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Plate 10 *(Far right)* Francesco del Cossa, *S. Vincent Ferrer* (No.597). After panel treatment, cleaning and restoration.

Plate 11 *(Right)* Francesco del Cossa, *S. Vincent Ferrer* (No.597). Before cleaning.

Plate 12 Francesco del Cossa, *S. Vincent Ferrer* (No.597). Detail of amulet, l.h.s., painted in 'mosaic gold'.

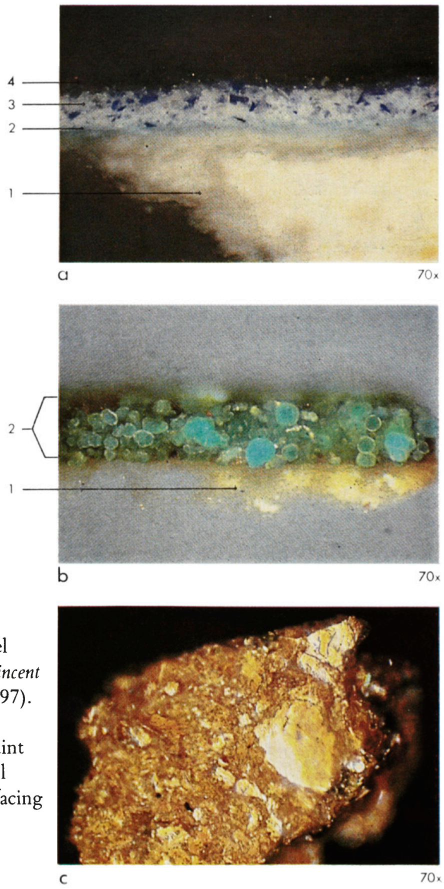


Plate 13 Francesco del Cossa, *S. Vincent Ferrer* (No.597). Photomicrographs of paint samples. Full caption on facing page.

Francesco del Cossa's 'S. Vincent Ferrer'

Alistair Smith, Anthony Reeve and Ashok Roy

Art-historical background

Alistair Smith

The cleaning of a painting, while always revealing, does not always result in a significant increase in the art-historical assessment of the picture. Such is the case with Cossa's *S. Vincent Ferrer* (Plate 10, p.44).

The treatment has uncovered the true brilliance of the painted surface. The modelling of the saint's black robe is now more visible, the colour of the sky more intense, and a whole number of relationships in the lines of the landscape and in the heavenly group have been established. In addition, the severity of the contours in the painting and the tension of their juxtaposition has increased owing to the heightening of tone. These changes could be described under the label of 'gain in visibility' or even 'aesthetic gain'.

It is, of course, important to the art historian that the true condition of the painting has been established by its recent cleaning. More interesting, perhaps, is the one new feature discovered by the removal of overpaint; although the exact nature of this revelation is doubtful. At each side of the panel, just where the lower clouds on which rest the outer angels meet the edge of the panel, there have been discovered two unpainted areas (see Fig.26, p.53). These may have been originally covered by parts of the frame, most probably by the tops of columns. Their discovery constitutes a very small addition to the factual basis on any attempted reconstruction of the complex of which the *S. Vincent Ferrer* was part.

In the absence of any real additions to our art-historical knowledge of the painting, this note serves to provide the art-historical context to the treatment and technical examination recorded below [1].

The panel showing S. Vincent Ferrer is universally accepted by scholars as having been the centre piece of a polyptych. Vasari mentions it, in his life of Lorenzo Costa [2]: 'By this hand, also, was the panel of S. Jerome in the Chapel of the Castelli, and likewise that of S. Vincent, wrought in like manner in tempera, which is in the Chapel of the Griffoni [in S. Petronio, Bologna]'.

It is certain that Vasari was mistaken in attributing the painting to Lorenzo Costa since there is documented in 1473, a claim for payment for the frame. The date makes it impossible for Costa (born around 1460, he could not have received such an important commission at the age of thirteen), and makes it clear that Vasari meant to write Cossa. It was one Agostino de' Marchi from Crema, a master cabinetmaker and inlayer who on 19 July of that year claimed payment for making the frame of the altarpiece of Floriano Griffoni.

