (1986), the distribution of calcium sulfate can be visualised by staining the mounted sample in cross section.

This test will stain all hydration states of $CaSO_4$ (as dihydrate, hemihydrate and anhydrite are all similarly soluble), and will not stain $BaSO_4$ (as it is almost insoluble). Staining results should be cross-checked against other analyses.

The staining results indicate there is little to no calcium sulfate in the cross-section. This agrees with the FTIR-ATR of this sample, opposite.



Cross section before staining.



After staining. No clear stratigraphic layer stained.

ST. PETER, HASCOMBE, SURREY

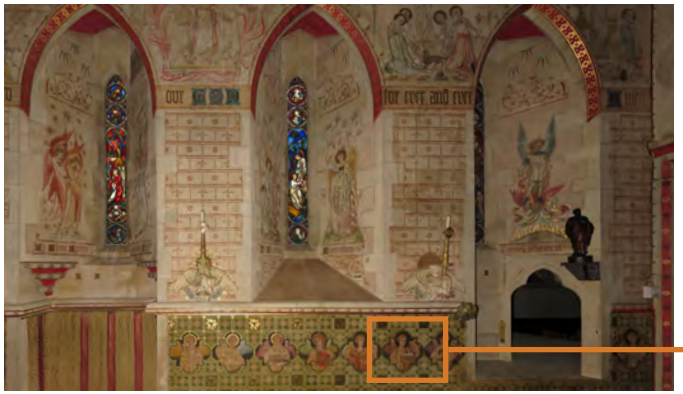
HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP03 / 5541

RATIONALE FOR SAMPLING

Taken to identify bulking material under gold (compare with FTIR on white bulk) and also examine raised gold versus flat gold for metal/mordant (SHaP01).



Context: chancel dado.

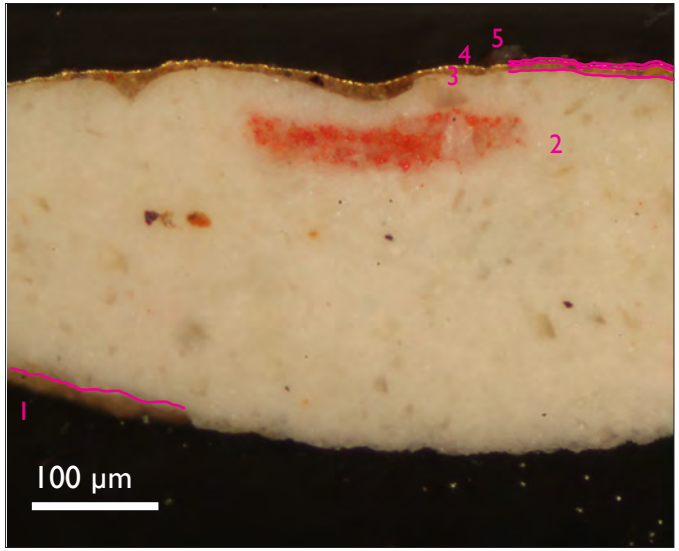
Detail: raised golden medallion.

Macro: sample location - selected area with brown glaze.

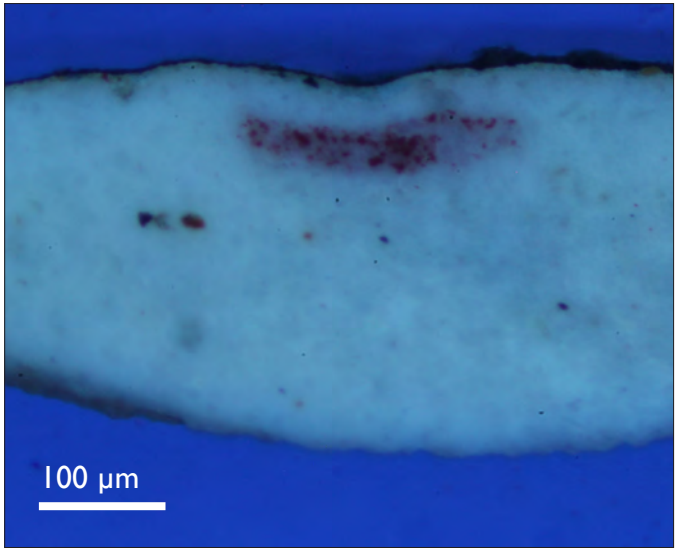
STRATIGRAPHY

Layer 5. Brown glaze
Layer 4. Gold leaf layer, even and continuous (1-2 µm)
Layer 3. Mordant layer: deeper in troughs, thinner on peaks, beige with black, red and yellow particles (5-15 µm). Same as sample SHaP01.
Layer 2. Lead white bulk with translucent, angular barium sulfate particles. It is bright, opaque white in UV (300 µm). Stray red in the bulk too, but very localised - possibly an accidental inclusion, XRF spectra gave no signal for Hg. FTIR confirmed it is lead white, rather than lead sulfate.
Layer 1. Traces of beige paint on white bulk

Plaster and ground layers missing from sample



Cross-section in visible light. Anomalous red in Layer 2.



