THE PERRY LITHGOW PARTNERSHIP

D. A. PERRY
01608-643645

R. P. LITHGOW
01608-658067

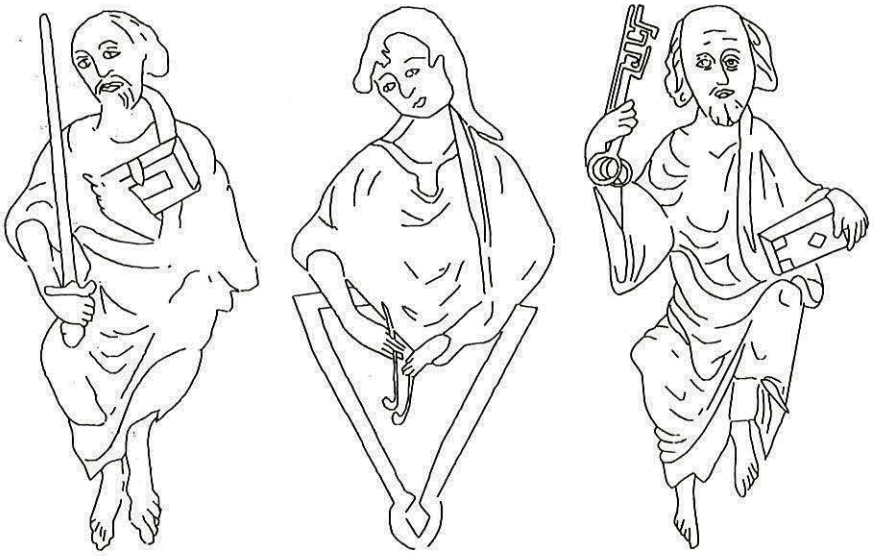
M. A. PERRY
01608-651642

● CONSERVATORS

5 CHURCH LANE
CHIPPING NORTON
OXON OX7 5NS
Telephone 01608-643645
Facsimile 01608-659133

Condition Survey
and
Emergency Conservation Treatment

PETERBOROUGH CATHEDRAL



THE NAVE CEILING
ST PETER, ST PAUL AND PSALTERY PLAYER LOZENGES

Richard Lithgow

October 1997

ABSTRACT

This is a record of emergency treatment carried out during April/May 1997 to re-attach flaking paint within three figurative lozenges on the nave ceiling: St Peter (*Ref: 30/31 II/III*), St Paul (*Ref: 26/27 II/III*) and Psaltery Player (*Ref: 25/26 I/II*). Included is a detailed graphic and photographic condition survey of each lozenge and a record of tests conducted as a preliminary to treatment. The test results are considered taking into account information gathered from previous specialist's reports, including a recent analytical study of paint samples taken from the St Peter, St Paul and Psaltery Player lozenges. The report presents some conclusions and options for future treatment of the nave ceiling particularly with regard to the painted surface.

Table of Contents

List of Figures

List of Plates

Plates 1, 2, 3 and 4 St Peter Lozenge (*Ref: 30/31 II/III*), before treatment. Showing the arrangement of diamond shaped border ornamentation: the key pattern wave pattern, stepped chevron pattern, grey chevron pattern, extended chevron pattern and the outer coloured bands.

Plates 5, 6, 7 and 8 St Peter Lozenge (*Ref: 30/31 II/III*), before treatment. Showing the southern and northern halves with raking light from the west (Plates 5 and 6) and ultraviolet illumination (Plates 7 and 8).

Plates 9, 10 and 11 St Peter Lozenge (*Ref: 30/31 II/III*), before treatment. Showing the figurative boards with raking light from the east (Plate 9) and the west (Plate 10) and a detail of the east half with ultraviolet illumination (Plate 11).

Plate 12 St Peter Lozenge (*Ref: 30/31 II/III*), after treatment. Showing the figurative boards with raking light from the east.

Plates 13 and 14 St Peter Lozenge (*Ref: 30/31 III*), before treatment. Showing the head with raking light (Plate 13) angled so that light reflects off the resinous black paint used in the 1835 restoration and the 'gum' like deposits around the right eyebrow, the hairline on the right side of the face and smaller spots within the beard and forehead areas. These reflective areas fluoresce in ultraviolet illumination (Plate 14).

Plates 15, 16, 17, 18, 19 and 20 St Peter Lozenge (*Ref: 30/31 III*). Showing areas of the head with raking light, before and after paint re-attachment. These photographs illustrate the nature of the flaking paint prior to this treatment phase and the extent of paint loss since the 1835 restoration.

Plates 21, 22, 23 and 24 St Peter Lozenge (*Ref: 30/31 III*). Showing the beard and neck area with raking light, before paint re-attachment (Plate 21) and with ultraviolet illumination (Plate 22). The same area is shown with raking light after treatment (Plate 23) and during the paint re-attachment process (Plate 24).

Plates 25, 26, 27 and 28 St Peter Lozenge (*Ref: 30/31 II*). Showing the feet and lower drapery, with raking light, before paint re-attachment (Plate 25). Before and after treatment details of the left foot and adjacent drapery are shown with raking light (Plates 26 and 27) and before treatment with ultraviolet illumination (Plate 28).

Plates 29, and 30 St Peter Lozenge (*Ref: 30/31 II*). Showing the right foot with raking light, before and after paint re-attachment.

Plates 31, 32, 33 and 34 St Peter Lozenge (*Ref: 30/31 III*). Showing the right hand holding the keys with raking light, before and after paint re-attachment (Plates 31 and 32). Similarly, the left hand resting on a book with raking light, before and after paint re-attachment (Plates 33 and 34).

Plates 35, 36 and 37 St Peter Lozenge (*Ref: 30/31 III*). Showing the paint reattachment process: paint relaxation using the Preservation Pencil (Plate 35); injecting the Plextol B500 solution into the void behind a flake (Plate 36); easing the distorted flake back into position using a dry cotton wool pad through long fibre tissue.

Plates 38, 39 and 40 St Peter Lozenge (*Ref: 31/III*). Details of a section of red drapery with, in the centre, a small patch of opaque film, which may be a residue of microbiological growth. Plate 38, with raking light, shows a small, raised paint flake on the black line, before re-attachment. Plate 39, the same area with ultraviolet illumination. Plate 40, after paint re-attachment using the Preservation Pencil on medium moisture setting: showing an adjacent highlight on the red drapery, which has been affected by the moisture and blanched.

Plates 41 and 42 St Peter Lozenge (*Ref: 31/III*). Details of a section of the key pattern border with raking light (Plate 41) and ultraviolet illumination (Plate 42). Showing a patch of opaque film, which may be a residue of microbiological growth. These photographs illustrate the parallel grooves, which occur on the original key pattern, coloured bands and grey chevron boards.

Plates 43, 44, 45 and 46 St Peter Lozenge (*Ref: 31/III*). Details of dark brown staining on a section of key pattern board, with raking light (Plate 43) and ultraviolet illumination (Plate 44). A patches of less severe staining bridging a wave pattern and a stepped chevron pattern board (Plate 45) appears very dark with ultraviolet illumination (Plate 46). Animal glue drips within the lower part of the pictures fluoresce strongly in ultraviolet light.

Plates 47 and 48 St Paul Lozenge (*Ref: 26/II*). Details of a section of key pattern border showing surface discoloration of the off-white background paint, with raking light (Plate 47) and ultraviolet illumination (Plate 48).

Plates 49, 50, 51 and 52 St Paul Lozenge (*Ref: 26/27 II/III*), before treatment. Showing the arrangement of diamond shaped border ornamentation: the key pattern wave pattern, stepped chevron pattern, grey chevron pattern, extended chevron pattern and the outer coloured bands.

Plates 53, 54, 55 and 56 St Paul Lozenge (*Ref: 26/27 II/III*), before treatment. Showing the southern and northern halves with raking light from the west (Plates 53 and54) and ultraviolet illumination (Plates 55 and 56).

Plates 57, 58 and 59 St Paul Lozenge (*Ref: 26/27 II/III*), showing the figurative boards: before treatment with raking light from the east (Plate 57) and the west (Plate 58); after treatment with raking light from the east (Plate 59).

Plates 60, 61 and 62 St Paul Lozenge (*Ref: 26/27 III*), showing the head and upper body: before treatment with direct light (Plate 60), before treatment with raking light (Plate 61), after treatment with raking light (Plate 62).

Plates 63 and 64 St Paul Lozenge (*Ref: 27/III*). Details of St Paul's hair with raking light, before and after paint re-attachment.

Plates 65, 66 and 67 St Paul Lozenge (*Ref: 26/III*). Details of the sword hand and central body area with raking light before and after paint re-attachment (Plates 65 and 66) and before re-attachment with ultraviolet illumination (Plate 67). The raking light photographs show an area of staining on the drapery.

Plates 68, 69, 70 and 71 St Paul Lozenge (*Ref: 26/III*). Show curling glue drips that have caused the underlying paint to flake: before and after treatment with raking light (Plates 68 and 69); before treatment with ultraviolet illumination (Plates 70 and 71).

Plates 72, 73 and 74 St Paul Lozenge (*Ref: 27/III*). Details of the book held in St Paul's right hand: before treatment showing the raised glue droplets and underlying paint flakes with raking light (Plate 72), ultraviolet illumination (Plate 73) and with raking light after glue removal and paint re-attachment (Plate 74). Plate 74 shows that the adjacent drapery paint has blanched having been affected by the moisture used to dissolve the glue.

Plates 75 and 76 St Paul Lozenge (*Ref: 27 II/III*). A section of the blue cusped border showing blanching of the paint adjacent to a re-attached flake on the black edging (Plate 75). Detail showing cold water and IMS tests on a replacement board (Plate 76): dabbing with a damp cotton wool pad through cotton wool for 10 seconds caused the paint to blanch; the same treatment using IMS had no effect.

Plates 77, 78 and 79 St Paul Lozenge (*Ref: 26/27 II*). Plate 77 shows the loose section of board within the red background beneath St Paul's feet before treatment. Plate 78 shows the same section after the insertion of a stainless steel screw; also, the split and displaced section of wave pattern board before treatment. Plate 79 shows the two sections of board after they have been secured with stainless steel screws.

Plates 80, 81, 82 and 83 Psaltery Player Lozenge (*Ref: 25/26 I/II)*, before treatment. Showing the southern and northern halves with raking light from the east (Plates 80 and 81) and ultraviolet illumination (Plates 82 and 83).

Plates 84 Psaltery Player Lozenge (*Ref: 25/26 I/II)*, before treatment with direct light.

Plates 85, 86, 87 Psaltery Player Lozenge (*Ref: 25/26 II)*. Showing the head and upper body with raking light before treatment (Plate 85), after treatment (Plate 86), and before treatment with ultraviolet light (Plate 87).

Plates 88, 89 Psaltery Player Lozenge (*Ref: 25/26 II*). Showing the head with raking light from the east, before treatment (Plate 88) and after treatment (Plate 89).

Plates 90, 91, 92, 93, 94, 95 and 96 Psaltery Player Lozenge (*Ref: 25/26 I*). Details showing the instrument: with raking light from the east before treatment (Plates 90, 92 and 94) and after treatment (Plates 91, 93 and 95); with ultraviolet illumination before treatment (Plate 96).

Plates 97, 98 and 99 Psaltery Player Lozenge (*Ref: 25/26 I*). Details showing the lower part of the instrument and the cusped border: with raking light before treatment showing the raised glue drips and underlying flaking paint (Plate 97); before treatment with ultraviolet illumination (Plate 98) and after treatment with raking light (Plate 99).

Plates 100, 101, 102 and 103 Psaltery Player Lozenge (*Ref: 25/26 I/II*). Plate 100 shows a test area for glue removal and cleaning adjacent to the east corner. Plate 101 shows a glue removal test on the green background adjacent to the head: the green background paint does not blanch, the small patch of white crystals on the top edge of the test was removed later with a Wischab sponge. Plate 102 and 103 shows paint re-attachment tests on the instrument: the moist warm air was used to relax the paint has caused the tests to blanch.

Plates 104, 105, 106 and 107 St Paul Lozenge (*Ref: 26/27 II/III*). Details of the patterned borders with raking light showing underpaint. Plates 104, 105 and 106 show the bold floral pattern underpaint on replacement boards that may have been re-used from the frieze. Plate 106 also shows the white embellishments of the grey chevron pattern with the impasto white lead underpaint. This occurs on

all original grey chevron pattern boards: the spacing always coincides with the white embellishments, suggesting only a minor deviation from the earlier design. Plate 107 shows the small trefoil pattern which occurs under the extended chevron pattern on some of the original boards.

Plates 108 and 109 St Peter Lozenge (*Ref: 31/II*). Details of flaking black paint on the stepped chevron pattern board subsequently used for paint re-attachment tests. The black appears to be much thicker than the off-white background paint which has not flaked.

Plates 110 and 111 Psaltery Player Lozenge (*Ref: 26/I*). Section of the stepped chevron pattern border used to test the effects of any residual consolidant, subsequent cleaning and appearance. Plate 110 shows the three tests following application of the consolidant solutions and before cleaning. Plate 111 shows the subsequent cleaning tests. These tests are fully described in Appendix 1.

Plates 112 and 113 Section of wave pattern and key pattern borders (*Ref: 31/I*). Plate 112 shows glue removal tests described in Appendix 1. Plate 113 shows a larger area cleaned with a Wischab sponge.

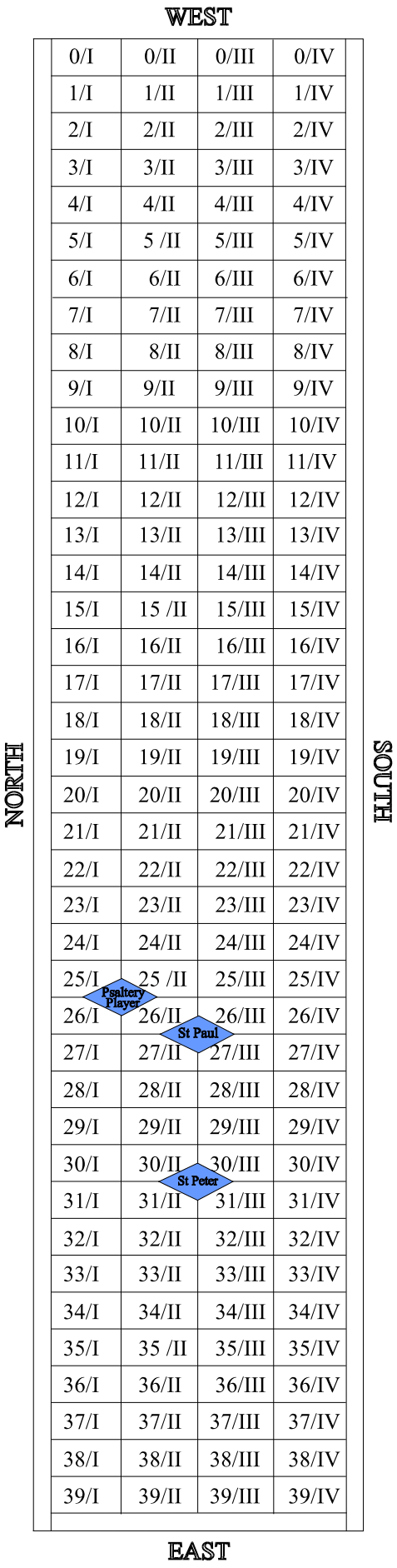
Plates 114 and 115 Section of stepped chevron pattern border (*Ref: 27/IV)*. Showing a test for cleaning and glue removal, before and after treatment. First the surface dirt was first removed with a Wischab; the thin glue film was then removed with warm water applied with small cotton wool swabs. This process leaves the glue affected paint noticeably 'cleaner' than the surround and causes some of the paint to blanch. Tests indicated that the glue cannot be removed effectively without the use of water. The methods used in this test for surface cleaning and for removing the thin glue film are recommended in this report. It will be necessary to disguise the ‘cleaner’, glue affected areas with water-colour paints.

Plates 116 and 117 Graffiti on the vertical frieze on the north wall below *Panels 26/27 I.* Showing two of the four similar inscriptions found in this area recording the removal of limewash from the nave walls in 1890. *George Stapleton, scraping at the Cathedral March 20th 1890 Aged 42 years. Jacob Munton Junior worked at this Cathedral 1890 aged 19 years.*

Plate 118 (*Panels 29/30 III)*. Detail of wood damage within a section of coloured bands border showing the hessian backing layer, applied in 1924. A piece of the exposed hessian has been painted black to make it less noticeable. There was no scaffolding in place for the 1924 repairs carried out in the roof space and no record of interventions since then; therefore, the black paint must have been applied to this patch of hessian before it was laid in place.

Plates 119 and 120 Roof space above the Psaltery Player Lozenge (*Ref: 26/27 II/III*). Showing the ceiling structure from above: the dust covered canvas layer covers the joist spacers but is under the noggins.

Plates 121 and 122 Roof space above the north aisle ceiling. Showing a small section of boarding from which the hessian layer has been removed. This test, using steam to dissolve the glue, was carried out during previous exploratory works by Pauline Plummer.



0/I	0/II	0/III	0/IV
1/I	1/II	1/III	1/IV
2/I	2/II	2/III	2/IV
3/I	3/II	3/III	3/IV
4/I	4/II	4/III	4/IV
5/I	5 /II	5/III	5/IV
6/I	6/II	6/III	6/IV
7/I	7/II	7/III	7/IV
8/I	8/II	8/III	8/IV
9/I	9/II	9/III	9/IV
10/I	10/II	10/III	10/IV
11/I	11/II	11/III	11/IV
12/I	12/II	12/III	12/IV
13/I	13/II	13/III	13/IV
14/I	14/II	14/III	14/IV
15/I	15 /II	15/III	15/IV
16/I	16/II	16/III	16/IV
17/I	17/II	17/III	17/IV
18/I	18/II	18/III	18/IV
19/I	19/II	19/III	19/IV
20/I	20/II	20/III	20/IV
21/I	21/II	21/III	21/IV
22/I	22/II	22/III	22/IV
23/I	23/II	23/III	23/IV
24/I	24/II	24/III	24/IV
25/I	25 /II	25/III	25/IV
26/I	26/II	26/III	26/IV
27/I	27/II	27/III	27/IV
28/I	28/II	28/III	28/IV
29/I	29/II	29/III	29/IV
30/I	30/II	30/III	30/IV
31/I	31/II	31/III	31/IV
32/I	32/II	32/III	32/IV
33/I	33/II	33/III	33/IV
34/I	34/II	34/III	34/IV
35/I	35 /II	35/III	35/IV
36/I	36/II	36/III	36/IV
37/I	37/II	37/III	37/IV
38/I	38/II	38/III	38/IV
39/I	39/II	39/III	39/IV

Figure 1 *Plan of the Nave Ceiling, Peterborough Cathedral.*

PART 1: INTRODUCTION

1.1 Preliminary

This report describes the condition survey, tests and emergency treatment to sections of the nave ceiling carried out by the Perry Lithgow Partnership in March/April 1997. The emergency phase of conservation was initiated by Julian Limentani and Gillian Lewis, the cathedral architect and consultant conservator respectively, following their inspection of the entire nave ceiling from a mechanical hoist in February 1996. They found that some of the paint on the St Peter (*Ref: 30/31 II/III*)[1] and St Paul (*Ref: 26/27 II/III*) lozenges had flaked and was highly unstable. In addition, liquid glue, used in the 1920s to adhere a layer of hessian to the ceiling as a backing, had in places penetrated between the boards, dried on the painted surface and seemed to be causing the paint to flake.

The affected areas are not due to be treated until 4-5 years hence, when they will be treated as part of the phased conservation programme planned to commence in 1997. The initial phases of that treatment may involve considerable works to the ceiling from above as well as to the painted surface. The architect and consultant conservator considered that any resultant vibration or temporary changes in the environment at this level would risk significant paint loss from these two unstable areas, therefore it was necessary to secure them before full treatment began.

1.2 Scope of the Work

The Perry Lithgow Partnership was commissioned to complete a detailed condition survey of the St Peter and St Paul lozenges, to conduct trials for the removal of the animal glue drips and, following appropriate tests and consultation, to re-attach the flaking paint. Two bridge scaffolds spanning the width of the nave provided access to sections *26-27* and *30-31* of the ceiling.

A preliminary visual examination of the accessible panels revealed areas of flaking and loose paint within the Psaltery Player lozenge (*Ref: 25/26 I/II*). The deterioration was similar to that on the St Peter and St Paul lozenges so a decision was taken to extend the emergency phase of treatment and include this area.