The frame of the complex is no longer in existence, and the various paintings presumed to make up the altarpiece are scattered. Vasari mentions a predella: 'the predella of this he caused to be painted by a pupil of his, who acquitted himself much better than the master did', and takes up the point again when speaking of Ercole de' Roberti, 'Ercole, then, who was a better draughtsman than Costa, painted, below the panel executed by Lorenzo in the Chapel of S. Vincent in S. Petronio, certain scenes in tempera with little figures, so well and with so beautiful and good a manner, that it is scarcely possible to see anything better, or imagine the labour and diligence that Ercole put into the work'. In 1888, Frizzoni [3] identified the predella with a painting in the Vatican Museum which is thought, by some critics, to show six scenes from the life of S. Vincent Ferrer. He also identified a *S. Peter* and *S. John the Baptist* whose composition and smaller size allowed him to place them on either side of the central panel of *S. Vincent Ferrer.*

In 1934 and 1940 [4], a more extended reconstruction was put forward by Longhi who suggested that two saints, S. Lucy and (possibly) S. Florian might have made up a higher tier. Against this association is the fact that the haloes of these two saints are differently treated from those already mentioned. If the male saint does, however, represent S. Florian, this would increase the chance of an association, the donor's name being Floriano Griffoni.

Longhi postulates some other paintings to complete a reconstruction of the polyptych (Fig.1). A number of these items are traced by Longhi to the 1841 catalogue of the Costabili Collection at Ferrara

Plate 13 Francesco del Cossa, *S. Vincent Ferrer* (No.597).

Photomicrographs of paint cross-sections (a and b) and the surface of a sample (c), photographed at 220 × magnification in reflected light; actual magnification on the printed page shown beneath each photomicrograph.

(a) Deep blue of sky, right-hand edge.

1. Gesso (gypsum) ground.
2. Pale blue underpaint containing lead white + a blue dyestuff (probably indigo).
3. Genuine ultramarine + lead white.
4. Glaze of pure genuine ultramarine.

(b) Dark green of foreground, lower left corner.

1. Gesso (gypsum) ground.
2. Malachite of spherulitic particle form in a layer rather rich in egg medium.

(c) Top surface of a fragment of 'mosaic gold' from the rail which runs behind the figure of the Saint.