Layer 5 brown glaze is more apparent in UV light.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

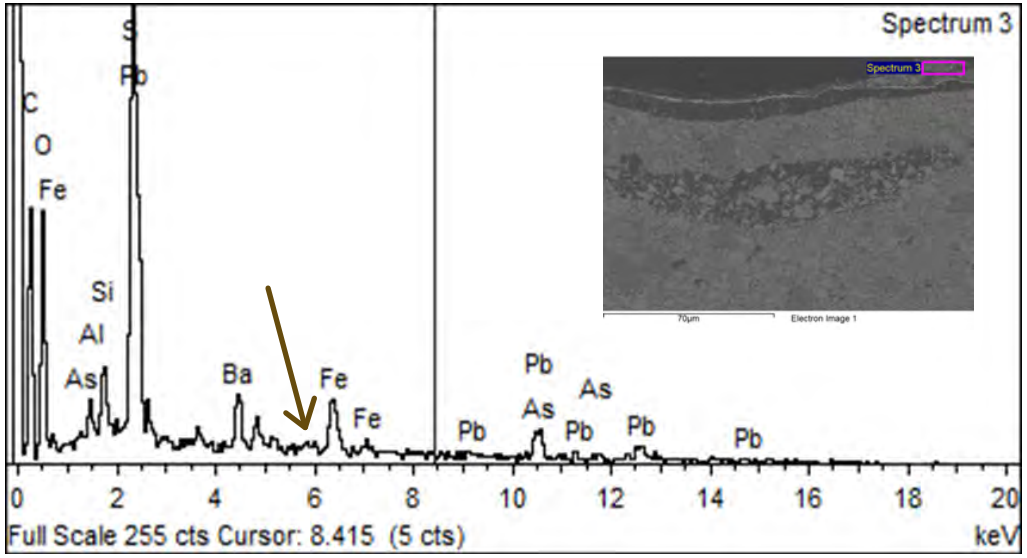
SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP03 / 5541

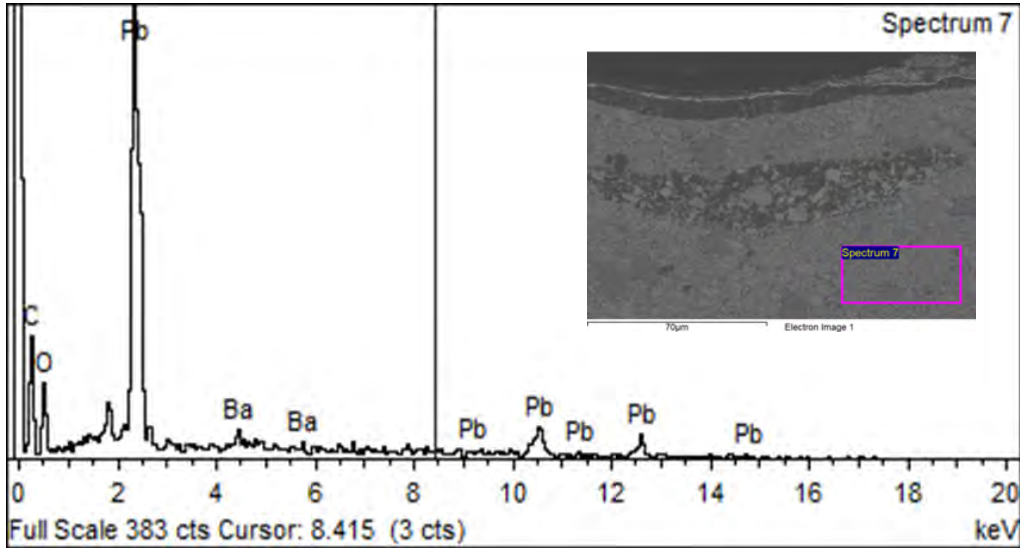
SEM-EDS

Spot / area analysis shows:

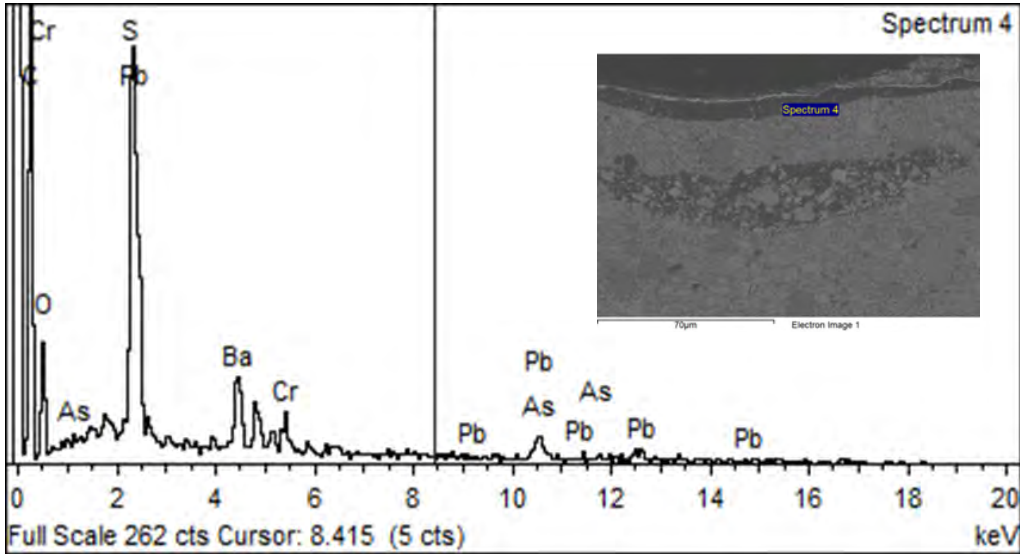
- Layer 5: Brown outlining contains Fe and an ambiguous signal for Mn, which suggests a brown iron oxide, not umber. *Compare with XRF of dark green, which does have a strong Mn signal, implying presence of umber.*
- Layer 4: Metal leaf confirmed as Au. Appears dense in backscatter, as a thin and continuous layer (i.e. foil). Au signal is clear.
- Layer 3: Mordant layer is dark in backscatter, suggesting not very dense / lots of organic component. Pb Cr and and Ca detected. No Fe signal, perhaps this mordant is different to the one used for SHaP01. Also thinner layer than SHaP01 mordant.
- Layer 2: bulk signal mainly Pb with large Ba and S inclusions. Red inclusion has Hg, Ba and S, indicating vermilion and barium sulfate.



Layer 5 contains Fe, Ba and lead. Query Mn peak.



Analysis of white bulk material in Layer 3, shows lead predominant, some barium.



Low density of mordant apparent in backscatter. Spectrum shows Pb,Ba and Cr.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

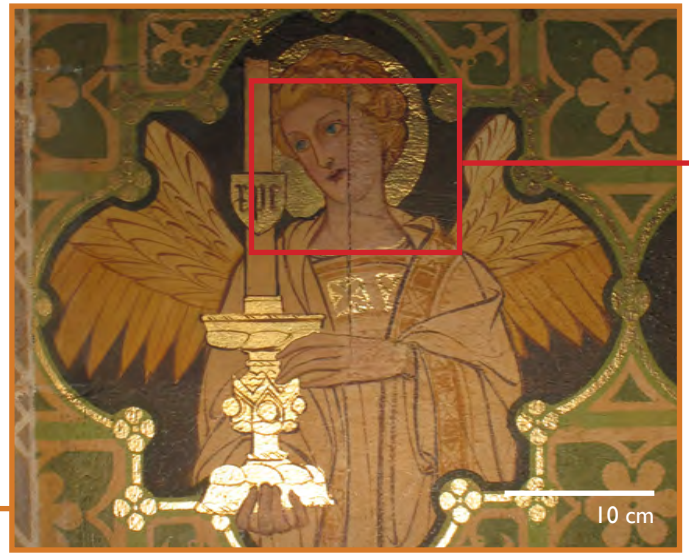
SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP04 / 5542

RATIONALE FOR SAMPLING

Which pigments are used in flesh mixture? Traditionally this is the type of painting which might be multilayered or complex. See if this is the case for Hardman's work.

Context: chancel dado.