1.3 Technical Analysis

The Cathedral has appointed a technical adviser, Helen Howard, and a documentation adviser, Adrian Heritage, both from the Courtauld Institute of Art, Conservation of Wall Paintings Department. They are to conduct paint sample analysis and co-ordinate the documentation throughout the planned treatment of the entire nave ceiling. A technical study of the paint layer on the three lozenges was conducted by Helen Howard and Adrian Heritage as part of the emergency treatment phase. The schedule did not allow time for the technical study to be completed before treatment began.

Prior to this phase there had been only limited technical analysis of the painted decoration. In 1995 a number of cross sections from the east section of the nave ceiling were subjected to microscopic examination as part of the survey conducted by Hirst Conservation[2]. In addition, Gillian Lewis obtained paint samples during the inspection of the entire nave ceiling from a mechanical hoist in 1996. Photographs of these cross sections were made available to the Perry Lithgow Partnership.

---

[1]These reference numbers refer to nave ceiling panels identified in Figure 1, a plan of the nave ceiling.
[2]*Nave Ceiling Peterborough Cathedral* Hirst Conservation, October 1995.

A photogrammetric survey of the entire ceiling is being compiled by Professional Services Survey Team, Photogrammetric Unit. Photogrammetric drawings of the St Peter and St Paul lozenges were made available to the Perry Lithgow Partnership.

PART 2: DESCRIPTION OF THE CEILING

The wooden nave ceiling at Peterborough is an extremely important survival. There are three ceilings of comparable age in Europe but all are much smaller: St Martin's, Zillis in Switzerland (1150); St Michael's, Hildesheim in Germany (1200); Dädesjö, Smaland in Sweden.

2.1 Date

According to Cave and Borenius[3] the roof of the nave of Peterborough Cathedral was erected in the latter years of the twelfth century and the ceiling was probably painted about 1220. Nordstrom[4] suggests 1236-37. Mackreth[5] suggests the layout of the ceiling clearly reflects the design which is painted on it, therefore, both belong together. Mackreth goes on to suggest that the ceiling was probably commissioned and completed under Abbot Benedict (1177-93).

2.2 Painted Design

The design is described by Professor E W Tristram in *English Medieval Wall Paintings: The Twelfth Century,* 1944.

> 'The painted design follows the arrangement of the boards and consists of three rows of diamond shaped panels, with a row of half-diamond shaped panels on either side. They are treated with borders of elaborate ornamentation, including zig-zag, wave, key, and other designs, all the diamonds having a small scroll pattern at the angles. The ornamentation covers the greater part of the space leaving only small diamond shaped compartments in which are depicted subjects of a varied nature. All twenty panels on the central line have figures within them, while on the outer lines foliated ornament alternates with figures and grotesques. Foliated ornament also fills the central compartments of the outermost rows of half-diamonds. The date of this work appears to be 1220.'

At wall plate level there is a frieze two boards wide running the length of the nave. This is painted with a bold floral design which has an eighteenth century feel (Dr Richard Gem pers. comm.).

The border ornamentation is the same for each diamond. The inner band a black key pattern on an off-white background. A black chevron or wave pattern with fleur-de-lis at the corners, also on an off-white ground. A crenellated or stepped chevron pattern, black on off-white. A grey, extended chevron pattern separated from the black background by a white line; the chevrons have white embellishments. An extended, black chevron or wave pattern with fleur-de-lis at the corners, all on an off-white ground. The outer design is of coloured bands, brown and off-white; the off-white band forming the background to a red and a black line. For the purposes of this report the six border designs will be referred to as identified in Figure 2.

---

[3] *Archaeologia LXXXVII* 'The Painted Ceiling in the Nave of Peterborough Cathedral' Cave and Borenius 1938.
[4] *Art Bulletin XXXVII* 'Peterborough, Lincoln and the Science of Robert Grosseteste: A Study in Thirteenth Century Architecture' Nordstrom 1955.
[5] *The medieval Nave Roof and Ceiling of Peterborough Cathedral* Mackreth 1997

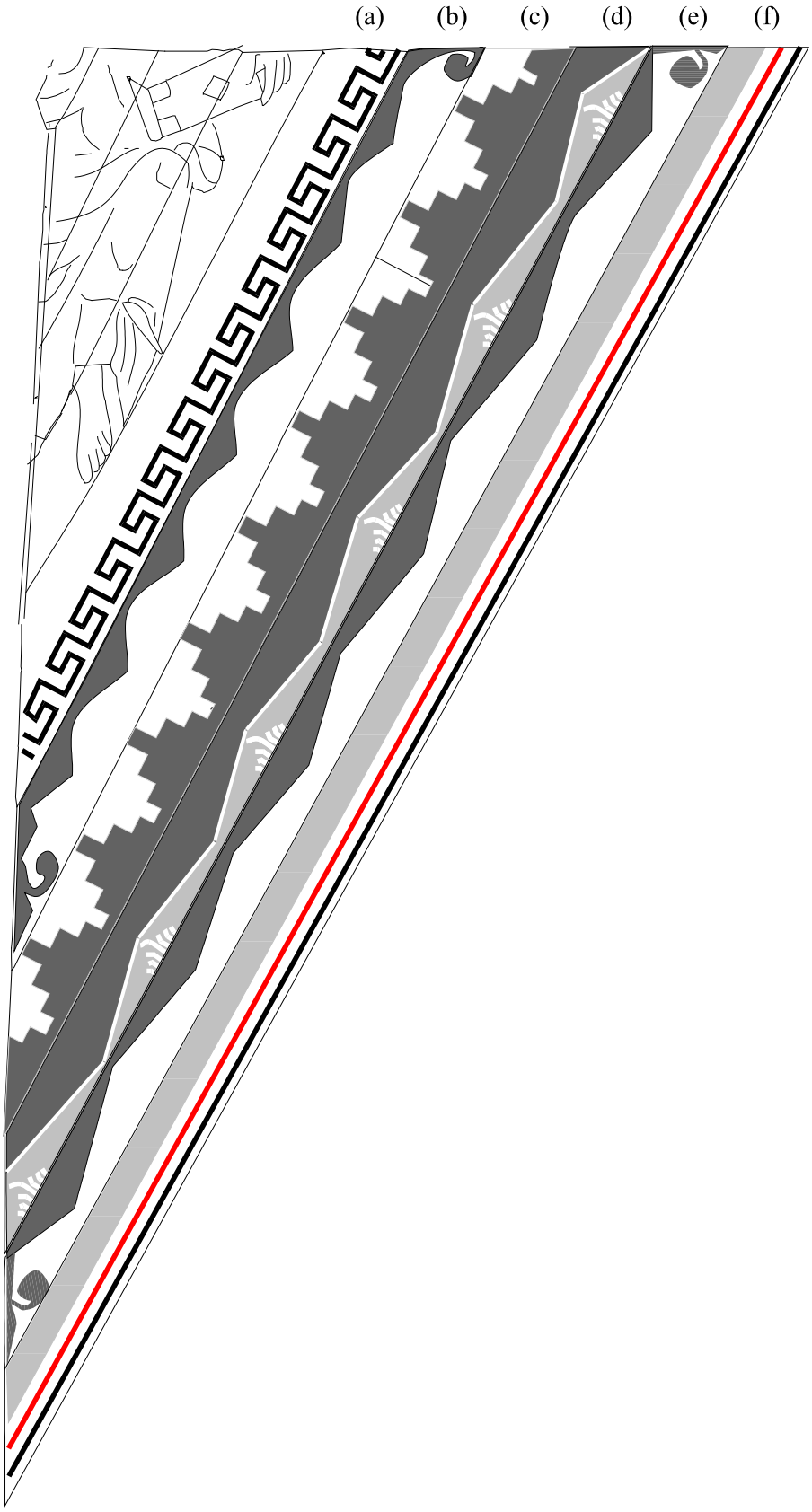


Figure 2. *The diamond border ornamentation: (a) key pattern; (b) wave pattern; (c) stepped chevron pattern; (d) grey chevron pattern; (e) extended chevron pattern; (f) coloured bands.*

2.3 Measurements

Nave ceiling: 62.2 m (204 ft) x 10.7 m (35 ft)
Horizontal panels within rows (II/III): 11 ft (3.35 m) x 5 ft 3 ins (1.61 m).
45° canted panels in the outer rows (I/IV): 8 ft 5 ins (2.56 m) x 5 ft 3 ins (1.61 m).
Central lozenges (boards within the key -pattern): 7 ft 7 ins (2.31 m) x 3 ft 9 ins (1.15 m).
Outer canted lozenges: 5 ft 9 ins (1.761 m) x 3 ft 5 ins (1.05 m).
The vertical friezes running the length of the nave immediately beneath the ceiling on the north and south walls: 19 ins (0.48 m) high .

2.4 Roof Structure

The roof structure is described in the report by Hirst Conservation. As this aspect is beyond the scope of the emergency paint consolidation phase it is referred to only in as much as it has a bearing on the treatment and recommendations contained in this report.

2.5 Ceiling Structure

The construction of the ceiling reflects the painted diamond pattern design. For the purposes of the photogrammetric survey the ceiling has been divided into numbered panels (*see Figure 1*). Each panel is constructed of diagonally placed overlapping oak boards forming a diamond where the four panel corners meet. The boards are fixed to the ceiling joists with round-headed iron nails at each corner. The joists are now suspended from later binders on a regular series of bolts.

Simpson[6] observes that the boards are tapered so they have a long, triangular cross section, the feather-edge of one is secured in a V-shaped groove cut into the thick edge of the next board (an early form of tongue and groove jointing). In fact, many of the boards have a half-rounded outer edge (*see Figure 3*). The specific sequence of cornered and half-rounded edges is followed over the entire ceiling and is a visually significant aspect of the design, particularly when the ceiling is viewed from clerestory level.

Another design feature is the series of parallel grooves within the thicker, outer halves of each key pattern, coloured bands, and grey chevron board. The grooved effect is achieved as much by the surface texture as by the indentations which are extremely shallow. The three grooves are smooth whereas the slightly raised bands either side and between are roughly finished (*see Figure 3 on next page*). None of the many replacement boards have either the half-rounded edge or parallel grooves, presumably the restorers thought these omissions would not be noticed from floor level.

[6] *Peterborough Cathedral: Proposals for the Archaeological Survey and Dating of the nave Roof and Ceiling* Simpson 1995.

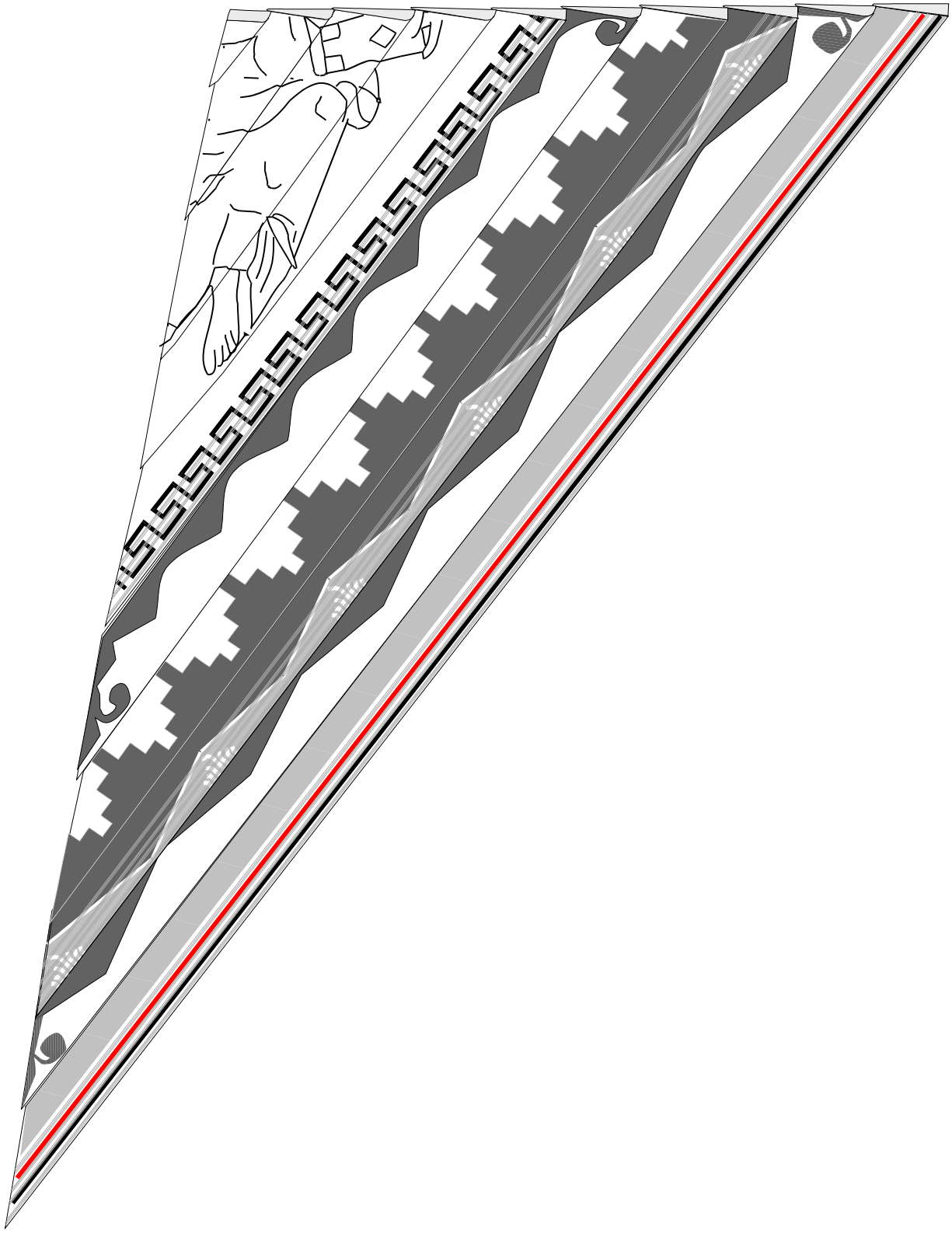


Figure 3. *Showing the sequence of boards with cornered and half rounded edges and identifying the boards with parallel grooves. Those without half-rounded edges are the key pattern, stepped chevron pattern, grey chevron pattern and coloured bands boards. Key pattern, coloured bands and grey chevron boards have the parallel grooves.*

2.6 Paint Layer

The technical study - completed by Helen Howard[7] - of the paint layer on the St Peter, St Paul and Psaltery Player lozenges and the surrounding areas indicate that original paint layers (dating to *c.* 1220) exist in a number of areas, usually beneath layers of overpaint. The original materials and methods of application are consistent with the techniques employed on the ceiling panels of the painted Chamber at Westminster Palace (*c*. 1263-6).

In samples where original paint layers are almost certainly present traces of lead white ground were identified. The following pigments are present in apparently original paint layers: natural azurite, vermilion, red lead ,basic verdigris, carbon black, lead white, red iron oxide and yellow iron oxide. Oil was employed as a binding medium in these layers; although, it is possible that a proteinaceous material was also used.

The painted scheme is known to have been restored between 1740 and 1750 and again in 1834; although, there are no detailed records as to the extent of these restorations. Pigments identified in paint over the original layers are as follows: Prussian blue, vermilion, red lead, basic verdigris, carbon black, lead white, red iron oxide, brown and yellow iron oxides and barytes. An oil-based medium was used for both restorations.

PART 3: RECORDED PREVIOUS INTERVENTIONS

The nave roof was replaced in 1834/5 and for a second time in 1924: structural alterations were made to the ceiling on both these occasions. The central tower was rebuilt in the 1880s, at which time some repairs were made to the eastern section of the nave ceiling. The painted decoration on the ceiling has been restored on at least two occasions: once between 1740-50 and again in 1834/5. The exact nature of each intervention is not fully documented and there may well have been earlier repairs and restorations which are not recorded.

3.1 Chronology

- *18th century:* 1740-50 - The dirty and flaking painted surface was washed down and restored in oil paint. It is not certain whether any of the ceiling boards were replaced at this time. The painted design on the frieze appears to originate from this century.

- *19th century:* 1834/5 - The nave roof was replaced by Ruddle (Mackreth) or Blore (Hirst Conservation). The nave ceiling was suspended on ceiling bolts from the binders and many deteriorated ceiling boards were replaced. It appears that the frieze was entirely replaced. It may be that some of the seventeenth century boards from the frieze were re-used as replacement ceiling boards. Charles Layton repainted the ceiling (Mackreth).

  1880s – rebuilding of the central tower by Pearson involved some disruption to the east end of the nave ceiling. Milled replacement boards inserted at the east end of the nave ceiling.

  1890 - Removal of limewash from the nave walls. Inscriptions recording this work found on an area of the frieze below sections 26/I &27/I (*see Plates 116 and 117*).

[7] *Peterborough Cathedral, nave ceiling: Scientific examination of the original decoration* H. Howard (Sept.1997).

- *20th century:* 1924 - The nave roof rebuilt by Moore: no scaffolding was put under the ceiling for this phase so the painted decoration could not have been treated. A protective hessian layer was applied to the upper surfaces of the boards and noggins inserted between the joists to serve as additional fixing points. The roof timbers and possibly the reverse of the ceiling boards were treated with a Silvertown insectiside solution (which included sulphur chloride and carbon bi-sulphide) at this time. Steel and galvanised screws of varying thickness' were inserted from above, mainly through the noggins, giving extra support to the longer ceiling boards. Any nail heads and nail ends protruding from the upper surface of the boards were hammered through before the hessian was put in place: as there was no scaffolding below, these nails either fell away or remained protruding from the painted surface. Dangerously loose nails were removed by Julian Limentani during the inspection from a mechanical hoist in February 1996.

3.2 Additions/Alterations to the ceiling structure

Hirst Conservation distinguishes between a number of different boards and fixings:

- ***Boards***

  Oak boards: Although most appear to be the original boards Hirst mentions later, replacement oak boards within the eastern section of the nave ceiling.

  Softwood boards: there are two kinds of softwood boards. The later unplaned boards show milling marks, visible through the paint layer and can only be 1880s at the earliest. The earlier planed boards must be 1840s or earlier. Both types of board are fixed from below and both bear overpaint from different restorations. Softwood boards on the frieze are planed and abut each other rather than overlap.

  No milled boards were identified within the areas accessible during this phase. Proper analysis of wood used to make the different types of board is necessary for positive identification.

- ***Fixings***

  A number of alterations and additions were made to the fixing methods during previous interventions: the points of steel and galvanised screws inserted from above protrude through the painted surface; a variety of additional and re-used original nails have been inserted from above and below, their protruding ends clenched. The position of all fixings within the St Peter, St Paul and Psaltery Player lozenges have been recorded on graphics as part of the condition survey (*see Parts 5 and 9*).

  Noggins: in the 1920s noggins made of laminated softwood were inserted diagonally and some at 90° to the ceiling joists. Hirst Conservation observed that they are made up of 2 or 3 wide boards laid flat onto the ceiling boards with stouter stiffeners fitted centrally on top. The noggins provided additional fixing points to secure the boards.

  Iron ceiling bolts and washers: the joists are suspended from the binders on a regular series of these bolts. The ceiling bolts must date from the 1835 restoration when there was scaffolding under the ceiling as they were inserted from below.

  Large cast clout headed nails: these have been used primarily to secure the ceiling boards to the joists so are placed at each corner of board.

  Smaller clenched iron nails: used to secure replacement boards and to attach overlapped boards.

Cut brad nails with small heads: Hirst Conservation identified these within the east section of the nave ceiling but none were found on the areas treated during this emergency phase.

Screws: corroded steel and galvanised screws, added in 1926, have penetrated through the boards from above. These have been used to secure some of the ceiling board edges as well as to secure boards to the noggins.

- ***Hessian***

  As part of the 1926 restoration the upper surfaces of the ceiling boards were covered in a layer of hessian adhered with an animal glue. The hessian was laid between the joists but covers the joist spacers. The noggins were positioned onto the hessian (*see Plates 119 and 120*).

3.3 Alterations to the Paint Scheme

The recent, preliminary technical survey of the paint layers[8] indicates that nearly all of the remaining original paint is hidden under repaint from the 18th and 19th centuries. There is some evidence to suggest that the present border designs and some of the background colours differ from the original scheme; although, analysis of more paint samples from a wider area of the ceiling will be necessary to establish the full extent of alterations.