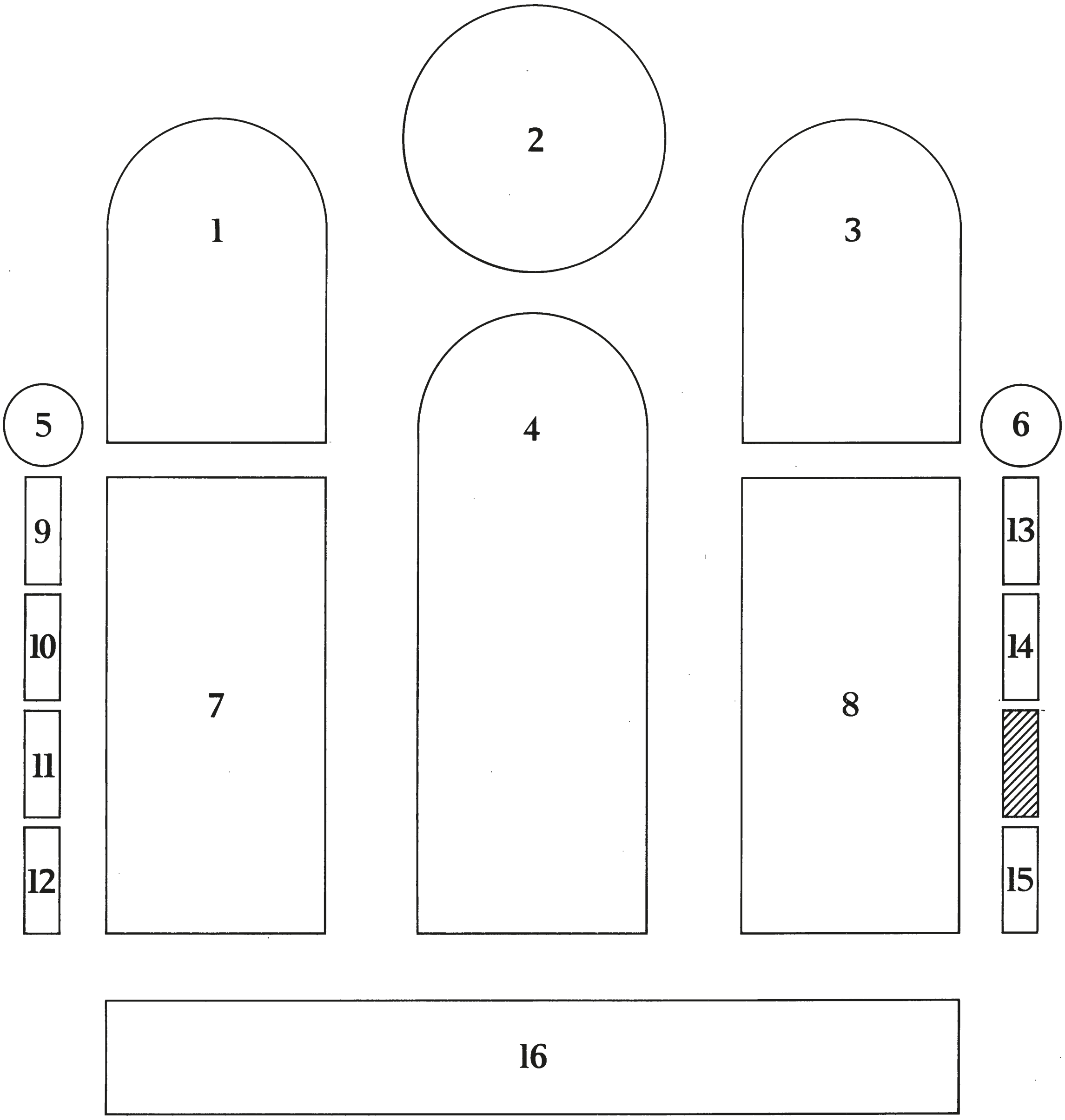


Figure 1 The Griffoni polyptych: suggested reconstruction after Longhi [5].
Key: 1. *S. Florian*, 2. *The Crucifixion*, 3. *S. Lucy* (National Gallery, Washington, D.C.); 4. **S. Vincent Ferrer** (National Gallery, London); 5. *The Angel of the Annunciation*, 6. *The Virgin* (Cagnola Gallery, Varese); 7. *S. Peter*, 8. *S. John the Baptist* (Brera Gallery, Milan); 9. *S. Michael* (Musée du Louvre, Paris); 10. *S. Anthony* (Van Beuningen Collection, Rotterdam); 11. *S. Apollonia* (Musée du Louvre, Paris); 12. *S. Petronius* (Baldi Collection, Ferrara); 13. *S. George*, 14. *S. Jerome*, 15. *S. Catherine* (Cini Collection, Venice); 16. *Six Episodes from the Life of S. Vincent Ferrer* (Vatican).

(where, incidentally, the National Gallery *S. Vincent Ferrer* is recorded as '*S. Hyacinth* by Marco Zoppo'). Previous to that, the altarpiece had been in the possession of Cardinal Pompeo Aldovrandi, his family having received, in the eighteenth century, the former Griffoni Chapel.

The literature on the school of Ferrara is remarkable for divergence in attributional opinion. The predella and several of the smaller paintings associated by Longhi have been attributed variously to Cossa, Tura and Ercole de' Roberti.

Critical opinion is, however, agreed on the status of the altarpiece. Vasari was the first to emphasize its high quality and no modern commentator has disagreed. Perhaps some indication of the high esteem in which the painting is held, is given by its inclusion in a recent Unesco publication, *An Illustrated Inventory of Famous Dismembered Works of Art. European Painting* (Paris 1974). Here it is included as one of half-a-dozen of the most important dismembered Italian altarpieces, in a group which includes Masaccio's famous 'Pisa Polyptych'.