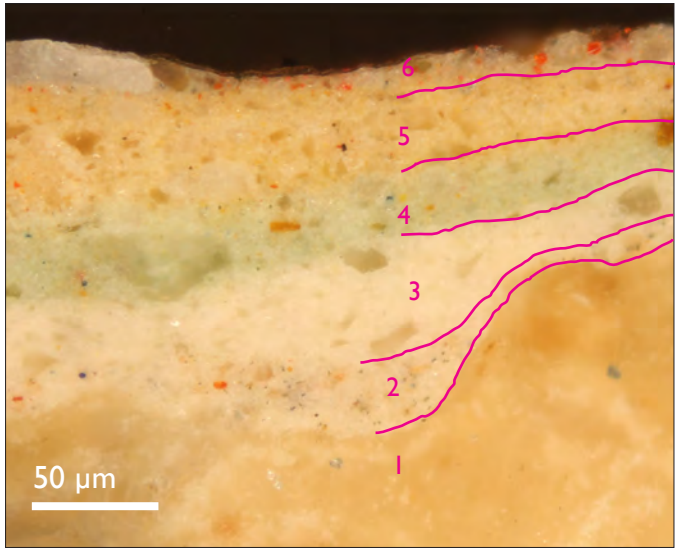
Detail: flesh of angel.

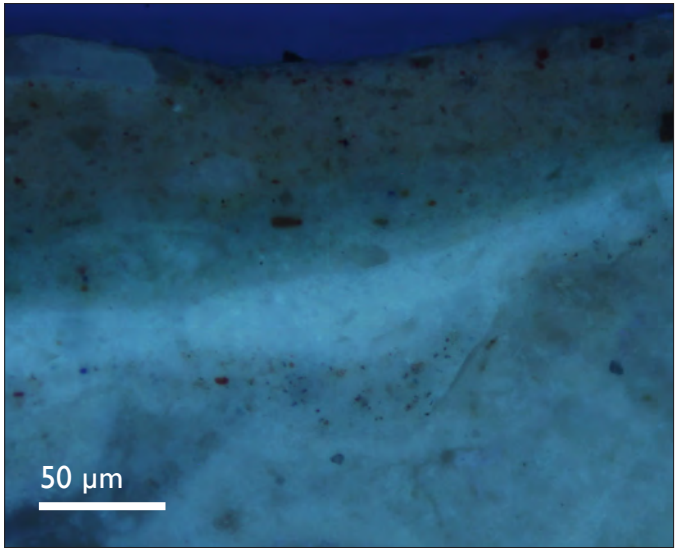
Macro: location of sample.

STRATIGRAPHY

Layer 6. Red small red particles in a lead and calcium white matrix (20 µm)
Layer 5. Fourth ground: pale yellow matrix with large square translucent particles and yellow and red particles (c. 60 µm)
Layer 4. Third ground: blue-green matrix with yellow, red and black particles (50 µm)
Layer 3. Second ground: white layer with large translucent particles. Bright white in UV light (50 µm). Possibly two layers, or separated out. Upper part of white less bright in UV.
Layer 2. First ground: greyish-white, with tiny black and red particles, uneven thickness
Layer 1. Plaster

The flesh is modelled with a vermilion glaze over the ground layer - very swift execution, no need to build up layers or work wet in wet.





The first four layers are the same as SHaP01. The flesh tone is achieved with a final vermilion glaze, modifying the ground.

ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP04 / 5542

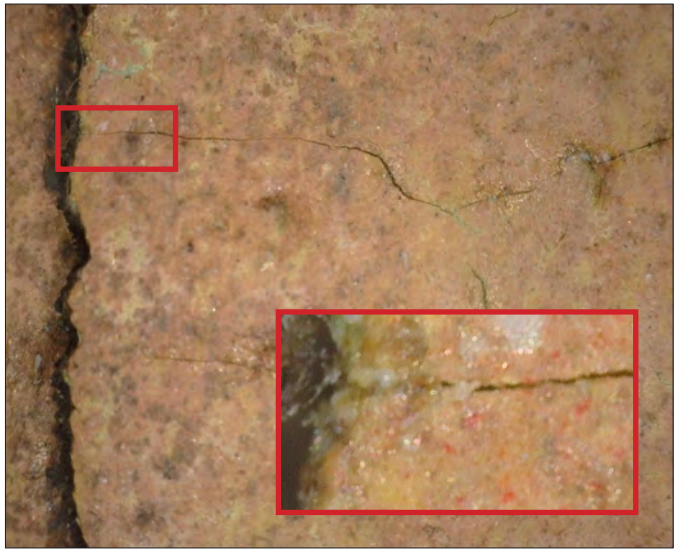
NON-INVASIVE MICROSCOPY AND SEM-EDS

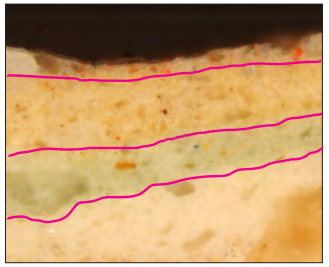
Mapping shows

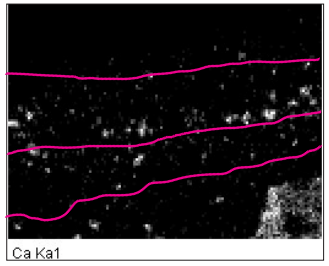
- The green, yellow and white layers have similar composition, all including Pb, Ca and Ba.

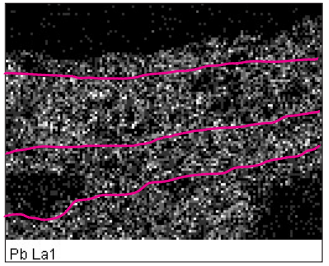
Spot / area analysis shows

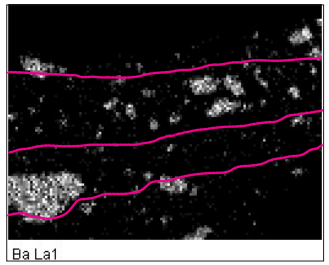
- Layer 6. the red particles contain Hg (vermilion) in a Pb and Ca matrix.
- Layer 5: the yellow matrix contains Pb, Ca and Ba. Large Ca particles without S, so probably calcite. Ba-based particles also identified.
- Layer 4: the green colour is not identified, but yellow particles are Fe-based.
- Layer 3: Second ground contains Pb, Ca and Ba.
- Layer 2: First ground contains Pb, Ca and Ba.
- Layer 1: Plaster contains Ca. No S signal, so not gypsum.