Under raking light it is evident that at least two alterations have been made to the original border scheme. A repeated pattern incorporating small trefoils exists under the extended chevron pattern on some, but by no means all, of the original oak boards (*see Plate 107*). A sample taken from this area, indicated that a combination of vermilion with lead white was employed to create the trefoil pattern. The thick lead white preparation, over which the pink paint layer appears to have been painted almost wet-on-wet, suggests that this design represents a later addition. A similar pink layer was detected in a sample taken from an area further along the board, but where no trace of an underlying design is visible even in raking light - indicating that the trefoil pattern may be more extensive than was initially thought. However, if the trefoil pattern is itself an addition and the original paint is missing from the area sampled, we have no indication, as yet, of the 13th century design in this border sequence.

Similarly, another apparent alteration to the painted scheme is visible with raking light under the white embellishments of the grey chevron pattern (*see Plate 106*). This occurs on all the original grey chevron pattern boards but not on the replacements. The spacing of this impasto underpaint (white lead) coincides with the covering white embellishments, suggesting only a minor deviation from the earlier design.

The painted scheme is known to have been restored between 1740 and 1750 and again in 1834; although, there are no detailed records as to the extent of these restorations. In 1789 Govenor Pownall wrote that the whole ceiling had been repainted in oil some forty years before; the original distemper was dirty and flaking. According to Cave the restorer told Pownall that he 'only retraced the figures', also, that 'parts came clean off the wainscot'. The frieze may have been replaced at this time as the painted design appears to be eighteenth century in origin.

There is underpaint evident on some of the replacement boards. These boards may have been re-used from the frieze as the overpainted design is the same bold floral pattern; seemingly eighteenth century in origin. The existing frieze is entirely nineteenth century. It appears that some un-deteriorated,

[8] *Peterborough Cathedral, nave ceiling: Scientific examination of the original decoration* H. Howard (Sept.1997).

eighteenth century boards from the frieze were re-shaped and used to replace deteriorated ceiling boards.

According to Mackreth, Charles Layton was paid £30 to paint the nave ceiling in 1835. The nave roof was replaced in 1834/35. Considerable repair work must have been carried out to the ceiling at as part of the same project: most replacement boards within the area accessible during the recent phase of treatment appear to have been inserted at that time. The frieze must have been replaced then also, since it is cut to accommodate the canted replacements. The 1834/5 restoration appears to have been much more extensive than the previous, eighteenth century work (if Pownall's 1789 account is to be believed): it follows that any alterations to the diamond border design are more likely to date from the nineteenth century restoration.

PART 4: RECENT ANALYTICAL INVESTIGATIONS AND SURVEYS

Within the last three years a number of surveys and investigations of aspects of the nave ceiling. Principally a programme of environmental monitoring over a fifteen month period and a condition survey of the eastern bay of the nave. Others include examinations of nails and a sample of wood taken from the ceiling and the recent photogrammetric survey. In addition, Helen Howard has recently completed a technical analysis of paint layer samples from of the St. Paul, St. Peter and Psaltery Player lozenges and surrounding areas.

A further programme of environmental monitoring is proposed for the duration of the conservation project will help to design a future heating strategy.

The rest of this section includes brief summaries of information gathered from the environmental monitoring and other investigations.

4.1 Environmental Monitoring: *English Heritage, January 1995 - June 1996. (no report for period 14 June to 19 September 1995)*

English Heritage conducted a programme of environmental monitoring from January 1995 to June 1996 to establish whether the painted ceiling is being adversely affected by the heating system. Heating in the Cathedral is provided by gas fired Gurney stoves, installed in the late nineteenth century. Originally coal burning, they were converted to oil in the 1960s and were subsequently refurbished and converted to use gas in 1990. Since that modification internal air temperatures have risen by around 5°C. K. Waterman[9] suggests that relative humidity (RH) would consequently have reduced by around 20% - thus altering the equilibrium moisture content of the wood. It is probable that the shrinkage of the painted ceiling coincided with the conversion of the Gurney stoves. Collected data throughout indicates an almost total absence of internal temperature gradient suggesting the heating is very effective in operation.

The following statements have been extracted from the five reports:

> *Report 1 (January-April 1995)* states: 'the maximum RH is between 55 and 62%, minimum 33.5 and 37%. These figures are low for a building of this type.'
>
> 'It is unlikely that a situation would arise where condensation will form on the wooden ceiling.'

[9] *Peterborough Cathedral: Environmental Monitoring Data 10 January to 4 April 1995* English Heritage.

Report 2 (April-June 1995) Main Body of the Building 'Vapour pressure data indicates that moisture is moving through the wood in either direction. As the ceiling is of a relatively light construction, the moisture should pass through with little effect on the wood.'

Roof Void "Daily variations of temperature can be clearly seen and it can also be seen how the roof boarding follows the external temperature.'

Report 3 (September-November 1995) records: 'RH is very stable averaging at 70%. It is probable that this will have contributed to the drying out and subsequent shrinkage of the ceiling'.

'There is no excess temperature variation across the ceiling, therefore any flexing or movement of the structure should be minimal.'

Moisture is moving fairly constantly in either direction across the ceiling. This should not lead to a situation where warping could occur through one side having a greater moisture content that the other.

Comparisons of the external and roof space temperatures shows the mass of the building fabric acts as a very effective buffer against sudden internal changes of conditions.

Report 4 (Nov. 95-Jan. 96) - During a one month period the reservoir at the base of the Gurney stoves was filled with water to act as a humidifier. 'During December there was a tendency for moisture to move predominantly from inside to outside which was counteracted by the humidification effect of the water in the Gurney stoves.'

'Moisture movement across the ceiling was generally from the cathedral to the roof space. This may have been caused by the extra moisture induced into the cathedral as in the previous monitoring period moisture moved backwards and forwards fairly evenly.'

Report 5 (February-June 1996) – 'When the heating is operating, the underside of the ceiling is generally warmer than the topside. The reverse is generally the case when the heating is turned off; this is the result of solar gains in the roof space. as the temperature is fluctuating across the ceiling it is more likely that movement of the timber will occur in the summer than the winter. Therefore the heating season appears to offer the most stable environment for the ceiling. By limiting the temperature the RH is kept to reasonable figures. If the temperature is too high the tendency is for the RH to fall.'

4.2 Pollution Test: *Barry Knight December 1994*

A sample of wood and a nail taken from the ceiling were tested for sulphate contamination (the effects of 100 years of coal fired heating). The results showed that a considerable amounts of soluble acid were present in both samples. Tests for chloride and sulphate both gave weak positive results.

4.3 Examination of Nails from the Ceiling: *David Starley Ancient Monuments Laboratory, January 1996.*

What is considered to be one of the original nails removed from the east end of the ceiling was subjected to a visual and metallographic examination. This confirmed the metal is phosphoric iron and that similar hand forged nails are known from the Roman period to the eighteenth century. Little else could be gleaned from the examination.

4.4 Investigation of the Eastern Bay of the Nave: *Hirst Conservation, October 1995.*

The fabric of the ceiling is described, evidence of previous interventions considered, the condition is assessed and a conservation strategy proposed. The report includes photographs, diagrams, drawings, photomicrographs and results of analysis.

4.5 Photogrammetric Survey: *Professional Services Survey Team*, *Photogrammetric Unit, November 1996.*

Drawings of the St Peter and St Paul diamonds were made available to the Perry Lithgow Partnership for this phase of treatment.

4.6 Peterborough Cathedral, nave ceiling: Scientific examination of the original decoration: *Helen Howard (Sept.1997).*

> *Extract from page 1:* 'Results indicate that original paint layers exist in a number of areas, usually beneath layers of rather crude overpaint, as in the flesh tones of St. Peter. It also appears that some original layers remain exposed - though juxtaposed with cursorily applied overpaint - as in the Psaltery Player, where parts of the instrument appear to be of 13th-century date. The original palette includes natural azurite, lead white, verdigris and vermilion, and the binding medium of layers containing lead white and verdigris has been identified as a drying oil.
>
> Of particular interest is the use of green underpainting for some of the flesh tones, in azurite combined with lead white and yellow iron oxide. It is significant that azurite was also used to indicate shadows in the flesh tones in the ceiling fragments from the Painted Chamber of Westminster Palace, dating from c. 1263-6. These panels, which survive in remarkably good condition, provide perhaps the closest surviving English parallel in terms of original function and date to the original scheme at Peterborough.
>
> The results of the investigation have clear implications for the conservation of the painted ceiling. The presence of calcium sulphate at the wood/paint interface, and also at varying concentrations throughout the paint layers, makes the painting profoundly sensitive to moisture. In addition, some 19th-century paint layers were also found to contain high concentrations of both calcium sulphate and clay-rich minerals, which accounts for their extreme moisture sensitivity. This was dramatically demonstrated by the severe blooming which followed even brief contact with water during the recent emergency conservation testing and treatment.
>
> There is also evidence of pigment alterations in both the original and later phases of painting. These include the transformation of natural azurite to copper oxalate, which indicates deterioration of the original painting, and which may be partly due to an episode of high humidity at some time in the past.'

PART 5: CONDITION REPORT

The primary aim of this phase of treatment was to document and re-attach the loose and flaking paint within the three designated lozenges. The scaffolding also afforded an opportunity to examine an area some distance from the east section - where scaffolding had been in place for the 1995 survey by Hirst Conservation - and to compare findings. In addition we were able to carry out a limited inspection of the relevant sections of ceiling from the roof space above. Detailed graphic documentation of the three lozenges, plotting the position of original and added fixings and illustrating categories of damage and deterioration, are included in Part 9 of this report.

5.1 Roof Structure

Hirst conservation state that the overall condition of the roof structure is sound, although there are particular problems which require attention. Their report proposes measures to improve the structural support of the ceiling joists. it is beyond the scope of this report to comment on these measures.

5.2 Ceiling Boards

There are a significant number of replacement boards across the entire ceiling[10]. The replaced boards were probably damaged by water infiltration or insect attack.

- *Insect attack* - Hirst Conservation state that the main roof structure was replaced in 1920s primarily due to insect attack and mentions evidence of beetle damage to several panels within the eastern bay. We found relatively few examples of wood damage resulting from past insect attack within sections 26/27 and 30/31 and nothing to indicate active attack.

- *Water penetration* - We identified a number of slightly spongy and relatively soft original boards which have probably deteriorated as a result of long term exposure to water infiltration. The paint layer has tended to flake on boards in this spongy condition; for instance, the worst flaking within the Psaltery Player lozenge is on one such board. They have not deteriorated to the extent that the wood is unsound or necessarily requires consolidation treatment. As yet it is not clear why the paint flakes on these boards in particular It is likely that many boards in a similar condition were replaced not because the wood was exceptionally deteriorated but because the covering paint was flaking. It is easier to paint onto a flat replacement board than to re-attach or even scrape off flaking paint and then repaint the loss. This theory is enhanced by our findings that there is comparatively little evidence paint loss that has been overpainted.

- *Movement/Displacement* - We discovered that a section missing from the south west key pattern board around the St Paul figure was in place when Cave photographed the area from ground level in 1938. A number of the boards in sections 26/27 and 30/31 were slightly displaced because of missing fixings (one end hanging down slightly for instance) but none were loose or in danger of falling.

- *Mechanical damage* - Previous efforts to secure loose boards by inserting excessively long screws and nails from above have resulted in splintering of the surface and splitting of the boards; made worse by subsequent corrosion which causes the metal to expand and increase pressure on the surrounding wood and paint. These added fixings may be obstructing normal expansion and contraction of the ceiling boards. Four small sections of fractured or split boarding had to be secured during this emergency phase of treatment.

[10]Detailed in *Peterborough Cathedral, Painted Ceiling - Nave, inspection Report* Wolfgäng Gartner May 1988

- *Fixings* - The positions of all fixings visible from below, including empty nail holes and protruding nails, have been plotted on the diagrams in Part 9 of this report. In addition, the condition of each nail head is recorded, although not the condition of each screw and nail end. It is sufficient to relate that the ends of the ungalvanised steel screws are all corroded to some degree and a number of the galvanised screws are also partly corroded: only a few of the clenched, iron nail ends are corroded.

- *Hessian* - The layer of coarse hessian applied to the reverse of the boards in 1926 does not appear to have deteriorated, neither does the animal glue adhesive. A more thorough examination of this layer is required to assess its condition and effect on the boards.

5.3 Paint Layer

- *Number of restorations and media* - The visible paint surface is from several periods as overpainting was partial in each successive restoration. The different paint layers have distinct characteristics. The later paints are smoother in texture whereas at least one early layer has a very granular surface. It appears that the he black paint used for the 1835 restoration either has a surface coating[11] or has a resinous medium that has tended to migrate to the surface causing shiny patches. There are three different blacks visible, each belonging to a different period of restoration.

- *Adhesion to the support* - By far the majority of the paint is well adhered to the supporting boards. The areas treated during this phase are not representative of the whole. Paint sample analysis has not as yet determined whether certain materials or aspects of technique have contributed to this damage. This appears to be the case as far as St Peter's face, hands and feet are concerned (*see Plates 13-34*): these were flaking extensively, although the surrounding paint and supporting oak boards were sound. It may be that these features were repainted more often and the thickened paint has contracted and lifted away from the support. Similarly, it appears that the black outline drawing on the figures and the black paint on the stepped chevron pattern boards is more prone to flaking than other paints, whether on sound boarding or on the slightly spongy surface of deteriorated boards (*see Plates 108 and 109*). It may be that black areas were repainted more often than most other areas.

  The primary cause of flaking paint on the nave ceiling is long term water infiltration leading to deterioration of the wood support and subsequent loss of adhesion. The worst areas of flaking paint within the St Paul and Psaltery Player lozenges are on deteriorated boards (*see Plates 63 and 92*). Also on the St Paul figure, staining within flaking drapery paint near to the sword-hand (*see Plate 65*) indicates this flaking resulted from water infiltration, even though the supporting board is sound.

  Flaking paint caused by the contraction of overlying glue deposits is described in the next section. All areas of flaking paint within the St Peter, St Paul and Psaltery Player lozenges are marked on the diagrams in Part 9 of this report. The different categories of flaking and the extent of paint distortion are defined and marked on grey-scale photographs in Part 10.

- *Loss of cohesion/powdering* - The dry, granular surface of the earlier paint together with the surface coating of dust gives the appearance of a powdering, unstable paint layer lacking cohesion. However our surface cleaning tests indicate that this is not the case. The dirt can be removed without loss of pigment.

[11] In her report Helen Howard makes reference to an unidentified surface coating or consolidant on Samples 17/2109, 18/2110 and 25/2117.

- *Pigment alteration* – The recent analysis of paint samples has identified some evidence of pigment alterations in both the original and later phases of painting. This includes the transformation of natural azurite to copper oxalate, which indicates deterioration of the original painting, and which may be partly due to an episode of high humidity at some time in the past. Similarly, the alteration of verdigris to form copper chloride, It seem likely that Silvertown treatment, applied in 1926 as an insecticide, may also be implicated in this alteration, since it would have provided a ready source of chlorides.

- *Surface discoloration* - Some of the later repaint, particularly the off-white background has yellowed. Further paint sample analysis is required to determine whether this is the result medium alteration, leaching of resinous material from the boards or a surface accretion[12]. Results of the glue removal tests suggest the yellowing is superficial.

5.4 Accidental Accretions

The paint layer bears various types of accretion.

- *Glue* - Liquid glue used in the 1920s as an adhesive for the hessian backing material has in places penetrated between the boards, dried on the painted surface and caused the paint to flake. On the horizontal central panels the glue tended to travel vertically down the edge of a board and drip onto the floor below: leaving a thick, raised droplet over the paint on the edge of a board. These thick droplets have contracted in the dry environment causing the underlying paint to flake. On the canted side panels the glue residue is more extensive. On penetrating the boards the glue travelled in rivulets across the canted surface before drying. In general, the glue has caused paint flaking only where it has collected in thick droplets or runs.

- *Staining* - There are many small but significant areas of brown staining caused, it would appear, by deposits in the wood mobilised by water infiltration or by the residue of an unidentified treatment or coating applied to the boards from above. Sample analysis has yet to identify the materials involved.

- *Microbiological attack* - There are a number of slightly opaque accretions on the surface. A sample was obtained by Helen Howard (Sample 25/2117) but the surface coating has yet to be identified. MBG would seem unlikely in such dry conditions but there has been water infiltration and these examples may be inactive MBG residue.

- *Surface coatings* - Helen Howard discovered evidence of surface coatings on three other paint samples. Sample(17/2109) from the stepped chevron pattern surrounding the St. Paul lozenge has a thin coating (or layer of consolidant) which produces a 'metallic sheen'. The silvery sheen on the surface of the paint layer in Sample (18/2110), also from the stepped chevron pattern surrounding the St. Paul lozenge, is due to a pale coating which has not yet been identified. FTIR analysis of the upper portion of Sample (28/2120) from the grey chevron pattern border surrounding St. Peter indicated that shellac may be present.

- *Superficial dirt* - A thick layer of dust and dirt covers all the painted decoration.

[12]Helen Howard's analysis of Sample 28/2120 by FTIR indicated that shellac may be present in the upper portion.

PART 6: TESTING PHASE

This section of the report summarises the rationale for testing and set out the conclusions derived from the test results. Specific details of all tests and results are tabulated in Appendix 1.

6.1 Preliminary

In consultation with the architect and consultant conservator it was agreed that the object of emergency treatment would be to re-lay and fix flaking paint within the three designated lozenges so that the painted decoration would withstand surface cleaning during subsequent phases of conservation. This dictated the use of slightly stronger adhesive solutions than would be regarded as otherwise necessary to stabilise paint in such an inaccessible position. A secondary element of this treatment was to identify a method of removing the animal glue film without damage to the paint surface; and then to remove glue overlying flaking paint within the three lozenges. In addition, limited surface cleaning trials would be carried out as controls, so that cleaned areas of undeteriorated paint can be compared with areas where paint re-attachment and glue removal have taken place.

The work to re-adhere paint flakes had to take place in situ with the loose, curling paint hanging down from the ceiling. Much of the equipment and techniques commonly employed to facilitate paint re-attachment could not be used in these circumstances. Any form of protective facing applied as a means of securing loose paint during the re-attachment process would be a hindrance. Such facings tend to obscure the damaged surface, making it difficult to see the flakes. Inevitably, many flakes are pushed back into place when a facing is applied; these flakes are easily overlooked during application of the adhesive so that they are not secured and may be lost as the facing is removed. In addition, there is a risk that residual facing adhesive on the paint surface will present problems in the future. Tests were undertaken to devise methods for relaxing the distorted paint flakes, introducing the adhesive and re-laying each flake while causing minimal disturbance to surrounding loose paint. Paint relaxation tests were conducted using cold and warm deionised water, various solvents and a Preservation Pencil at different settings.

6.2 Paint Re-attachment

- *Paint relaxation* - Initial paint relaxation trials indicated that Industrial Methylated Spirits (IMS), xylene, and deionised water each relaxed the paint over time; however, the distorted flakes remained too inflexible for re-laying. Trials with the Preservation Pencil were more successful but initial results were misleading. The Preservation Pencil, used with an ultrasonic humidifier, is capable of providing a fine, delicate jet of moisture or dry air from ambient temperature to 100ºC. The first group of tests indicated that heat was effective in relaxing the paint but caused unacceptable blanching on the paint surface: also, that warm moisture (40ºC) achieved similar relaxation over time without causing blanching. Extensive testing involving all three processes found that moisture was the prime cause of surface blanching. Blanching depends on the type of moisture output which is controlled by the varied heat and moisture settings, and types of nozzle, available on the Preservation Pencil. It was found that warm dry air can be used to relax the paint flakes without adverse effect. The discovery that even minimal contact with water may cause some of the paint to blanch is highly significant and affects all aspects of the proposed treatment programme. Only certain of the nineteenth century paint colours are prone to blanch after contact with water; these are identified in Appendix 2. The blanching must occur as a result of migration of soluble parts of the medium or other paint constituent. The recent technical survey identified a high proportion of clay-rich minerals and calcium sulphate in some of the paint layers making

them extremely water sensitive as the clay-based materials swell readily in the presence of moisture.

Since moisture, rather than temperature, causes the nineteenth century paint to blanch subsequent tests were aimed at devising a method of securing the paint flakes without the use of water; or at least minimising water contact with the paint surface. The subsequent discovery of clay-based materials in the overpaint and calcium sulphate in the paint layers and at the wood/paint interface serves as justification this approach.

An satisfactory level of paint relaxation is achieved using the larger nozzle on the Preservation Pencil at 40ºC and on minimum moisture setting: any moisture emitted by the Pencil at this temperature setting evaporates without affecting the paint surface. The nozzle is held close to the surface for 3-5 minutes, depending on the thickness of the paint and the level of distortion. Immediately following this process undiluted industrial methylated spirits (IMS) is injected behind the flake to pre-wet the void. IMS applied in this way does not cause surface blanching or adversely affect the adhesives effectiveness.