References

1. Much of the information which follows is available in M. Davies's catalogue, *The Earlier Italian Schools* (1961), p.149ff.
2. In the original Italian in Vasari (Milanesi edition 1878 – 85), Vol. III, pp. 133 – 4 and pp.142 – 3.
3. FRIZZONI, G., *Zeitschrift für bildende Kunst* (1888), p.299ff.
4. LONGHI, R., *Officina Ferrarese* (1934), p.48ff., and *Ampliamenti nell' Officina Ferrarese* (1949), p.5ff.
5. LONGHI, R., *op. cit.*, pp.46 – 7.

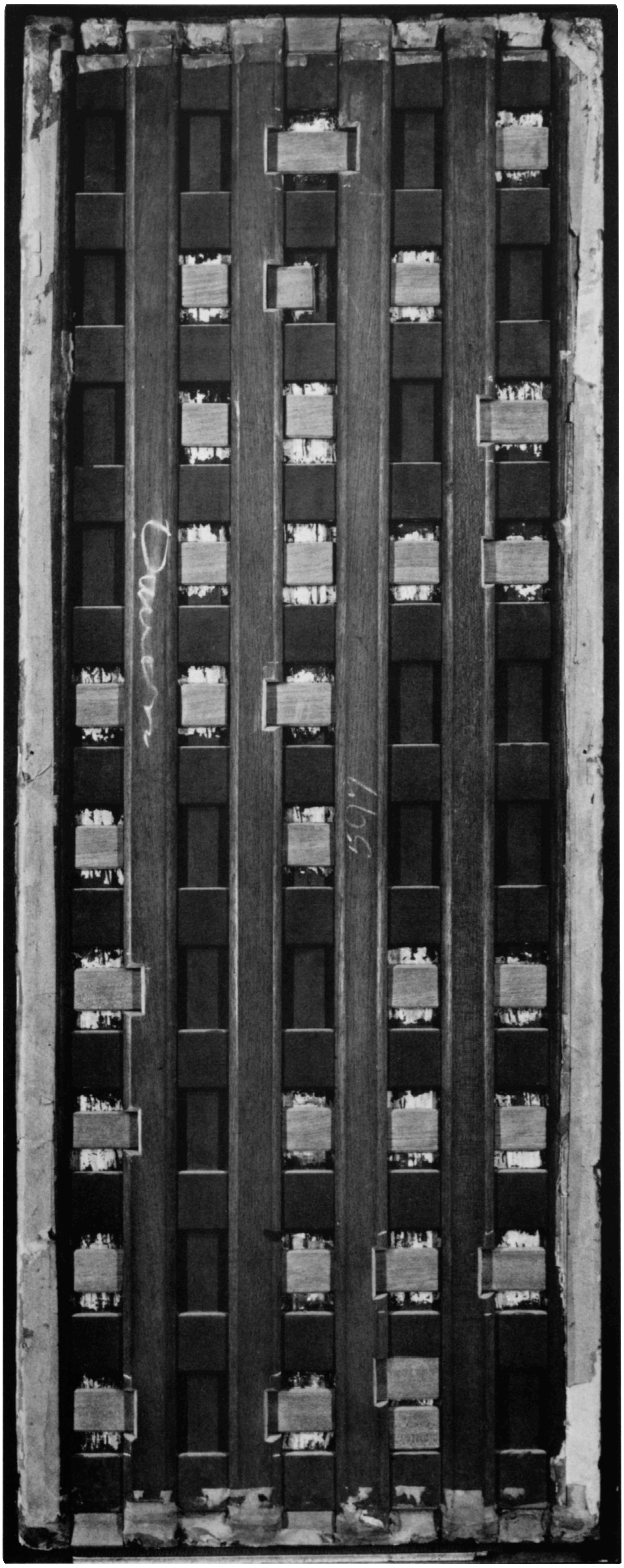


Figure 2 The back of the panel before treatment.

The treatment of the support

Anthony Reeve

The central panel of the Griffoni chapel altarpiece depicting S. Vincent Ferrer by Francesco del Cossa (*c.*1435 – *c.*1477) was acquired by the Gallery in 1859 and a recorded summary of the treatment carried out on the picture up to the present day was then begun.

The picture is painted solely in tempera on a poplar panel consisting of one member with an overall thickness of about one-quarter of an inch, though when originally painted it would probably have been between about one and two inches in thickness. On arrival at the Gallery a canvas was applied to the back as protection. In 1885 it was cleaned, to what extent is not clear, and some cracks were repaired.