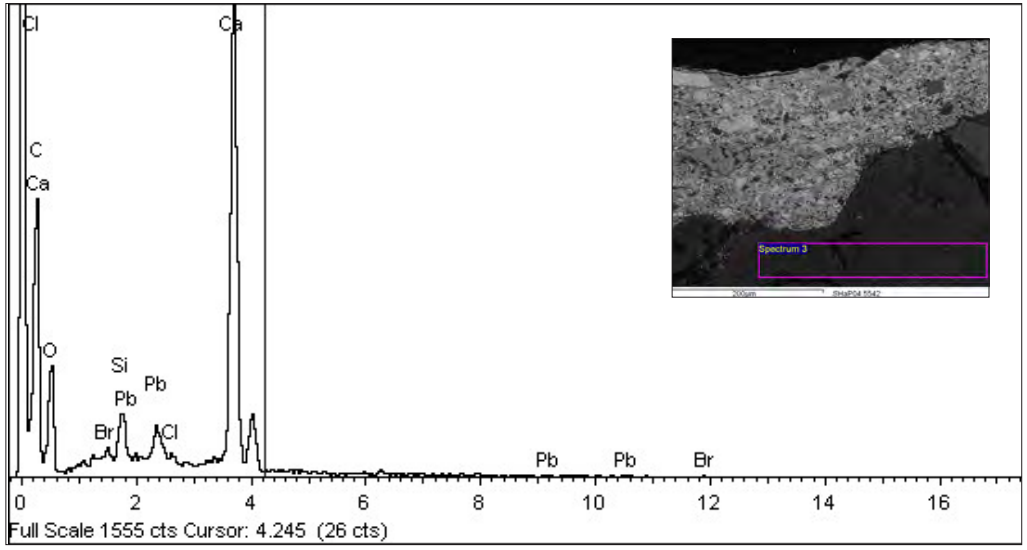


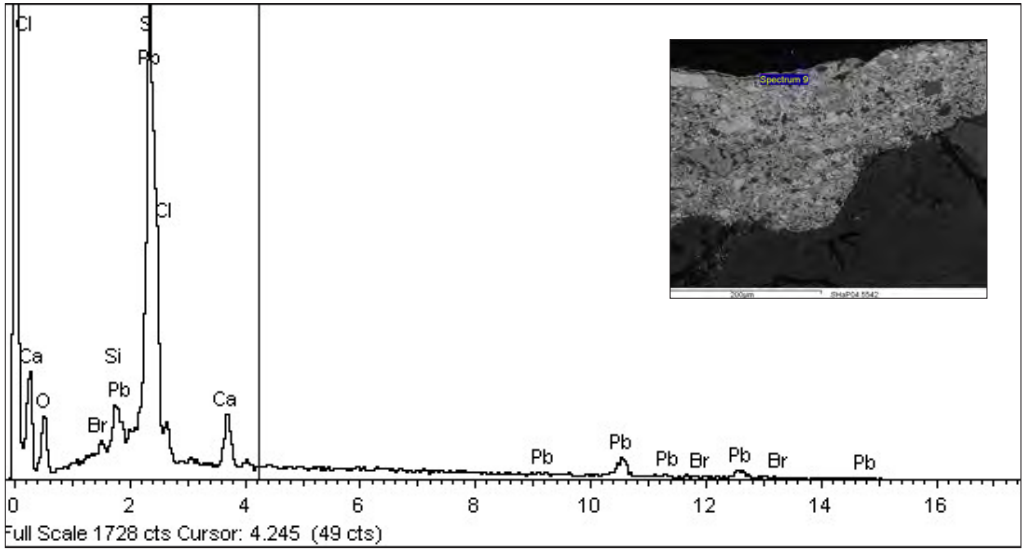












ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP04 / 5542

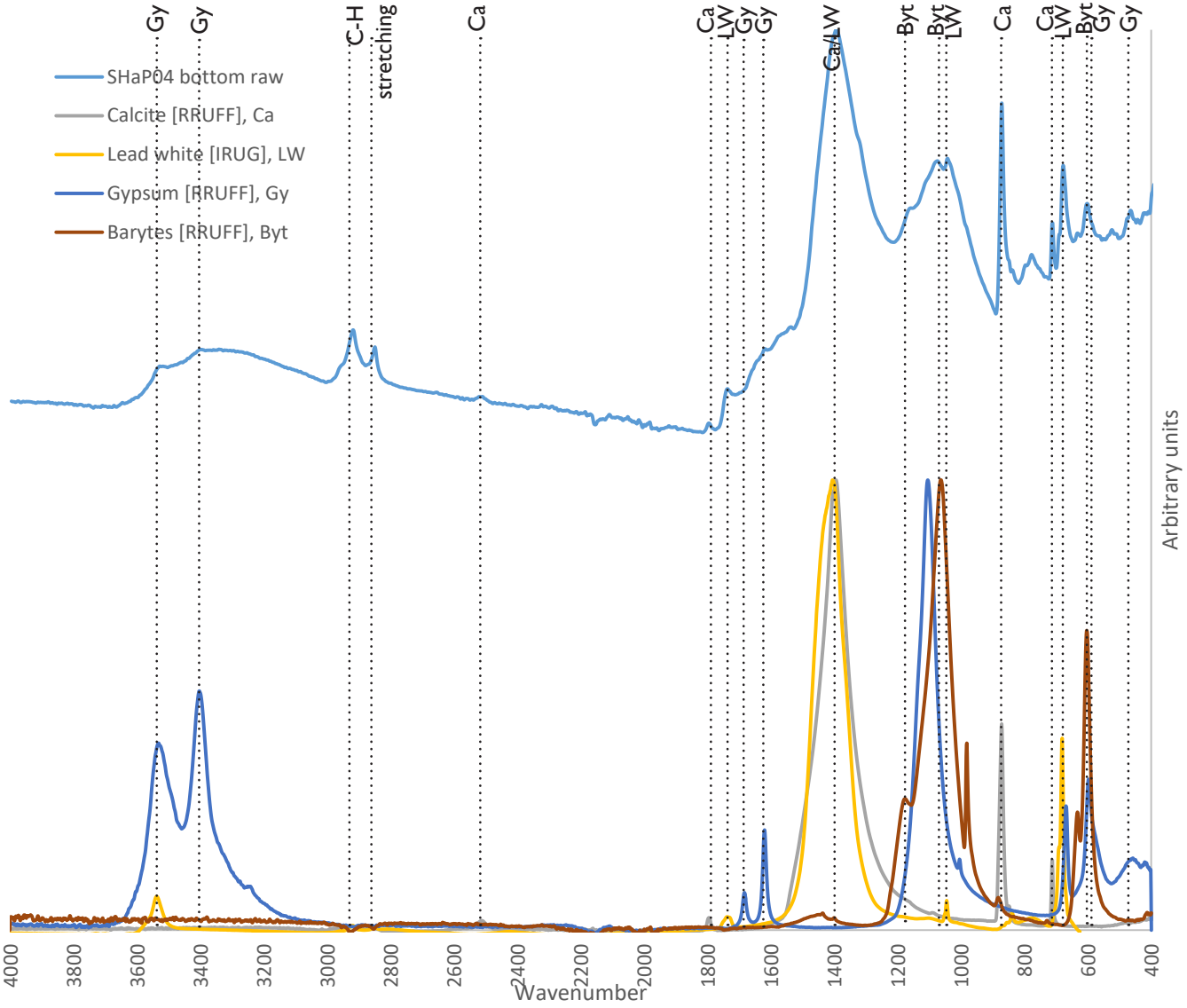
FTIR-ATR

Sample placed with lower stratigraphy in contact with diamond window. Findings thought to pertain to ground(s) more than paint layer.

Main components detected at the bottom of the cross-section are;

- calcite,
- lead white
- barytes
- some gypsum.

The presence of an organic material is evident from the C-H stretching at ~2850 and 2950. No further comment on binder was possible.



ST. PETER, HASCOMBE, SURREY

HARDMAN - *c. 1883-6*

SITE IDENTIFIER: SHaP

SAMPLE NUMBER: SHaP04 / 5542

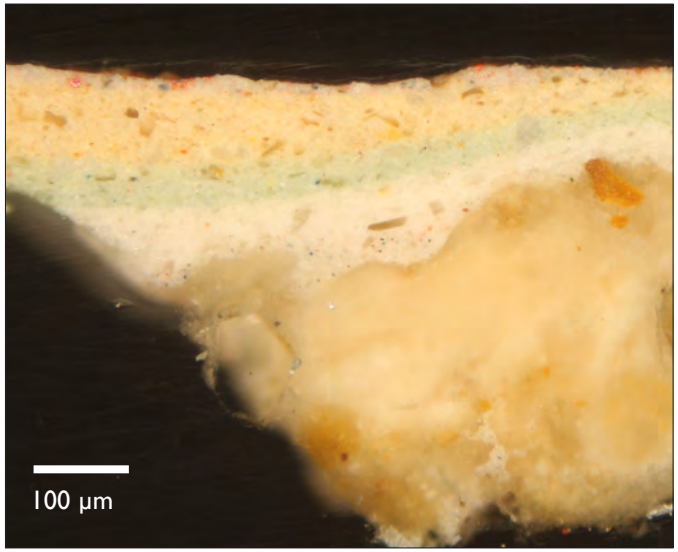
CHEMICAL STAIN