- *Adhesives* - A wide variety of natural and synthetic fixatives have been used in the past to re-establish adhesion between a paint layer and its support. Most of these have been found to have significant disadvantages, particularly in an uncontrolled environment. Our approach during this phase was to test appropriate fixatives known to have good ageing properties and that are least likely to be affected by variations in environmental conditions. The tests were to establish appropriate solution strengths and devise effective methods of application in these circumstances; rather than to test the properties of various fixatives.

  Trials were carried out using three adhesives:

  Plextol B500 - An acrylic dispersion and therefore water-based: its stability is good and it has appropriate handling properties. It is now widely used as a paint fixative on both wall paintings and panel paintings.

  Paraloid B72 - An acrylic resin dissolved in an organic solvent. Paraloid B72 is a methacraylate-based copolymer which through tests has been classed as one of the most stable synthetic resins available to conservators.

  Isinglass - This is a gelatin product derived from the collagen of fish bladders. It is a popular, traditional adhesive purer than gelatin and less prone to cross-linking and darkening. It has low surface tension and is therefore efficient at wetting out surfaces and flowing into fissures in the paint layer. Its disadvantages are that it is more prone to microbiological attack and becomes brittle at low RH levels. The addition of 1% honey improves flexibility.

  Tests using Paraloid B72 in xylene were generally unsatisfactory. Contact with the solvent alone did not relax the distorted paint flakes adequately; the use of heat in combination with a xlyene solution was discounted on health and safety grounds. In areas where the paint layer is relatively thin and the flakes less distorted Paraloid B72 tests were more successful. It was necessary first to inject a 10% solution to act as a pre-consolidant and to decrease absorbency of the wood: following a second application of the same solution the paint flakes were pressed back through tissue with a xylene swab. A considerable amount of the consolidant remained on the paint surface following re-attachment. As it was going to be necessary to treat closely grouped flakes individually, later potential difficulties in removing the excess consolidant, without weakening the adhesion between already re-adhered paint and support, appeared insurmountable.

Limited tests using isinglass were conducted before water had been identified as being the primary cause of surface blanching. Distorted paint flakes were relaxed using warm air and moisture from the Preservation Pencil. Different strength isinglass solutions were injected and the flakes pressed back into place with a damp swab through tissue. Isinglass proved to have good re-adhesion and handling properties but the paint surface blanched on drying so these tests were not continued. We found subsequently that it was the method of application rather than the isinglass itself that caused surface blanching.

Plextol B500 has .been identified as the most suitable material for re-adhering paint flakes on the nave ceiling. However, a different method is necessary for re-laying distorted paint flakes underlying thick glue deposits as described in the Glue Removal section below. Through testing we were able to identify an efficient method of applying the adhesive and pressing back the flakes that involved minimal contact of moisture with the paint surface. A 15% solution in deionised water is required when re-laying large, distorted flakes where the paint layer is relatively thick; a 10% solution is adequate for securing the small thinner flakes. Following paint relaxation and pre-wetting a very small droplets of the adhesive solution are injected, through a fine syringe needle, behind an individual paint flake. The flake is then pressed back into place with a small pad of dry cotton wool covered by Japanese tissue. The dry cotton wool immediately absorbs the majority of excess adhesive displaced as the flake is re-laid. The tissue is carefully peeled from the surface after the cotton wool is removed. Cleaning tests established that any residual adhesive on the surface following re-attachment by this method will not significantly impair subsequent removal of surface dirt.

Attempts to identify a method of re-attaching paint flaking as a result of contracting glue runs and to then remove the overlying glue were only partially successful. The glue has to be very soft before the underlying paint flake is relaxed enough to be re-laid. Unless practically all the glue is removed from the flake before it is eased back, whatever is used as an intervention layer when pressure is applied – whether tissue, melinex or silicone release paper – may stick to the surface and pulls the paint flake away.

The best results were obtained by carefully dabbing the area with a small piece of sponge to remove as much glue as possible; then, using the same sponge delicately easing the relaxed flake back into position. Injecting Plextol solution behind the flake was less successful than relying on residual animal glue alone as the adhesive. There is some risk of failure: if a flake detaches while the glue is being removed, any attempt to re-position it fails because the remaining surface glue sticks to the intervention layer. However, these tests were conducted on very distorted paint flakes: where the paint is only slightly cupped or lifted on one side there is little risk of loss.

6.3 Surface Cleaning

Hirst Conservation conducted extensive cleaning trials using solvent and water-based solutions as part of their 1995 survey and listed the results in their report. In the light of their findings we confined our tests to the use of deionised water, IMS, white spirit, and 'dry cleaning' techniques using soft brushes and Wischab sponges[13]. Neither IMS or white spirit were effective in removing the surface dirt layer; in fact a small amount of red pigment was moved by the white spirit. IMS/ deionised water proved to be no more effective than deionised water alone.

Before moisture was identified as the primary cause of surface blanching cleaning tests were carried out with deionised water at different temperatures applied by means of cotton wool swabs, a sponge and the Preservation Pencil: the surface dirt was removed adequately in all cases. Having found that

[13] Wischab sponges are cakes of synthetic rubber granules that collect the dirt and self-abrade when rubbed across a surface.

water caused the paint to blanch and identified which colours were susceptible, we ascertained that the duration of contact determined the level of blanching.

Soft brushes dislodged some surface dirt but at least 50% of the dirt layer remained in place. Cleaning tests with the Wischab sponges were particularly successful; the surface dirt is removed efficiently without affecting the paint layer. Although some of the earlier paint has a granular surface and appears to be powdery and lack cohesion this proved not to be the case. The surface coating of dust and dirt can be removed using a Wischab sponge without loss of pigment: obviously, any flaking paint must be re-attached first. A major advantage of this method is that no potentially harmful residues are left on the paint surface; the synthetic rubber granules are inert.

6.4 Glue Removal

Tests indicated that there is no alternative but to use water to remove the animal glue film. Solvents had no effect; heat, rather than having a softening effect, made the glue brittle and contract further. The glue is more easily removed using warm rather than cold water; although, on vulnerable colours the shorter contact time is not noticeably reflected by a lessening of surface blanch.

It appears that some of the paint surface was affected by the liquid glue before it dried. In one test area the off-white paint appears cleaner following glue removal than an adjacent area that had not been coated with glue but was intentionally cleaned with a warm water swab for a comparable time as a control.

Where the glue deposits are relatively thin and the underlying paint stable the glue is best removed using small, warm water (c.a. 55ºC) cotton wool swabs. This method is more precise than using the Preservation Pencil which may affect adjacent non-glue covered areas.

For the thick, raised droplets of glue, whether or not the underlying paint is flaking, it is necessary to use the Preservation Pencil on maximum moisture setting at 40ºC and gradually dab the dissolved glue away with a small sponge. Warm water on a cotton wool swab does not remove the thick runs or droplets completely, even when applied for a considerable period.

PART 7: CONSERVATION TREATMENT

In consultation with the architect and consultant conservator it was agreed that treatment during this phase should be confined to the painted boards within the key pattern border of the three designated lozenges: St Peter, St Paul and the Psaltery Player. The object being to re-lay and fix all flaking paint within the three lozenges to the extent that the re-attached decoration would withstand surface cleaning during subsequent phases of conservation. In addition we were instructed to secure temporarily any areas of loose or damaged boarding accessible from the scaffolding.

7.1 Re-attachment of Paint Flakes

The areas of flaking paint within the three lozenges are identified on diagrams in Part 9 of this report. The types of damage within the worst affected areas are marked on grey-scale photographs in Part 10. All flaking paint, other than that underlying thick glue deposits, was re-attached using a Plextol B500 solution as the adhesive and a technique devised during the testing phase to minimise water contact with the paint surface. Where possible the flakes were treated individually; although, areas micro-flaking and some interconnected larger flakes had to be re-laid in groups.

The initial process involved relaxing the distorted paint flake to a point where it could be eased back into place without fracturing. This degree of flexibility was achieved by applying a delicate jet of warm dry air from a Preservation Pencil, set at 40ºC and to minimum moisture output. The nozzle was held close to the surface for 3-5 minutes. Industrial Methylated Spirits (IMS) was injected behind the relaxed paint flake to pre-wet the void. The IMS was followed immediately by small droplets of the adhesive solution - a 10% or 15% solution of Plextol B500 in deionised water depending on the distortion and thickness of the paint. The flake was then eased back into place with a small pad of dry cotton wool through Japanese tissue: the dry cotton wool absorbed excess adhesive displaced as the flake was pressed back.

During the paint re-attachment process we noticed that the pre-wetting agent IMS and particularly the adhesive solution caused a dark yellow residue to exude from the wood support. Occasionally this left a tide-mark deposit on the paint surface around a re-laid flake. Tests showed that this deposit could be wiped from the paint surface without difficulty using an IMS swab even if left in place for some days. Samples of this residue were collected and are being analysed by Helen Howard.

7.2 Removal of Glue Film

For this emergency phase of treatment glue removal was confined to runs and droplets overlying flaking paint within the three designated lozenges. In fact, the St Peter lozenge had very few surface glue deposits and only one overlying flaking paint. The lower half of the Psaltery Player lozenge had the most extensive deposits as the glue was able to travel down the canted surface before drying. A considerable amount of glue had penetrated gaps between the St Paul boards forming raised droplets on the edges. In general, only where there were thick glue deposits had the underlying paint flaked.

Tests indicated that thin deposits of the glue film could be removed by swabbing with warm water. Raised droplets and thick runs overlying flaking paint would not be dissolved completely by this method; also, pressure applied when rubbing with a swab would be likely to dislodge paint flakes. It was necessary to use the Preservation Pencil on maximum moisture setting at 40ºC and gradually dab the dissolved glue away with a small sponge. Using the smaller of the two round-ended nozzles confined the spread of the moisture. This advantage is somewhat off-set as the moisture output is considerably reduced, thus slowing the process: the small area of paint surrounding the glue is subjected to less moisture but for a longer period.

Each paint flake was eased back into place with a small sponge once most of its overlying glue had been removed. The Plextol solution was inserted behind less distorted flakes but test had indicated that for the severely curled and lifted flakes better results would be achieved by relying on residual animal glue as the adhesive. A number of paint flakes with overlying glue were lost during this process but the majority were re-attached successfully.

7.3 Treatment of Support

Four small sections of loose, damaged boarding, two each within the St Peter and St Paul lozenges were considered too unstable to leave so they were temporarily secured during this phase. Each section of board has been secured with the smallest possible stainless steel screws placed through existing nail holes. The screws are fixed into added backing boards which appear to date from the 1840s work. Two 1in. No. 6 countersunk screws were used to secure the loose sections within the St Paul lozenge: one on the edge of the wave pattern board in section 27 II, the other within the red background beneath St Paul's feet. Within the St Peter lozenge a 1¼in. No. 8 round headed screw for a loose section including part of St Peter's right sleeve; a 1¼in. No. 6 countersunk screw with a small stainless steel washer to hold the edge of the fractured, point on the north end of the extended chevron pattern board.

These fixings are intended as a temporary holding measure. When this section of the nave ceiling is next treated, as part of the proposed phased conservation programme, this type of damage will be secured with fixings inserted from the roof space above.

PART 8: RECOMMENDATIONS FOR FUTURE TREATMENT

The technical analysis completed by Helen Howard and Adrian Heritage, the tests carried out as a preliminary to this phase and the experience gained from completing the emergency treatment has added considerably to the knowledge gained from previous surveys and investigations. This additional information relates mainly to aspects of the painted decoration rather than the structure of the nave ceiling. We do not have sufficient expertise within the Partnership to suggest specific structural interventions: if invited to tender for the proposed programme of conservation, we would seek to collaborate with conservators familiar with the treatment of structural timbers as well as fine panelling and other decorative woodwork.

8.1 Hessian Covering Layer

In their 1995 report Hirst Conservation suggest the hessian on the reverse of the painted boards should be removed to facilitate a full examination and to allow fixing and consolidation works. In our opinion, removing the hessian layer would be an unwarrantable intervention unless there is clear evidence either that the layer is deteriorating or that it is causing the ceiling boards to deteriorate. We accept that hessian and animal glue are potentially more unstable than the recommended replacement (polyester sailcloth and Beva 371). However, the present covering has been in place since 1924 and we found no visible evidence of deterioration during an admittedly superficial inspection of the sections covering the St Peter, St Paul and Psaltery Player lozenges. At present the hessian is adding to the stability of the ceiling; removing it may disrupt and exacerbate splits in the boards. The only way to remove the layer would be to use steam to soften the adhesive: even then significant deposits of animal glue would remain on the reverse of the ceiling boards. The process would introduce a considerable amount of moisture into the roof space above the nave for long periods of each year throughout the phased programme, risking insect attack and microbiological growth. In addition, it has now been established that the paint layer on the underside of these boards is particularly water sensitive.

We demonstrated to ourselves that it is possible to locate individual fixings using graphics similar to those in Appendix 1 of this report. Small cuts could be made through the hessian covering for access to existing fixings and to facilitate the accurate placement of additional fixings. In some areas, such as where it is considered necessary to reposition displaced boards there may be no alternative but to remove a section of the hessian: in those instances the 1920s covering should be replaced with an appropriate alternative such as polyester sailcloth and Beva 371.

8.2 Treatment of Ceiling Boards

As stated above we would work in co-operation with specialist conservators for this aspect of the treatment. It will be necessary to determine whether or not existing nails and screws are actively corroding and if they continue to restrict movement, causing the ceiling boards to split. Also, to assess whether corroded and protruding fixing may be removed without damage to the panels. Aesthetic considerations are not as important in this instance since the protruding fixings are too small to be distracting from ground level. Other treatment options regarding the replacement and insertion of additional fixings, the treatment of deteriorated and damaged wood as well as the

replacement of missing sections of board must be evaluated and an approach defined before treatment commences.

8.3 Treatment of the Paint Layer

- *Surface cleaning* - Our tests have shown that cleaning with Wischab sponges will produce good results. This 'dry' method is preferred for a number of reasons: solvent-based solutions are ineffective in this instance; much of the paint surface blanches after contact with moisture; the majority of the paint is stable and will withstand the gentle surface abrasion necessary without preliminary consolidation; no potentially harmful residues will be left on the paint surface; it will be possible to achieve an uniform level of cleaning overall the ceiling without difficulty.

- *Staining* - We carried out no specific tests for the removal staining. The stains result from unidentified substances seeping through the ceiling boards as well as penetrating gaps between the boards. Removing these stains is likely to prove difficult if not impossible: the full thickness of paint is affected in the majority of cases. Stains that remain visually unacceptable after treatment could be disguised with overpaint.

- *Re-attachment of flaking paint* - The methods and materials used for the re-attachment of flaking paint within the St Peter, St Paul and Psaltery Player lozenges will be appropriate for all other similarly affected areas of the nave ceiling.

- *Consolidation of the paint layer* - No areas of powdering pigment were identified within the sections accessible during the emergency treatment; however, in their report Hirst Conservation state that some areas may be too fragile to clean without first consolidating. Where it is necessary to restore paint cohesion. the choice of consolidant will depend on the affected paint medium.

- *Removal of glue film* - This process will form a major part of the phased conservation programme. Only the raised droplets and thickest runs on the surface have contracted and caused the underlying paint to flake: these deposits should be removed using a Preservation Pencil and sponge as described in the previous section of this report. The thinner glue deposits are much more widespread particularly on the canted north and south sides. At present these are noticeable only when light is reflected off the shiny surface; but, because dirt is trapped by the glue, the film will become more evident after the paint surface is cleaned with Wischab sponges. Tests have shown that subsequent glue removal, using warm water on cotton wool swabs, leaves the treated areas noticeably 'cleaner' than their surroundings and causes some of the paint to blanch. It will be necessary to disguise this effect with water-colour paints.

- *Removal of overpaint* - Some of the previous repainting is crudely done and appears not to do justice to the original scheme; nonetheless, it should be preserved. Removing overpaint would constitute a major intervention. There would be a risk of damage to underlying layers and no guarantee that what the layer exposed will be visually coherent and more acceptable.

- *Reintegration*- It will be important to define a policy for this aspect of treatment during phase one of the proposed programme. This should specify the technique, materials and extent of inpainting required to existing paint losses and replacement timber: similarly, for disguising stains and toning in 'cleaner' areas after glue removal.

- *Surface coating* - There is no justification applying a surface coating and a number of reasons for not doing so. The present layer of surface dirt can be efficiently removed without damage to the 'unprotected' paint using Wischab sponges. It is safe to assume that future accretions of dirt may be removed in a similar fashion. The ceiling will always be vulnerable should water penetrate the nave roof. A surface coating may hinder the drying out process, exacerbate any damage and

impede remedial treatment. The solvents required to remove even a stable coating, such as Paraloid B72 may damage the paint.

8.4 Documentation

- *Technical analysis* - It became evident during the emergency phase that photography, use of a video microscope and the taking of paint samples will not possible while there is other activity on the scaffold. The programme must allow sufficient time for these processes and other aspects of the condition survey for each section to be completed before treatment is initiated.

- *Documentation* - Presumably Adrian Heritage will wish to establish standard formats for recording all aspects of the phased conservation programme: reference numbers, graphics, notations, photography etc.. This would apply to both source material and report presentation. Specific examples of the required formats should be made available at the tendering stage. There was not time between Adrian's appointment as documentation consultant and the start of the emergency treatment for him to draw up these requirements. The graphics and grey-scale photographs used to record information for this condition survey and conservation record were limited by the computer equipment available to us at the time the information was recorded. We have recently acquired a more powerful computer, flatbed scanner and slide scanner. This equipment will enable us to produce clearer and more accurate documentation for considerably less cost.

- *Photography* - Are the photographs taken during the photogrammetric survey adequate for reference as part of the preliminary condition survey? Adrian Heritage said he would visit the Photogrammetric Unit to inspect enlargements. If not additional photographs should be taken either before the access scaffolding is put in place for each phase; or, from the scaffold before it reaches its full height.

8.5 Scaffolding

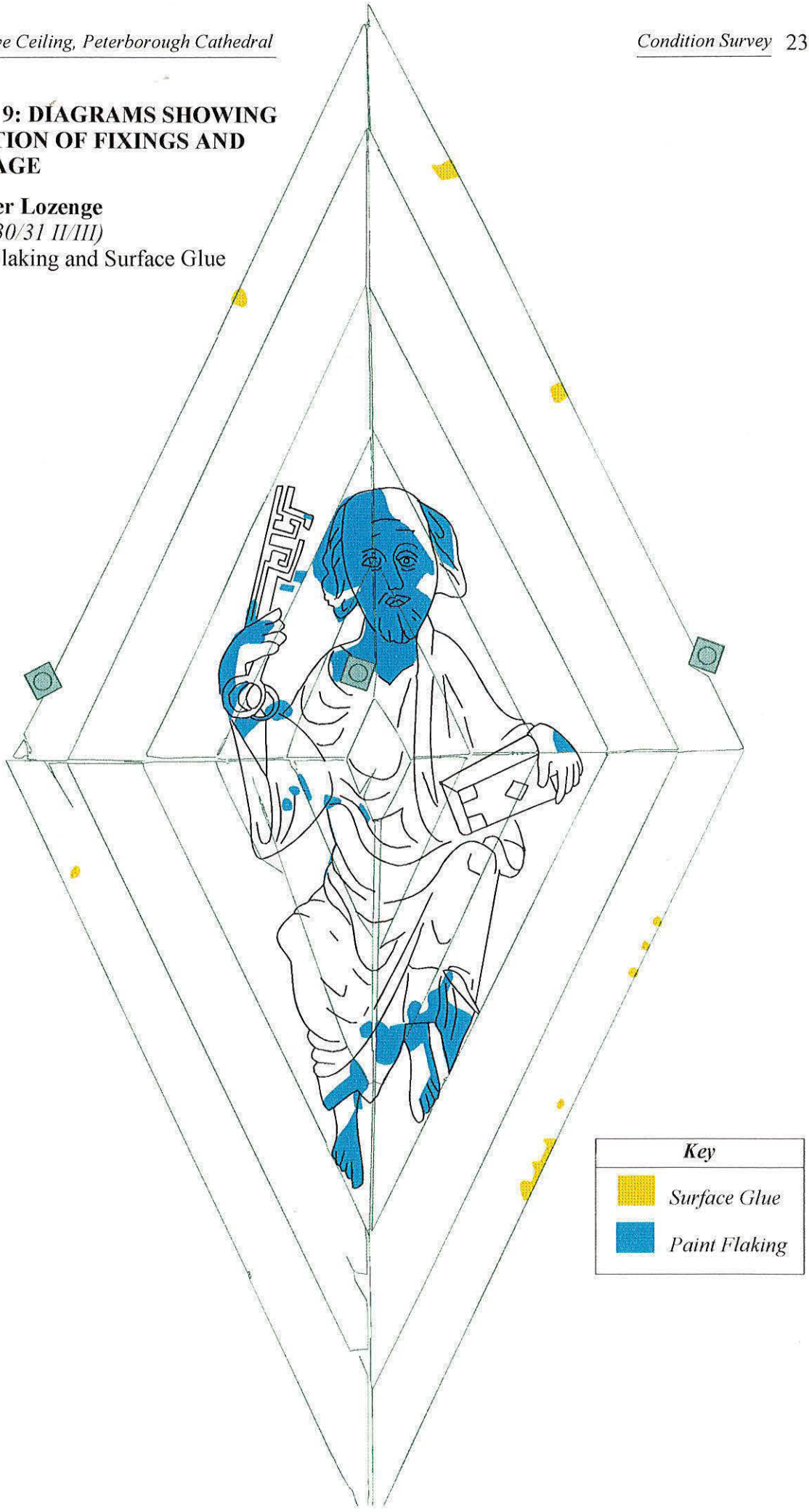
The scaffolding arrangements for the emergency phase afforded comfortable access to the horizontal and canted sections of the ceiling. The same design should be used in future. Covering the boards with the two layers of hardboard is particularly important: even more so if the paint surface is to be cleaned with Wischab sponges. These wear down quickly, shedding quantities of rubber granules small enough to fall through the safety netting: for this reason, scaffold boards on the two lower lifts (providing access to the canted sides) should be similarly covered.

PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

1. St Peter Lozenge

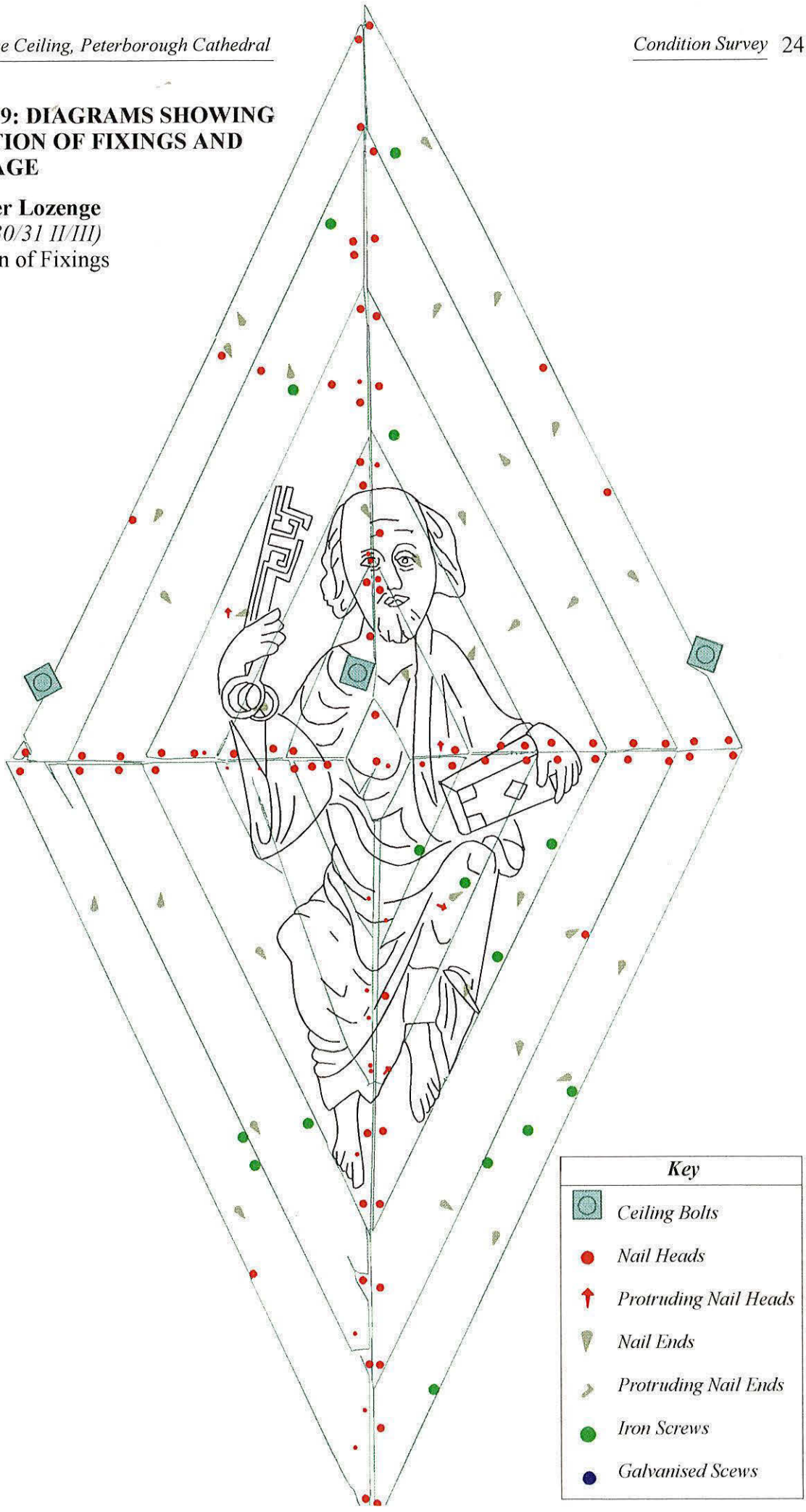
(Ref: 30/31 II/III)

Paint Flaking and Surface Glue



PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

2. St Peter Lozenge
(Ref: 30/31 II/III)
Position of Fixings

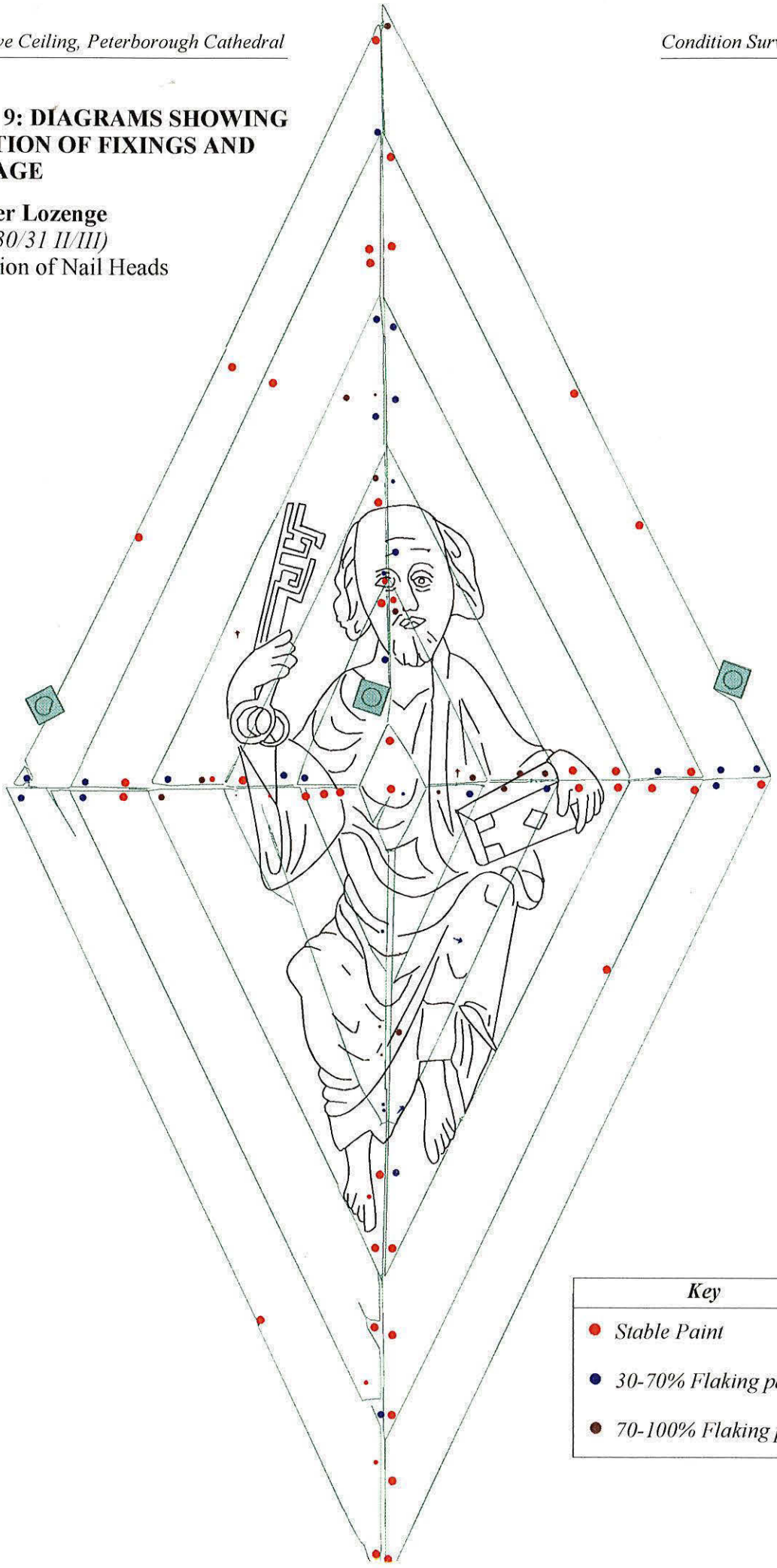


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

3. St Peter Lozenge

(Ref: 30/31 II/III)

Condition of Nail Heads

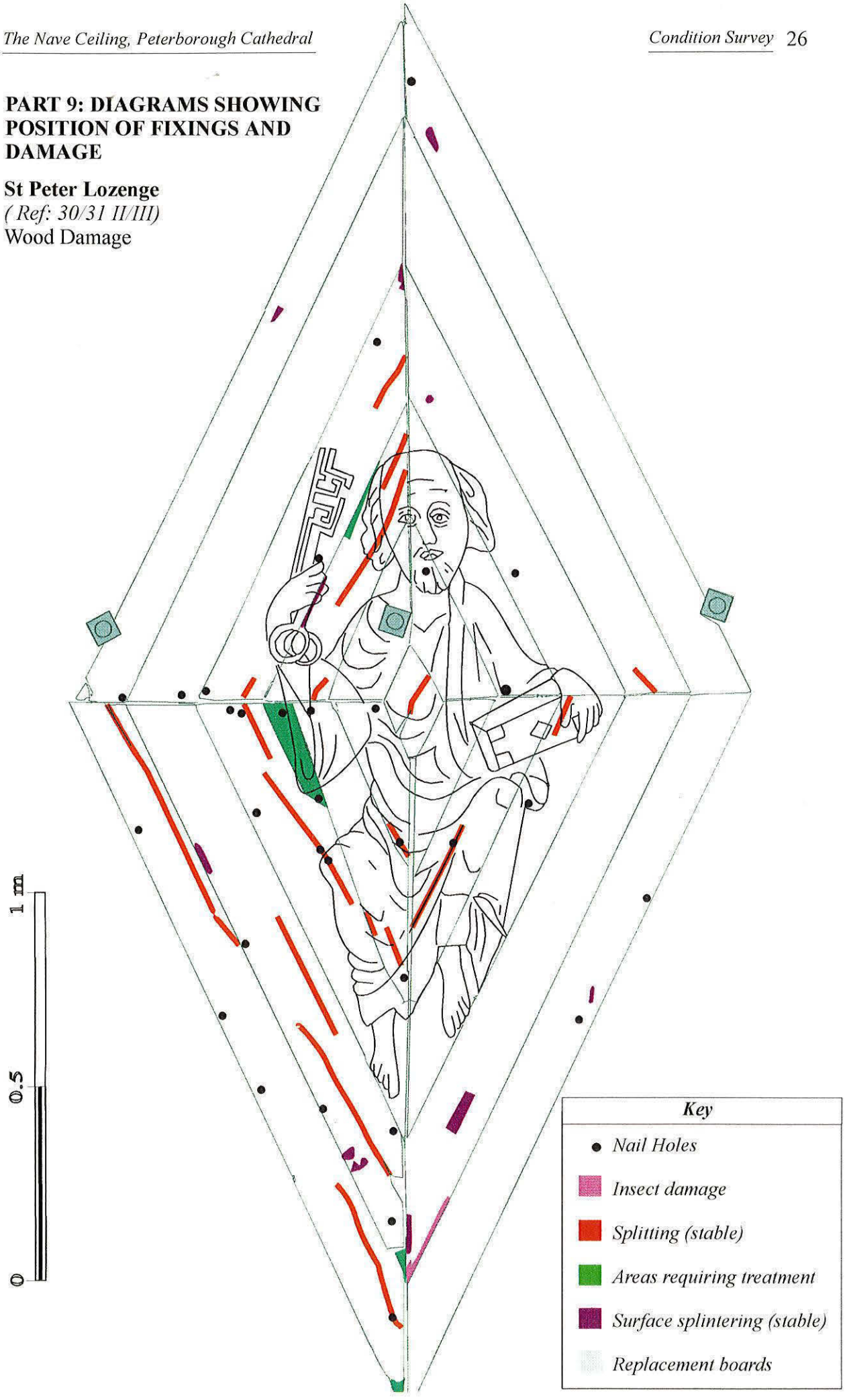


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

4. St Peter Lozenge

(Ref: 30/31 II/III)

Wood Damage

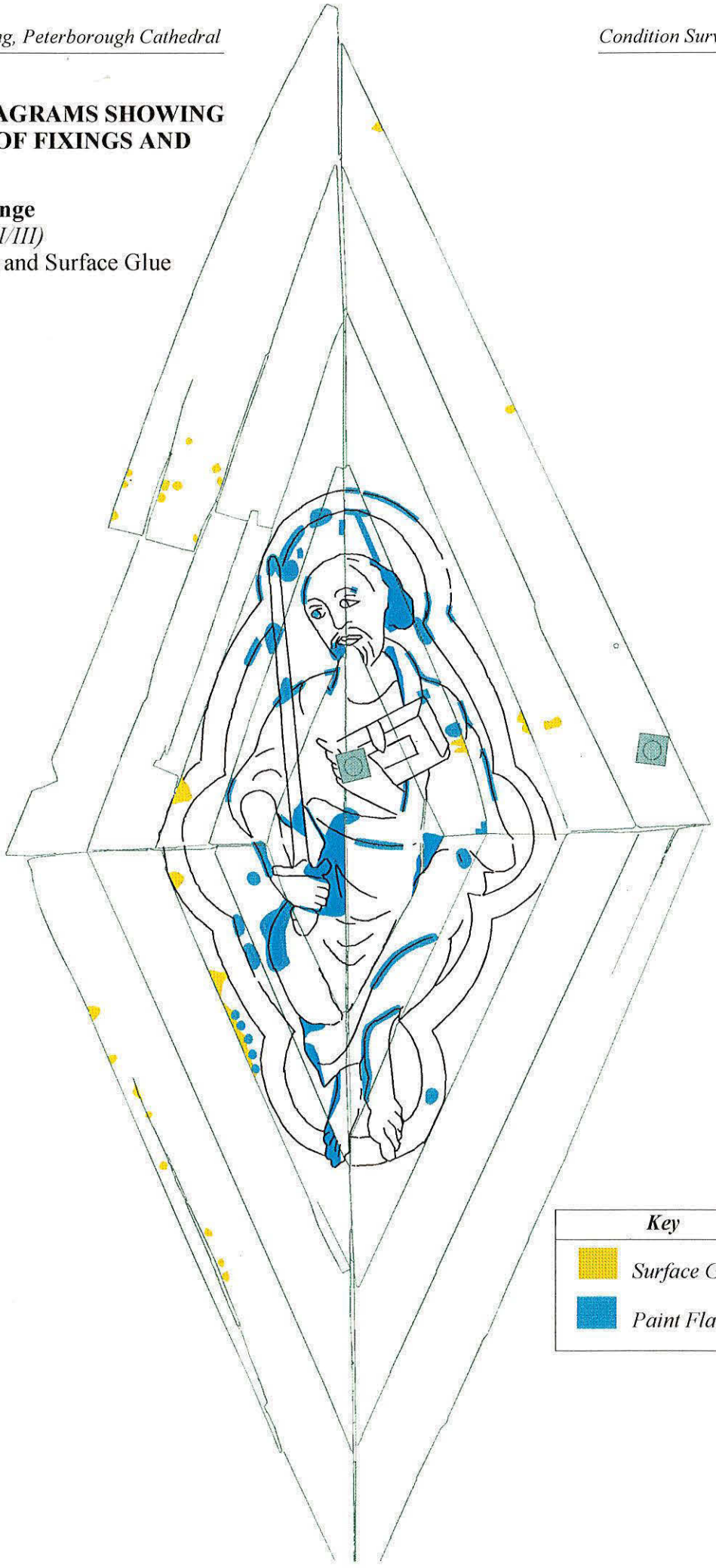


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

5. St Paul Lozenge

(Ref: 26/27 II/III)

Paint Flaking and Surface Glue

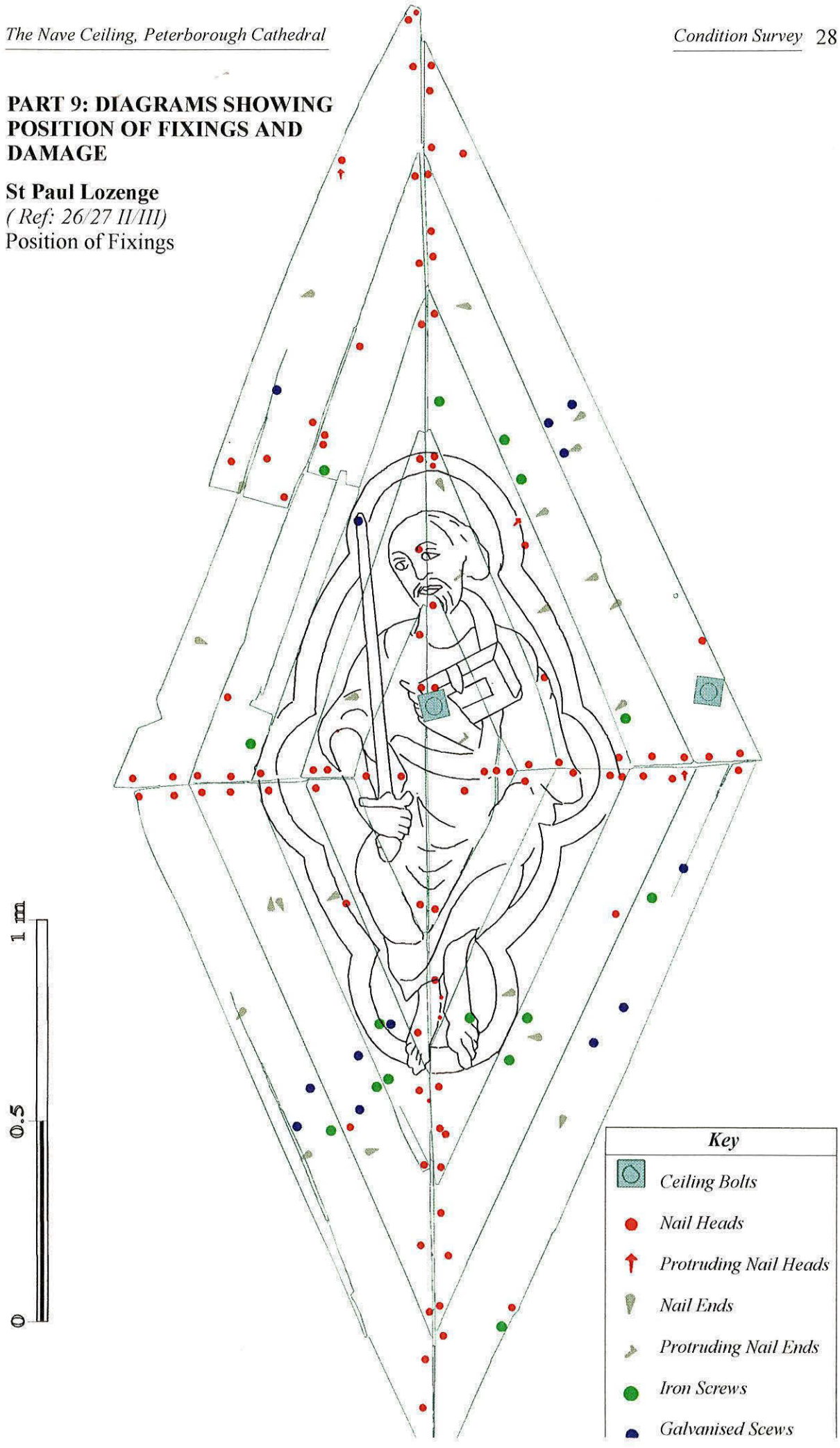


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

6. St Paul Lozenge

(Ref: 26/27 II/III)

Position of Fixings

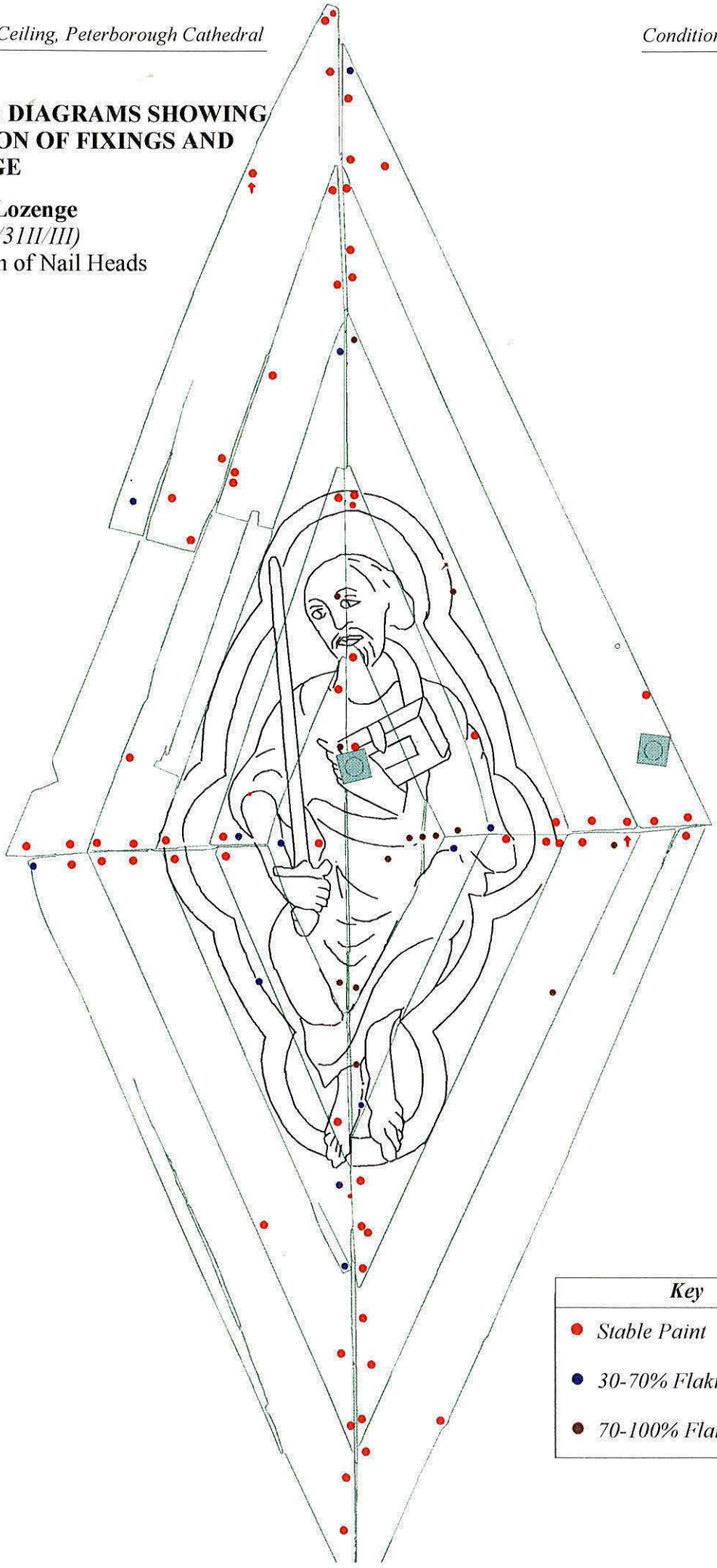


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

7. St Paul Lozenge

(Ref: 30/31II/III)

Condition of Nail Heads

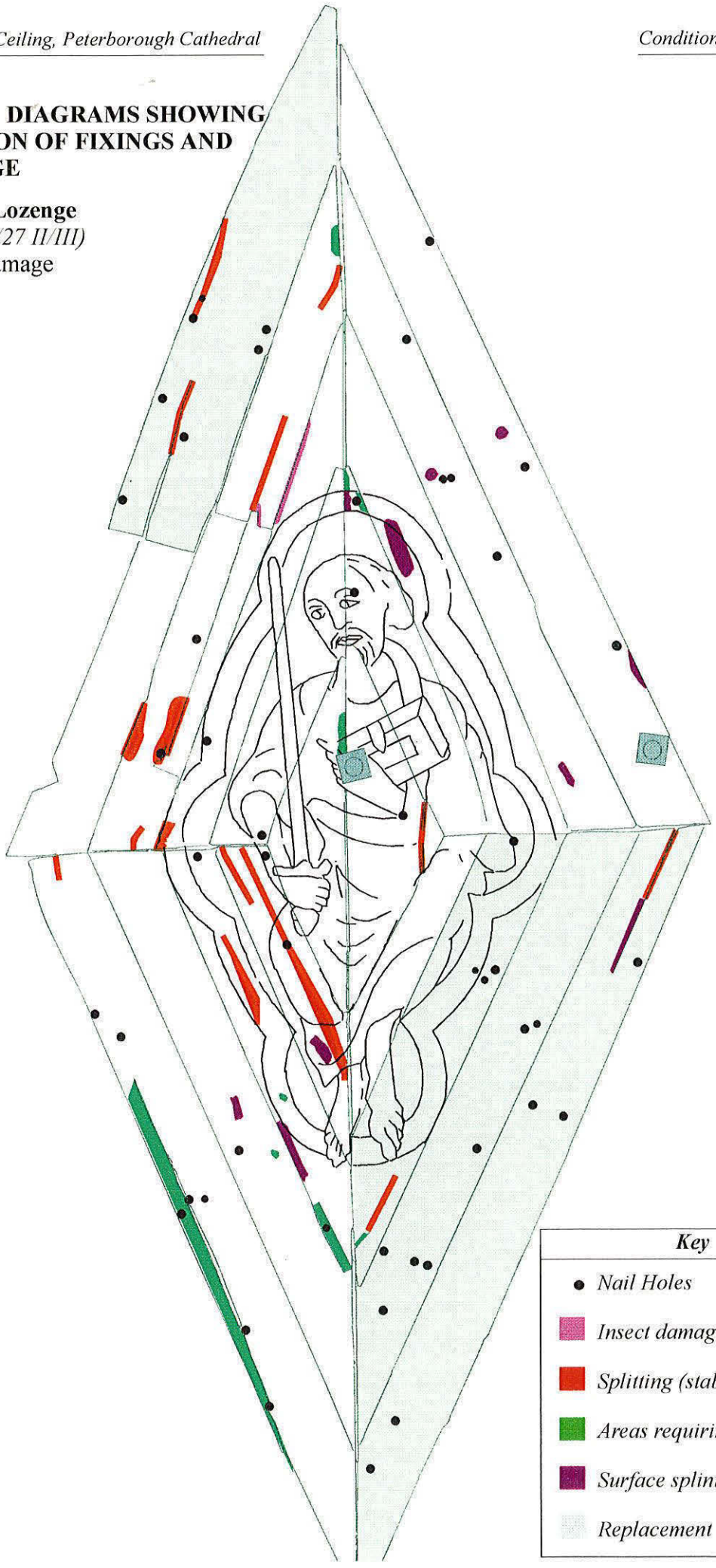


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

8. St Paul Lozenge

(Ref: 26/27 II/III)

Wood Damage

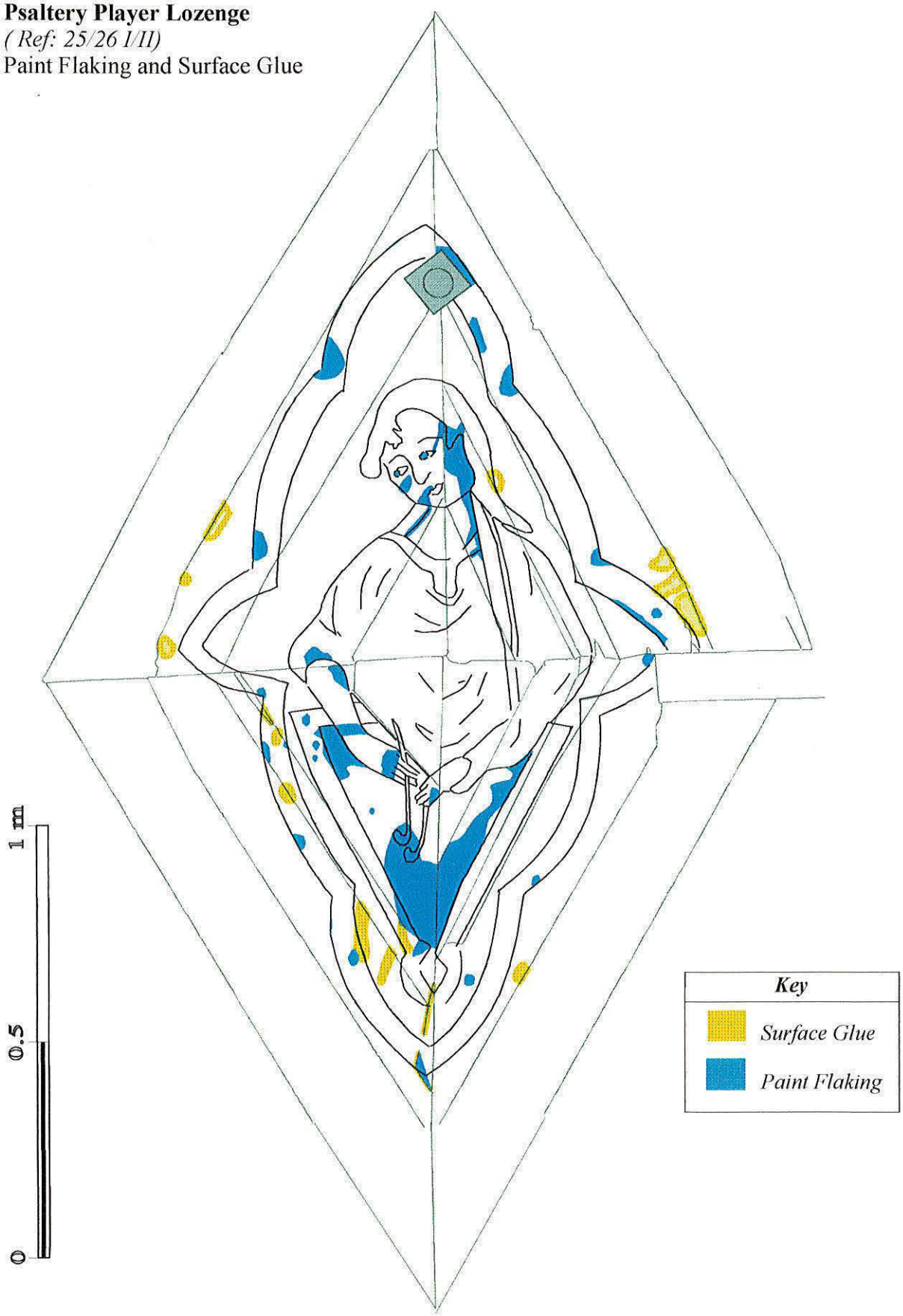


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

9. Psaltery Player Lozenge

(Ref: 25/26 I/II)

Paint Flaking and Surface Glue

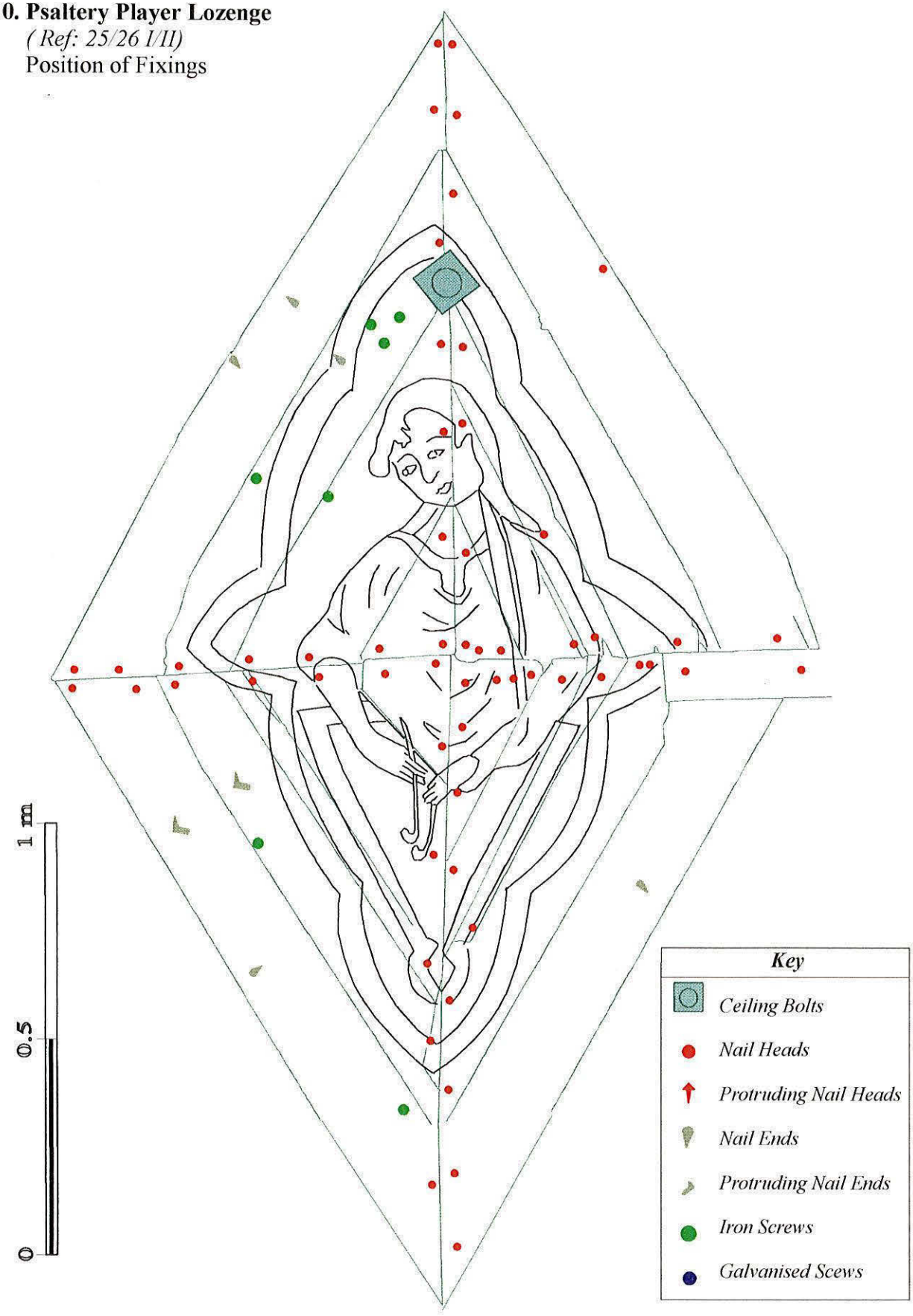


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

10. Psaltery Player Lozenge

(Ref: 25/26 I/II)

Position of Fixings

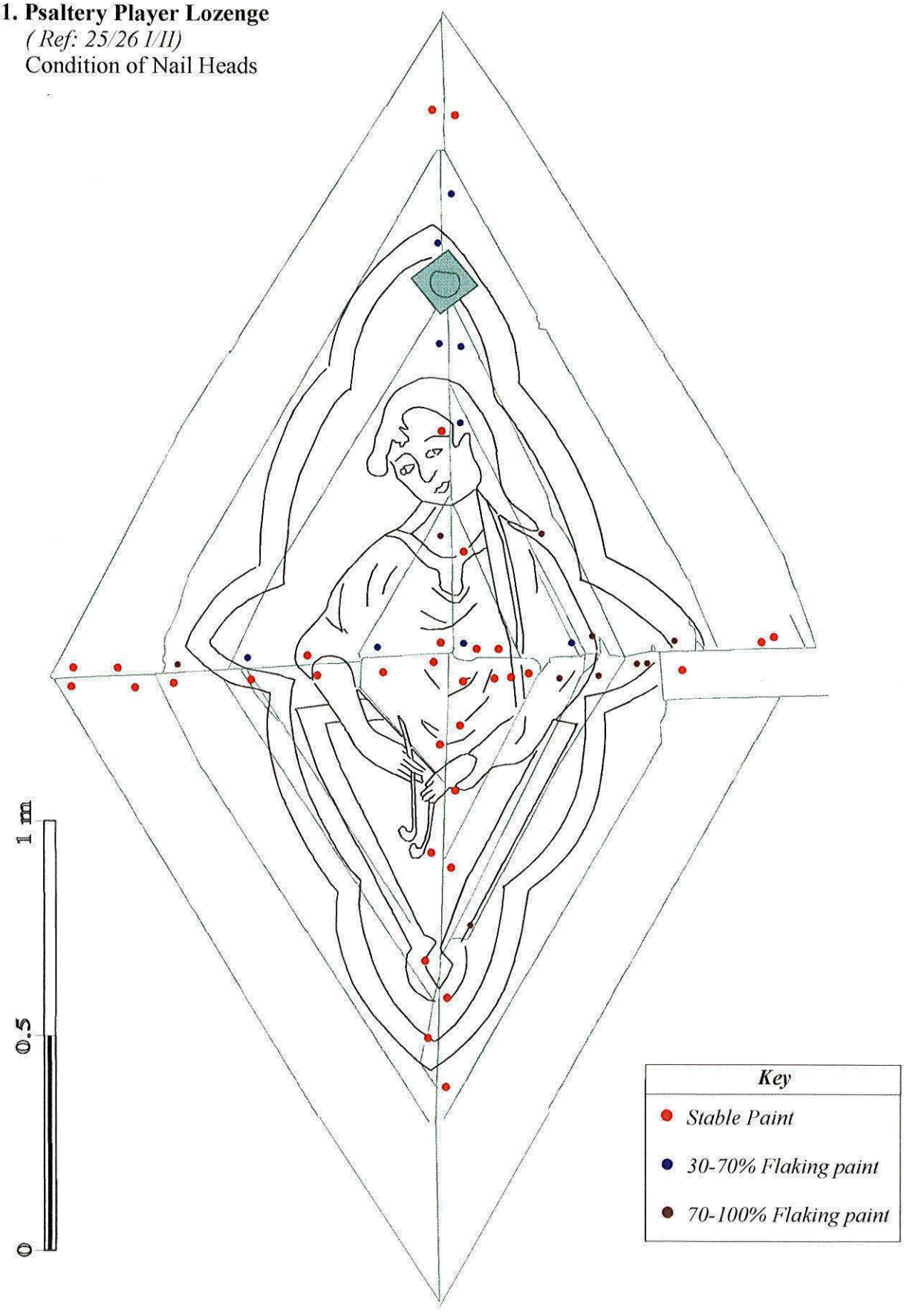


PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

11. Psaltery Player Lozenge

(Ref: 25/26 I/II)

Condition of Nail Heads



PART 9: DIAGRAMS SHOWING POSITION OF FIXINGS AND DAMAGE

12. Psaltery Player Lozenge

(Ref: 25/26 I/II)