Following a protocol described by Matteini (1986), the distribution of calcium sulfate can be visualised by staining the mounted sample in cross section.

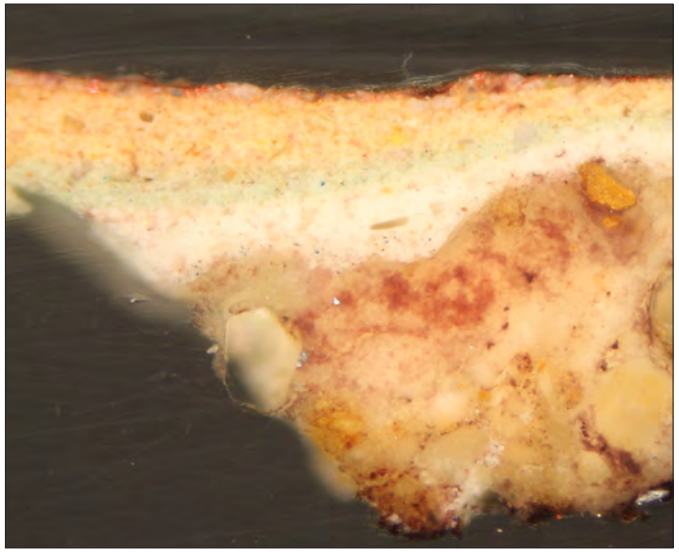
This test will stain all hydration states of $CaSO_4$ (as dihydrate, hemihydrate and anhydrite are all similarly soluble), and will not stain $BaSO_4$ (as it is almost insoluble). Staining results should be cross-checked against other analyses.

The staining results are ambiguous, possibly due to the porosity of the sample. For instance, the densest staining is in the plaster inclusions, which disagrees with the EDS results from samples SHaP02 and SHaP04.

Essentially, the gypsum peaks evident in FTIR-ATR of this sample, opposite, are not satisfactorily explained by staining.



Cross section before staining.



After staining. Some wine deposit through the stratigraphy.

ST. PETER, HASCOMBE, SURREY

SITE IDENTIFIER: SHaP

HARDMAN - *c. 1883-6*

STRATIGRAPHIC SUMMARY

Stratigraphic component	*Components*				*Found on Sample #*	*ID method*	*Comments*
Plaster	Calcium-carbonate binder.				SHaP02 SHaP04	EDS	In both nave and chancel, Ca but no S was detected with EDS, so assume calcium carbonate bound plaster.
Sealant	*Chancel*		*Nave*				**Difference** between nave and aisle schemes.
	No sealant.		Apparent presence of sealant - fluoresces blue in UV light.				
Ground(s)	First ground: greyish-white, uneven thickness. EDS indicates mainly lead, with carbon black and iron red particles, some Ca.		First ground: greyish-white, uneven thickness. EDS indicates mainly lead, with carbon black and iron red particles, some Ca.		Chancel: SHaP01, 04 Nave: S02	EDS FTIR	**Grounds in nave and chancel are different.** The first two grounds seem to be common between the two area. Then the chancel has a third and final beige ground layer, whereas the chancel has a third green ground and a fourth yellow ground. SHaP02, from the nave does not contain gypsum, unlike SHaP04, from the chancel. This suggests the gypsum must be in the green or yellow grounds of the chancel. All the grounds at Hascombe contain barytes, unlike Asthall (also by Hardman) which has little-to-no barytes in the [single] ground layer. As lead white is never found without baryte, whether in the ground, as a pigment, or in impasto details, it is possible the lead white sourced for this project was already extended, rather than the firm themselves extending their materials. Kaolin also found in many samples analysed with FTIR, possibly another extender.
	Second ground: white layer with large translucent particles. Bright white in UV light (50 µm). Some Ca in EDS mapping.		Second ground: white layer. Lead matrix with calcium and some barium also identified by EDS. (50 µm).				
	Third ground: blue-green, lead based with iron yellow, red and black particles (50 µm). Occasional large Ba particles. Green not identified. Some Ca in EDS mapping.		Third ground: pale beige matrix with large square translucent particles up to 30 µm. More and larger Ba particles compared to second ground. Some Ca in EDS mapping.				
	Fourth ground: pale yellow matrix. Lead-based with many fairly large Ba particles and yellow and red iron oxide particles (c. 60 µm) and more Ca than other ground layers.		*No fourth ground.*				
Paint. *Generally applied in thin (c. 15 µm) single layers.* *Multiple layers found in areas of stencilling or gilding.* *Barytes found in all paint layers as well as ground.*	Lead white - *often mixed into other pigments listed below to modify hue.*				SHaP03	EDS, FTIR	Impasto lead white (also with baryte) used as bulking material.
	Cobalt blue				eye, vase	MSI, XRF	No Sn signal, so cobalt blue rather than cerulean.
	Prussian blue				angel sphere	MSI, FTIR	Identified by FTIR and MSI, not XRF as concentration too low.
	Prussian blue		French ultramarine		SHaP02	FTIR, EDS	
	Chrome yellow	Yellow iron oxide	Prussian blue	Lead white	SHaP01 and 02	EDS	Green-looking particles contains Ba and S by EDS - optical effect?
	Chrome yellow	Prussian blue	French ultramarine	Lead white	SHaP01	EDS, FTIR	
	Chrome yellow	Prussian blue	French ultramarine	Umber	Darker green	XRF, FTIR	Spot analysed by XRF and FTIR is located close SHaP01 spot.
	Chrome yellow				flower	XRF	Seemingly used alone, or with very small quantites of iron oxide.
	Chrome yellow		Yellow iron oxide		angel hair	XRF	
	Red iron oxide		Vermilion		angel sphere	XRF	
	Vermilion				flesh tones	XRF	Flesh is modelled with a vermilion glaze over ground layer - swift.
	Brown iron oxide (query Mn presence)				gold modelling	EDS	Chosen for reddish colour? May be different to other outlining.
	Carbon black				ground layer 3,	EDS	Lead white with some calcium and iron.
Attachments	Flat gold leaf - mordant contains Fe and Cr				SHaP01	EDS	Different appearance of mordants in cross section - over raised medallion mordant is thinner, and less dense than the flat gilding.
	Raised gold leaf - mordant does not seem to contain Fe. Impled two mordants used.				SHaP03	EDS	

Binder: FTIR analysis showed the presence of an organic component, but no further comment could be made as to its nature.