Wood Damage

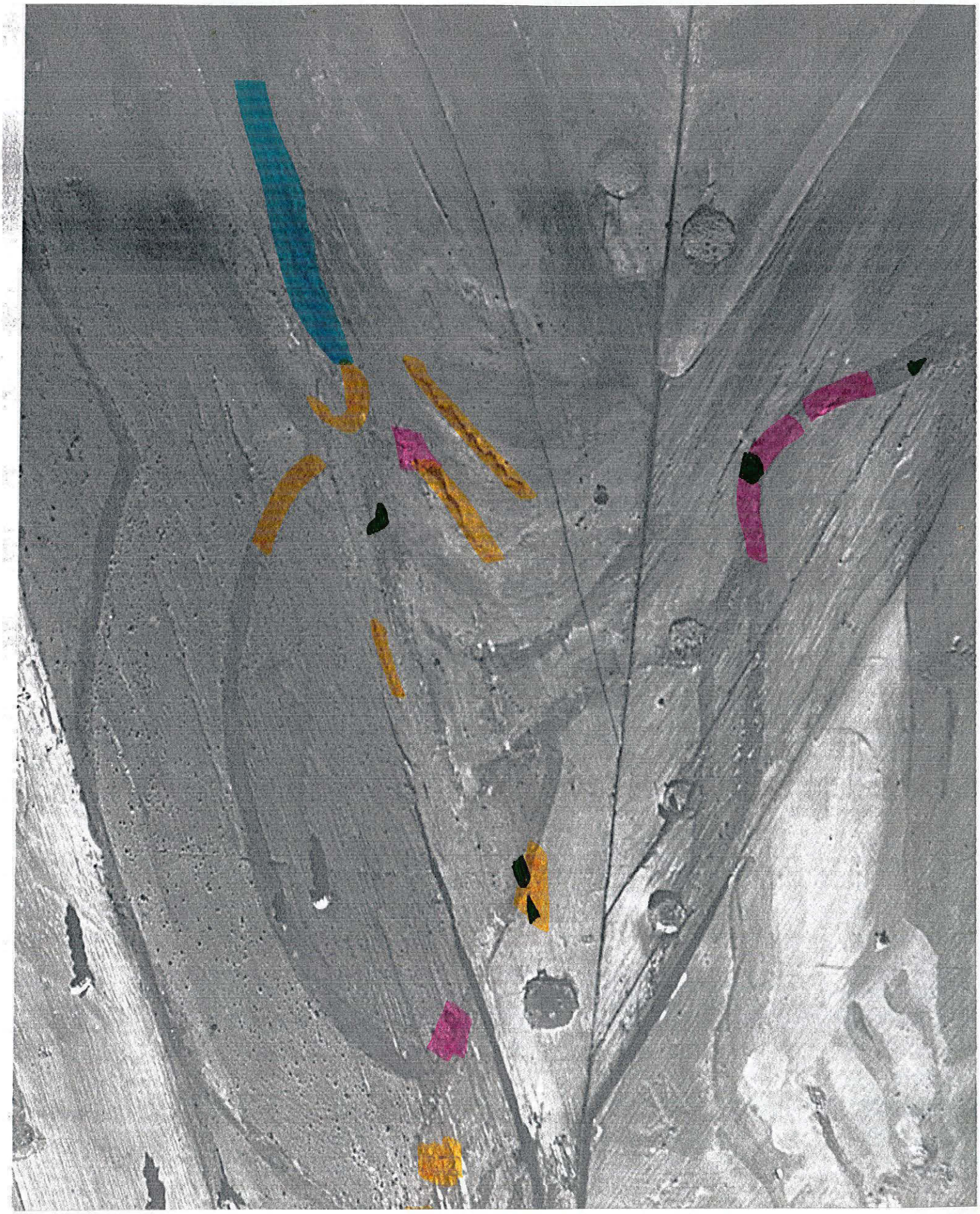

Delaminating
Curling
Scrolling
Microscrolling(min. resolution: 5mm x 5mm)
Areas of Loss
Repainted Loss

Delaminating Curling Scrolling Microscrolling(min. resolution: 5mm x 5mm) Areas of Loss Repainted Loss

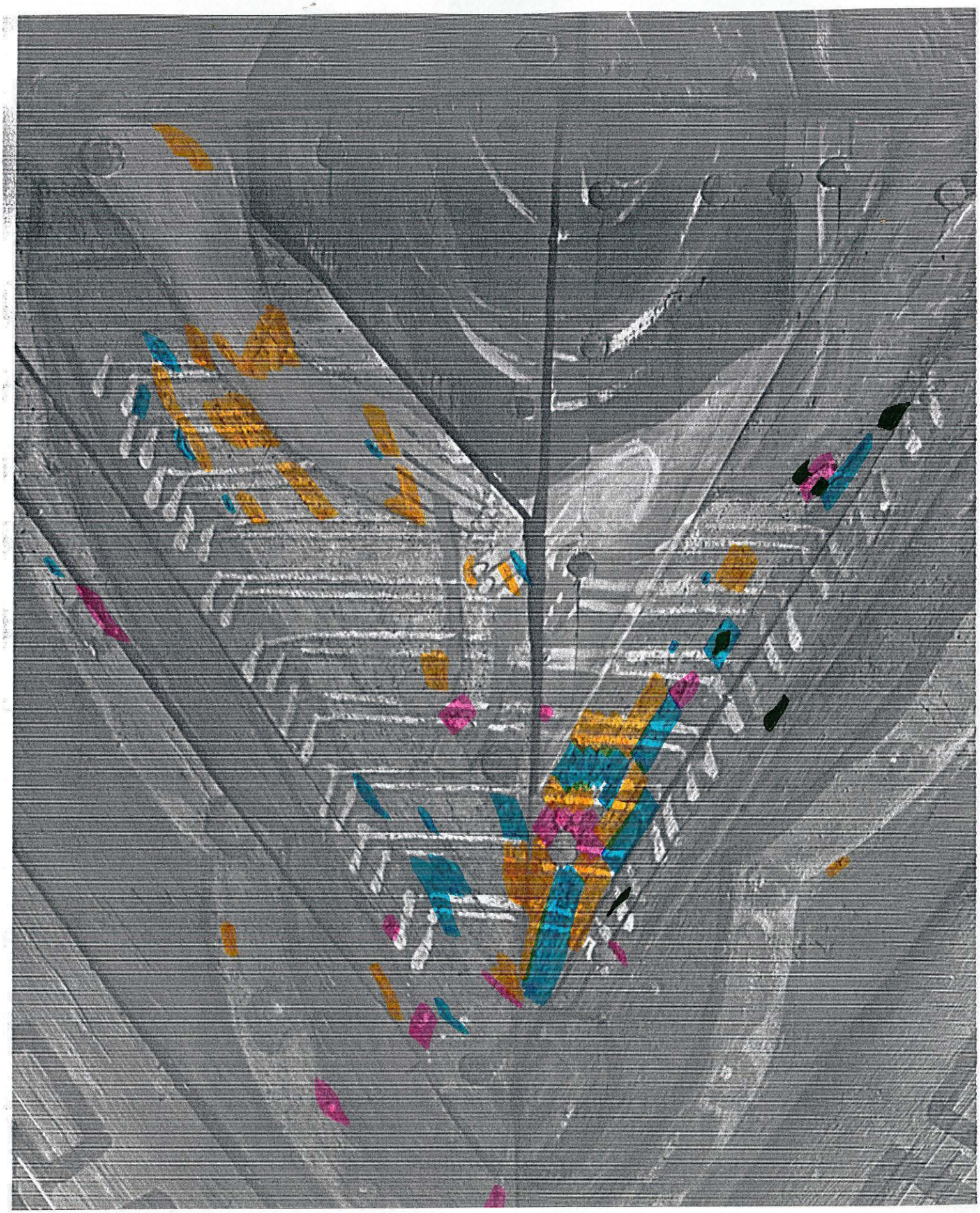

Delaminating
Curling
Scrolling
Microscrolling
Areas of Loss
Repainted Loss
(min. resolution: 5mm x 5mm)

Delaminating Curling Scrolling Microscrolling(min. resolution: 5mm x 5mm) Areas of Loss Repainted Loss

Delaminating Curling Scrolling Microscrolling(min. resolution: 5mm x 5mm) Areas of Loss Repainted Loss


Delaminating
Curling
Scrolling
Microscrolling
Areas of Loss
Repainted Loss
(min. resolution: 5mm x 5mm)

Delaminating Curling Scrolling Microscrolling(min. resolution: 5mm x 5mm) Areas of Loss Repainted Loss



Delaminating Curling Scrolling Microscrolling(min. resolution: 5mm x 5mm) Areas of Loss Repainted Loss

REFERENCES

Articles and Books

C.J.P. Cave & Prof.T. Borenias (1938)	The Painted Ceiling in the Nave of Peterborough Cathedral.
Leslie T. Moore ARIBA, (21 Nov.1923)	Peterborough Cathedral Roof and its Repair: The Architects Journal Vol:58 No.1507.
Professor E W Tristram, (1944)	English Medieval Wall Paintings: The Twelfth Century
Jack Higham (1995)	The Painted Wooden Ceiling of Peterborough Cathedral.
Gov.Pownall (6, 13 March and 3 April 1788)	Observations on Ancient Painting in England: in a letter to Rev. Michael Lort.
Folke Nordstrom (1955)	Peterborough Lincoln and the Science of Robert Grosse tests: A Study in 13th century Architecture and Iconography in Art Bulletin Vol.37.
J.L. Cartwright (Sept.1968)	The Painted Ceiling: Friends Journal.
Britton (1828)	The History and Antiquities of the Abbey and Cathedral Church of Peterborough.
Mackreth (1994)	Abbot Benedict and Candebury: Friends of Peterborough Cathedral p. 4-9.
Rickert (1954)	Painting in Britain, The Middle Ages: Pelican History of Art.
VCH (1906)	A History of Northamptonshire Vol. 2.
Willis (1730)	A Survey of the Cathedrals of Lincoln, Ely, Oxford and Peterborough.
Cobb, Gerald (1980)	English Cathedrals - The Forgotten Centuries.
Dean (1984)	Architecture at Peterborough in the 13th Century: J. Brit Archaeology Association 137, 114-129.
King E.J. (1973)	The Estate of Peterborough Abbey 1086-1310: C.U.P..
Pevsner N. & Metcalf P (1985)	The Cathedrals of England: Harmondsworth.
Winkley B. (1838)	Illustration of the Cathedral Churches of England and Wales.
Moore L.T. (1925)	Peterborough Cathedral Roof and it's Repair.

Reports

Eve Baker (8 Aug.1977)	Peterborough Cathedral.
Wolfgang Gartner (May 1988)	Peterborough Cathedral, Painted Ceiling - Nave, Inspection Report.
Barry Knight (Dec.1994)	Peterborough Cathedral: Pollution Test.
J. Limentani (28 Dec.1994)	Peterborough Cathedral Nave Ceiling, Report to Dean and Chapter on what has been done and the next steps.
Gavin Simpson MA (May 1995)	Peterborough Cathedral Proposals for Archaeological Survey and Dating of the Nave Roof and Ceiling.

D.F. Mackreth (Revision 1 Jun.1995)	Peterborough Cathedral Nave Roof and Ceiling: Preliminary Comments.
English Heritage (10 Jan.-4 Apr.1995)	Peterborough Cathedral. Environmental Monitoring.
English Heritage (5 Apr-13 Jun.1995)	Peterborough Cathedral. Environmental Monitoring.
English Heritage (20 Sept.-1 Nov. 1995)	Peterborough Cathedral. Environmental Monitoring.
English Heritage (2 Nov.1995-31 Jun.1996)	Peterborough Cathedral. Environmental Monitoring.
English Heritage (1 Feb.-26 Jun.1996)	Peterborough Cathedral. Environmental Monitoring.
Hirst Conservation (Oct.1995)	Peterborough Cathedral. Nave Ceiling Vol.1.
Hirst Conservation (Oct.1995)	Peterborough Cathedral. Nave Ceiling Part 1. Photographs.
Hirst Conservation (Oct.1995)	Peterborough Cathedral. Nave Ceiling Part 2. Photographs.
J. Limentani (5 Dec.1995)	Peterborough Cathedral. Nave Ceiling: Report on progress of the monitoring and investigation.
David Starley (Jan. 1996)	'I'he Examination of the Nails from Peterborough Cathedral: English Heritage AML.
J. Limentani (19 Feb. 1996)	Peterborough Cathedral Nave Ceiling – Report following the examination of the Ceiling from a Mechanical Hoist.
Gillian Lewis (Feb 1996)	Peterborough Cathedral Nave Ceiling: Updated Condition Notes.
J. Limentani (8 Mar.1996 rev. 16 Sep.1996)	Peterborough Cathedral: Nave Ceiling: A Method Statement of the Proposed Repairs.
Gillian Lewis (Sept. 1996)	Peterborough Cathedral: Nave Ceiling Urgent Work.
J. Limentani (Nov.1996)	Peterborough Cathedral Nave Ceiling Outline of proposals for it's Restoration and Conservation.
Don Mackreth (Feb.1997)	The Medieval Nave Roof and Ceiling of Peterborough Cathedral.
J. Limentani (30 Aug.1995)	General requirements for Contractors and Sub-contractors working on Cathedral premises.
J. Limentani (6 Dec.1996)	Scaffolding to carry out minor works to two areas of the Nave ceiling.
J. Limentani (18 Dec.1996)	Urgent works to re-secure flaking paint.
H. Howard (Sept.1997)	Peterborough Cathedral, nave ceiling: Scientific examination of the original decoration.

APPENDIX 1

TESTS

PAINT RE-ATTACHMENT

Materials available: Plextol B500; Primal AC33; Paraloid B72 in xylene and acetone; Isinglass (5g/water 200ml=original solution); Beeswax (25g/white spirit 125ml); Dammar (50g/white spirit 250ml); Cosmoloid 80 (25g/white spirit 125ml).

Method Statement

Agreed with Gillian Lewis that the aim of this treatment is to relay & re-fix the flaking paint to the extent that the consolidated areas may be cleaned during the next phase of treatment.
It appears that a 15% solution of Plextol B500 should be used on the thicker paint of flesh tones. A 10% solution will adequate for the thinner paint (black lines and green). The Preservation Pencil should be applied for 4-5 mins at 40ºC at minimum moisture setting. The consolidant is then injected behind the flake and the flake is pressed back with a damp cotton wool pad through tissue. The area is then dabbed in the same manner to ensure consolidant is removed from the surface. We will not clean the surface dirt at this stage.

Suitability of materials:
Article on Isinglass suggests that it becomes brittle at 55?% RH. Environmental monitoring by English Heritage has indicated a mean RH at the ceiling of 46.95% (4/95).
There is already evidence of possible MBG (microbiological growth).
There is the possibility of steam treatments being used to remove hessian above.

Wax-based consolidants dismissed for usual reasons - effected by heat; dryness; moisture; surface effects on the paint layer: visual & physical.

Some concern expressed over the possibility of cleaning after treating with Paraloid.
Consolidation tests also showed some darkening of the paint layer.

Plextol & Primal considered to be most applicable materials in these circumstances: user-friendly; relatively easy to remove excess; ability to clean after treatment; no visible effect on the surface; Primal is a Class A material (Adrian Heritage to find out why Plextol is not, as it has superseded Primal). Data sheets give Plextol as 50% solids; Primal is 48%.

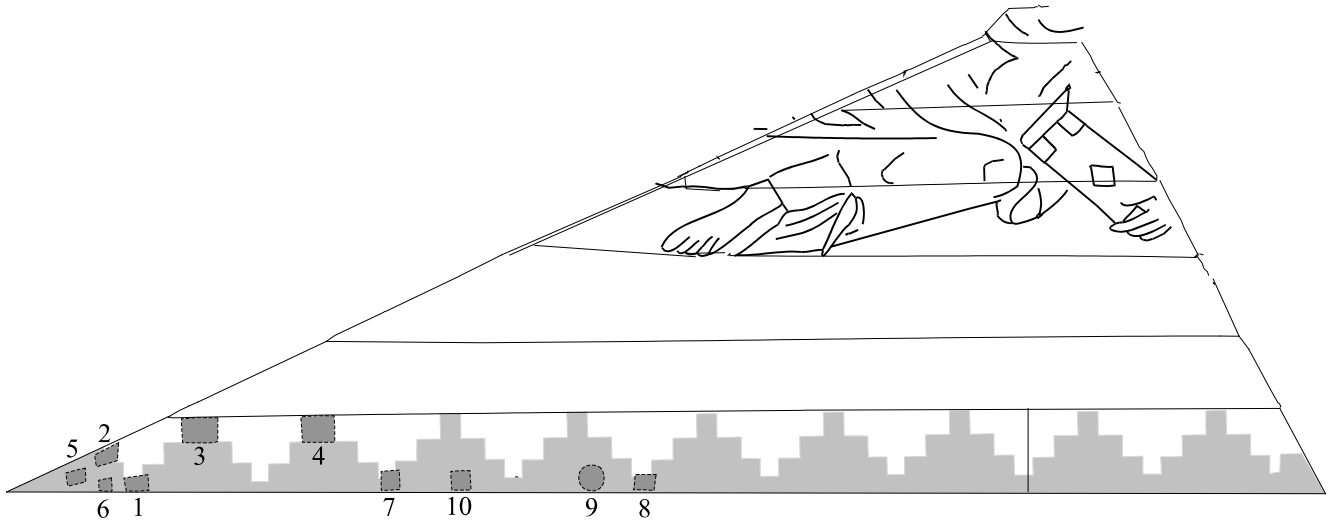
PAINT RELAXATION

Methods of treatment
Variety & extremes of distortion of flaking require the flakes to be relaxed prior to any consolidation. Preservation Pencil (PP) used to deliver gentle heat & moisture to the flakes; also acts as a pre-wetting agent.

Initial testing with Preservation Pencil
Heat levels: at 80ºC+ the surrounding paint layer showed unacceptable blanching; gradually reduced heat to 40ºC at which point relaxation or glue softening took place without adversely affecting the paint layer. Lower temp. Were tried but it was found that the lower the temp. the longer the PP had to be in use, thereby increasing the amount of moisture & possibly risking blanching. PP at 30ºC has no apparent effect on paint layer, but 40ºC does. There seems to be a vast difference between the 2 temps. Perhaps try 35ºC?????
Moisture levels: tests carried out at a variety of moisture settings to establish the optimum (i.e. minimum) amount of moisture required to aid flake relaxation. A setting of 2 (on a notional scale of 1-10) was found most effective.
Nozzle size: when the smallest nozzle was used it was found that the decreased opening inhibited the regular flow of moisture, causing pressure to build up and the moisture to escape through gaps in the humidifier, rather than at the point of delivery.
The medium nozzle allowed free flow of the mist. The fan-shaped nozzle was dismissed because of the wide field of delivery.

1. CLEANING AND PAINT RE-ATTACHMENT

St Peter *(Ref. 31/II)*



Cleaning

Test	Materials & Methods	Results
1	Deionised water on a cotton wool swab	Removes surface dirt, some initial agitation required
2	IMS/deionised water 1:1 swab	As 1, but acts quicker & needs less agitation
3	Wischab sponge	Removes surface dirt well with minimal rubbing; good for stable areas
4	Deionised water sponged through Japanese tissue	Minimal surface dirt removal

Paint Re-attachment

Test	Materials & Methods	Results
5	Pre-wet with IMS; Plextol 10% injected behind flake, pushed back with damp swab through tissue. Excess consolidant removed by wiping with damp swab	Minimal re-adhesion. The Plextol was too readily absorbed by the wood support. May have to consider pre-consolidation to inhibit porosity of support
5a	Flake pushed back again after 15 mins.	Stuck back well initially, but then loosened slightly
5b	Plextol 10% reapplied as above	Support porosity still such that the flake did not totally re-adhere
6	Plextol brushed on to very small square & left on surface to act as a visual control for consolidant removal	Very slight surface darkening; no shine. Quickly absorbed by wood
7	Paraloid B72 10% in xylene injected to relax flake	Some apparent relaxation achieved
7a	Paraloid (as in 7) reapplied after 30 mins & pushed back	A fracture was heard but flake appeared to be reattached
8	Pre-wet with IMS & deionised water 1:1; Plextol 30% injected behind flake; area relaxed with PP at 100ºC/mist 5 & then pushed back through tissue	Stronger solution to try & avoid need for pre-consolidation. Good adhesion but slight surface shine. Area may be less absorbent
9	Same treatment as 8 but Plextol 20%	PP dries surface & relaxes flakes but Plextol remains wet behind, thereby enabling flake to be reattached. The surface was then cleaned with a swab and on drying showed quite extensive blanching, over & above the blanching that was already clearly in evidence before treatment
10	Pre-wet as in 8; Isinglass (50% of 'Original Solution') injected behind flake. Area relaxed with PP as in 8 & flake pushed back & cleaned	Very good readhesion & handling properties, but considerable blanching on drying over & above the blanching that was already clearly in evidence before treatment

2. CLEANING TESTS

Very small tests on the red background of the 'violin player' lozenge on the north side (*Ref 30/1).*

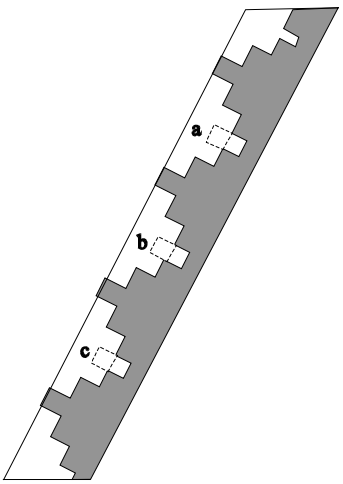
Test	Materials & Methods	Results
1	PP at 40ºC (min. mist). Dirt removed with cold water swab	Area 'blanches' immediately but then darkens as it dries. Adequate level of cleaning
2	Cold water swab	Evident blanching
3	100% w. spirit swab	Moves the red pigment

3. REMOVAL OF RESIDUAL CONSOLIDANT

(St Paul scaffold, north side) 'stepped chevron pattern' adjacent to east side of Psaltery Player (R*ef. 26/1*)

Rationale

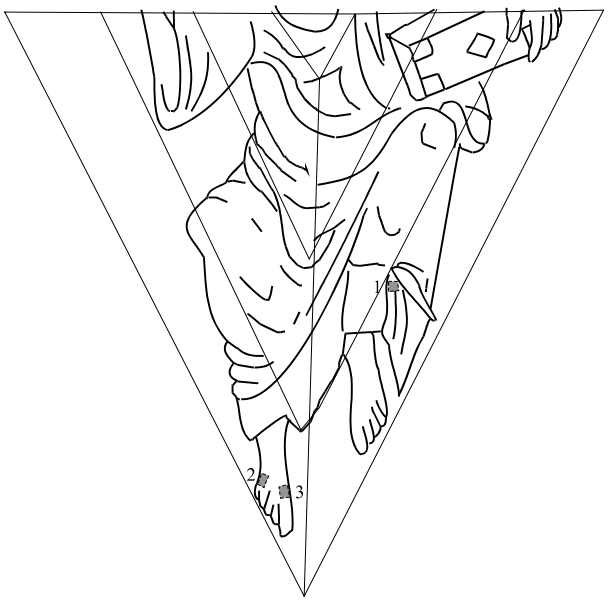
To test the effects of any residual consolidant on the ability to clean subsequently and the appearance of the treated area. The paint layer here was stable.



Test	Materials & Methods	Results
a	Areas treated similarly to flaking paint i.e. pre-wetted with PP 40ºC (mist 1) for 2 mins; 5% solution Plextol B500 injected & left in place for 1 min. then area pressed with damp swab through tissue to remove excess. Each area has its own control, as cleaning takes place *across* each test. When dry half the test area and surround was wiped over with a damp Slurpex sponge.	Significant surface dirt was removed from the area when wiped with the sponge. The 'consolidated' and subsequently 'cleaned' area appeared *cleaner* than surrounding 'un-consolidated', but cleaned area. The result suggests that using this solution and method of application and will not inhibit the removal of the surface dirt from the re-attached paint.
b	As (a) but using 10% solution Plextol B500	As (a)
c	As (a) but using 15% solution Plextol B500	As (a)

4. PAINT RE-ATTACHMENT TESTS

Tests on St Peters feet (Ref: 31 II/III)

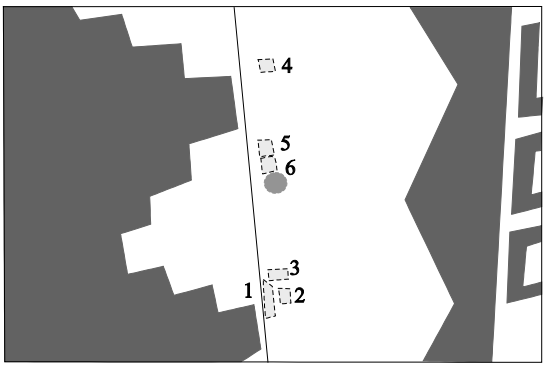


Test	Materials & Methods	Results
1	**Flaking blue drapery on east side foot** Area relaxed for 5 mins with PP70ºC, small nozzle. A 15% soln. of Plextol in water/IMS (1:1) was injected & heat continued during injection. NB The IMS was introduced into the Plextol to attempt to reduce the amount of water involved. The heat was then removed and a pad of dry cotton wool was used to press back the flake, through tissue. The process was repeated with damp cotton wool to remove excess consolidant and then finally repeated with a dry pad.	The flake relaxed nicely with the heat and relaid well, without any obvious blanching; also the Plextol/water/IMS works and travels well. But when the tissue was removed immediately it was clear that it had stuck partially to the residual consolidant, which had been dried by the PP. Therefore it appears to be a mistake to apply heat once the consolidant has been applied. However, the heat both relaxes the flake & dries off residual moisture. The aim was to reduce the water content and as the PPwas all but dry, the only extraneous water was from the damp swab.
2	**Little toe of right foot** Same test as 1. but no heat after injection, until tissue removed.	Appears to work well but there is a slight sticking of the tissue to the surface.
3	**Right foot, adjacent to big toe** PP90ºC same settings and treatment, but more attention paid to removing excess consolidant.	Immediate impression is that it works well - Good (improved/quicker) flake relaxation (2mins rather than 5 mins); Tissue releases better than in tests 1&2 though there is a v. slight tackiness, it is not enough to cause undue concern; No apparent blanching.

It seems we have come a full circle, since we had previously dismissed excessive/high heat as being the cause of the blanching. These tests on Paul & Peter seem to suggest that water plays the largest part in the problem.

5. GLUE REMOVAL TESTS

Tests carried out on chevron panel, north side St Peter over ladder (ref. 30/1)



Test	Materials & Methods	Results
1	Glue softened with PP 100ºC (max. Mist, med. nozzle) & removed with wet swab	Glue readily removed & seems to remove ingrained dirt also. Some blanching evident
2	Cold water swab on non-glue area	Removes surface dirt only
3	Warm water swab on non-glue area	Removes surface dirt only, slight blanching
4	PP at 60ºC (mist 5/small nozzle) on non-glue area; dirt removed with cold water swab	This test was to see whether the PP removes ingrained & surface dirt & whether it causes blanching. No blancking occured.
5	PP at 60ºC (mist 5/med. nozzle) on glue area; glue removed with cold water swab	Dissolves glue well, though not as readily as 1. Evident blanching.
6	PP at 40ºC (mist 5/med. nozzle) on glue area; glue removed with cold water swab	Dissolves glue adequately

Further localised tests were carried out on glue areas:

Test	Materials & Methods	Results
#	Cold water swab	Will eventually remove glue, but only with prolonged & thus potentially disruptive agitation.
#	Warm water swab	More effective, but requires significant agitation.
#	Preservation Pencil. At 80ºC and above.	Causes unacceptable blanching, but very effective glue & dirt removal is achieved by wiping over afterwards with either a sponge or swab.
#	Preservation Pencil. Cold moisture - i.e. from humidifier only.	Soltens the glue after 5-10 mins. of application.

Further tests for glue removal were carried out on the Psaltery fig. & are detailed below.

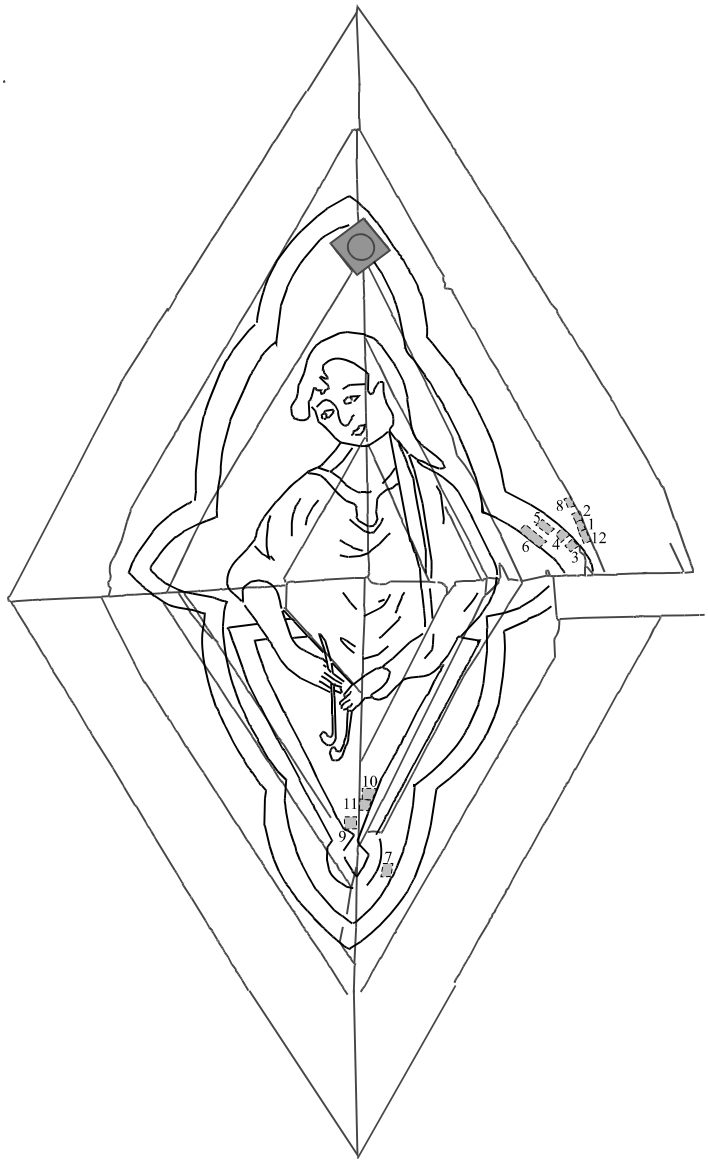
Conclusions
The tests seem to establish that heat over 40ºC causes blanchang, as opposed to blanching. However, this temp. is sufficient to soften the glue effectively. A minimum mist setting is adequate in most cases, using the medium nozzle. The PP is preferable to swabs because of the minimal surface agitation required.

6. PAINT RE-ATTACHMENT; GLUE REMOVAL; FLAKE RELAXATION & CLEANING.
Psaltery Player (*Ref: 25/26 I/II*)

Observation on technique

The strings on the Psaltery have been repainted i.e. they go over bare wood. Therefore the loss pre-dates 1835, whereas the loss on the face has occurred after 1835 since the surrounding area has been repainted.

Extensive testing carried out on the Psaltery fig. for paint re-attachment; glue removal; flake relaxation & cleaning. Refer to diagram for position of tests.
Psaltery fig chosen because of similar paint layer flaking to SS Paul & Peter



Glue removal

Test	Materials & Methods	Results
1	PP 50ºC (mist 2/med. nozzle) on glue	Effective glue & dirt removal; minor blanching.
2	Cold water swab on non-glue (control)	Removed surface dirt but less effectively than 1
3	Cold water swab	Removed surface dirt: acceptable level of cleaning
4	PP as 1. Cleaned with cold water swab. Test for blanching, as though attempting to relax flake.	Possibly slight blanching occured
5	PP 40ºC (mist 2) on curled flake	After 2-3 mins. The flake was successfully relaxed
6	PP cold moisture (mist 1) for 15 mins	Flakes brittle before application: after 15 mins. responded slightly, but still too brittle to risk relaxing. When attempted 1 flake cracked.

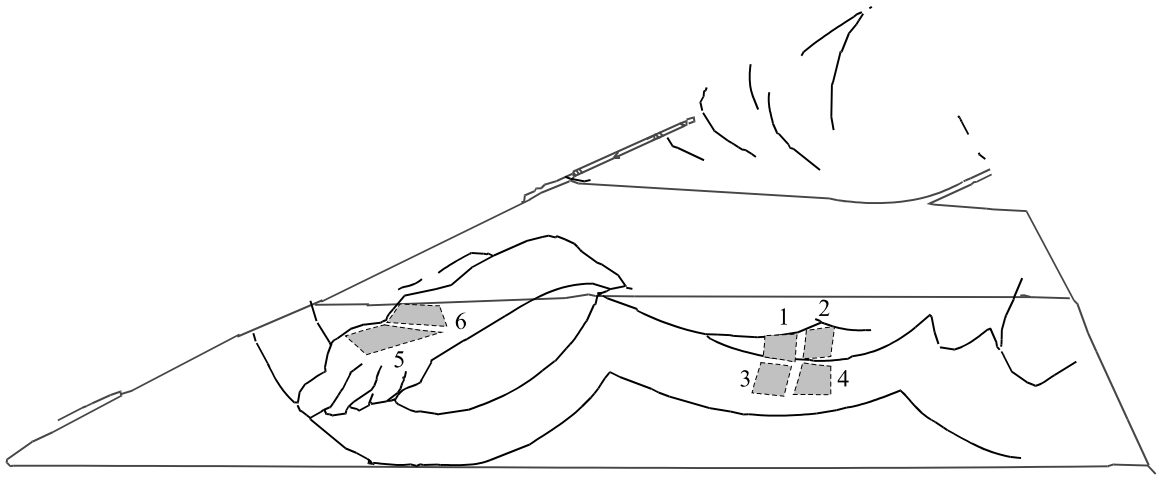
Glue Removal and Re-attachment

Test	Materials & Methods	Results

5a	Same area as Test 5 injected with 10% Plextol; pushed back through tissue as before	A tiny piece of the curled flake fractured during the pushing back & did not stick; the remainder adhered satisfactorily
6a	Same area as Test 6 injected with 10% Plextol	The fractured area did not stick back very successfully, the remainder appear to be consolidated
7	PP cold moisture (mist 2) for 15 mins. on delaminating flake.	Flake relaxation is marginally improved, but not enough for consolidation purposes. On drying a white, crystallised tide-mark appeared. This was removed by wiping over the surface with a damp Slurpex sponge. It did not re-appear.
7a	As 7 for 30 mins. Plextol 15% injected & re-laid as before	Flake re-laid successfully & able to clean surface 1 day later
8	Thick glue drip & peeling paint layer softened rapidly with PP 40ºC (mist 2) & pressed back as before	The peeling paint relaxed completely but impossible to persuade flake to remain in situ - no consolidant.
9	Flaking paint briefly softened with PP 40ºC (mist 2) & Plextol 5% injected & pushed back	Some fracturing - perhaps not softened enough
10	Curling paint flakes softened for 5 mins PP 40ºC (mist 1) & Plextol 10% injected & pushed back	Apparent good adhesion, though some sense of fracturing. Adhesion still good the next day although tiny paint loss when cleaning with a swab was attempted
11	Flakes relaxed with PP 40ºC (mist 1) for 2-3 mins & Plextol 15% injected & pushed back	The flakes are thicker & delaminating & require stronger solution. c/f with 10. Good adhesion. Excess consolidant apparently removed with surface dirt
12	To attempt to remove thick glue drip from flaking red paint the PP 40ºC (mist 1) was applied for 5 mins	Glue softened completely. By 'pulling-away' the glue from the flake with a Slurpex sponge & then delicately pressing the flake back with the sponge, the flake went back successfully
12a	As 12 with Plextol 15% injected behind flake after softening	In this case the attempt was unsuccessful and the paint flake was lost.
13	Green background, delaminating flake: PP 35ºC; 5 mins; Plextol 10% in water. Pressed back through tissue with damp pad; fresh damp pad used to 'rinse' surface through tissue. No attempt to remove surface dirt.	Flake was successfully reattached. Minor blanching was evident.
14	Curling/scrolling flakes on the strings of the instrument: PP same as 13., Plextol 15% in water. Pressing back as 13.	Reattached successfully. Slight blanching.
15	Glue drip on hair, scrolling the paint layer: PP as 14. No consolidant	Impossible to remove all the glue & when pushing back, the glue stuck to the tissue & pulled the flake away.

Supplementary
Having achieved objective of re-adhering flakes it may be possible to then re-consolidate with a weaker solution of Plextol e.g. 5%, simply to fill 'voids', thereby facilitating the cleaning process. Little pressure need be applied, only enough to remove excess consolidant:
Test 5b Pre-wet with PP 40ºC (mist 1), injected with Plextol 5%. Absorbed nicely but tiny loss suggests that stronger solution. is required.

7. BLANCHING TESTS
Tests for blanching on St Paul replacement board (*Ref: 27/II*).



#	Materials & Methods	Results
1	Damp (water) swab held on red drapery for 20sec, then dry swab for 10 sec	Blanching evident after 1-2mins
2	Damp (IMS) swab for 20 sec, then dry swab for 10 sec	No obvious blanching, but slight white ring/'tidemark' around test area
3	As 1.on blue/green cusped frame	Very significant blanching evident after 2 mins
4	As 2. .on blue/green cusped frame	Slight ring; no obvious blanching
5	As 1. on flesh tones	Blanching evident as it dried
6	As 2. on flesh tones	'Tidemark' ; insignificant blanching

The assumption is that the moisture is causing the blanching, yet some moisture is required for the refixing process to work effectively. Need to establish a method of fixing using the minimum (if any) amount of water necessary.

Tests on red drapery (St Peter) adj. to MBG
The aim is to firmly establish whether it is the heat or the water that causes the blanching.
No PP No consolidant. Dry/damp/dry pads. i.e. no heat and minimal water
The test was carried out on an area of paint known in previous tests to blanch.
Result: Extensive blanching after 2 mins.

NB We then attempted to eliminate as much of the water in the Plextol as possible by replacing it with IMS. Knowing that an excess of IMS causes the Plextol to come out of its emulsion state and 'rubberise', we established that a 10% addition was satisfactory.
A further test was therefore carried out on the blue drapery of St Peter's foot:
PP90ºC; min. mist; small nozzle; 3 mins. Pre-wet with IMS (the delay between the pre-wetting & application of the Plextol allows the IMS to disperse to the extent that it is acting solely as a pre-wetting agent). The consolidant - 15% Plextol; 10% IMS; 75% water - was injected behind the flake and pressed back with a dry pad of cotton wool, through tissue. The tissue was removed and the area quickly wiped with a slightly damp Slurpex to remove excess consolidant (this had been proved as a successful method of removing the residual consolidant sufficiently to allow subsequent cleaning during previous tests).
The lack of any surface tackiness during the removal of the tissue suggests that the previous solutions of consolidant had carried too high a ratio of IMS to Plextol and were causing a clearance problem.
The results were so successful that this was the method selected for the reattachment process.

APPENDIX 2

TESTS IDENTIFYING PAINT LAYERS SUSCEPTIBILITY TO WATER-INDUCED BLANCHING

ST PETER	**POSITION**	**EFFECT/BLANCHING**
Red drapery	To east of central lozenge etc	Insignificant
Pink shading on red drapery	To west of left hand	Present when swab used; not present when wiped with damp slurpex
Yellow/white highlight on red drapery	Sleeve of left arm	Minor
Flesh tones	Left hand	Minor
Flesh tones	Left foot - after full consolidation	Present
Light blue drapery	Over left foot - after full consolidation	Present
Black outlines	Several areas	Insignificant or not present, unless already present
Dark blue drapery	Over left foot - after full consolidation	Insignificant
White/cream	Background to 'patterns'	Insignificant with swab,but present after prolonged treatment
Light blue/green	Background to figure	Insignificant/acceptable; but earlier tests were affected by prolonged heat/moisture
Yellow/brown/white	Hair	Minor; mainly appears on the brown, tho' may simply be cleaner
ST PAUL		
Green	Background to figure, by foot	Minor. Previous tests show it can be removed
Yellow/brown	Drapery by sword handle	Took a long time to dry but no apparent blanching
Light blue	Cusped frame	After full consolidation it was very evident, but only occurred occasionally
White/yellow	Sword - after full consolidation	No obvious blanching
Brown/grey	Hair	Possible blanching- or is it just cleaner?
PSALTERY		
Light green	Background to figure	Minor; previous tests indicate it can be removed
Pale pink/cream	Cusped frame	Minor - acceptable
Red	Background	Minor/insignificant
Grey/brown	Frame of instrument	Present
Blue/green	Repaint on background	Minor
Cream	Background to key pattern	Insignificant

APPENDIX 3

Photography

Cameras	2 x Cannon EOS1000 FN
Lens	2 x Cannon 28-105 AF
Flash	Cobra 700 F
Slide film	Kodak Ektachrome E100 S
Print film	Fuji Reala (100 ASA)
Slide film for UV photography	Fugi Provia 1600

All visible light photography was carried out using the Cobra 700 F flashlight either on or off camera. Photography under UV illumination was carried out at night using 4 CLE blacklight long-wave, ultra-violet tubes (4 ft). A Lee UV2B filter together with a Hoya Haze-UV filter were used on the camera lens for all UV photography.