The next entry of June 1931 states that the picture had previously been cradled and that the panel was very thin, dry and cracked, and the beginning of new cracking was showing on the surface. The remedial treatment carried out at that time was the application of thirty-five mahogany buttons in between the cradle bars (Fig.2) and the securing of paint loosened by the cracking. This treatment was said to have stopped the cracking. On three occasions loose paint was secured by blister-laying, in 1940, 1955 and 1956. In 1949 a small test was made in the top left-hand corner to see if the spandrels were part of the original panel. It was found that they were, though the surface of the spandrels was thought to have been planed, as rather more of the worm-channels could be seen than would have been expected.

The surface of the picture can be seen in raking light which shows some of the corrugations of the panel. These are mostly not complete splits in the panel as they have not penetrated through the paint and ground (Figs.3 and 4). The only complete splits can be seen in the X-radiograph (Fig.5). There are two running down from the top edge, one through Christ's face to a depth of 8 inches, another 4 inches from the left edge to a depth of 6½ inches. Two other splits near the right bottom corner extend *c.* 8 inches up from the bottom edge.

Other slight surface variations due to cracks, one visible in S. Vincent Ferrer's black robe running through his feet, and one in the cloud above his head 2½ inches long, had unfortunately been glued at a previous time at an uneven level and it was not safe or practical in this case to break and rejoin them.

The X-radiograph which was taken after panel treatment shows the extent of the old worm activity and confirmed that the spandrels were original. The bottom left corner of the picture had also suffered a slight loss in the past due to worm damage eating away the panel.

The consolidation of the panel

While the picture was off exhibition for panel treatment it was decided to clean and restore it, though this article concentrates on the treatment of the support. To begin treatment the picture was faced using one layer of Eltoline tissue paper, the facing mixture being made of dammar varnish and wax applied by brush starting from the centre of the panel to avoid creases in the paper. When this was thoroughly dry, the picture was placed face down on a suitable table on a layer of fireproof blanket and Melinex.

The picture at this stage was comparatively flat, being held in place by the cradling (Fig.2), so during the removal of the cradle an even pressure had to be maintained over the whole panel until all the cradling and buttons were removed otherwise the panel might have twisted and further cracking might have occurred. The fixed bars of the cradling were sawn through to within $\frac{1}{16}$ inch of the back of the panel and then in one-inch lengths as the whole of the panel was traversed, and then they and the buttons were removed in small pieces with gouges working along the grain to minimize any possible stress on the panel. Fig.6 shows the removal of the cradling and how the panel was held flat by covering the exposed areas with a thick rubber sheet and with boards which were clamped on. The black layer of preservative and filler had been brushed onto the back of the panel after it had been planed down, presumably to reduce moisture absorption and to fill the numerous worm holes. This layer was scraped away from the original panel and Fig.7 shows the panel after everything had been removed. The warp demonstrates the tension the panel had been under when cradled. The panel now had weaknesses where the cracks were open, so they had to be glued. 'Cascamite', a urea-formaldehyde glue, was used as an adhesive and the cracks glued from the centre outwards. The cracks were glued one at a time. This was done by re-opening them by applying slight downward pressure on either side and the glue was then worked into the cracks. The panel was then allowed to go back to its warped position which brought the sides of the cracks together. A layer of Melinex was then placed over each crack, a strip of wood placed over that and a small weight used to keep the sides of the cracks together overnight. Fig.8 shows how the cracks were supported while being glued.

The cracks did not in most cases go through to the paint itself, so they could be repaired in this manner working from the back. After all the cracks had been secured (there were more than twenty of them) the panel had to be prepared for the new support. Firstly, the warp of the panel was reduced by placing it on a moisture tray (Fig.9). This was done by supporting the picture on a wooden frame (the tray) and laying damp blankets on the table underneath. In this case the whole of the back of the panel was exposed to moisture as the warp was uniform and the panel was of one member. The overall effect of this part of the treatment was to flatten the panel and hence enable it to be supported unstressed to prevent further cracking. Once held in this position by the new support and allowed to dry the wood will stay in its new position without cracking, providing it is not exposed to excessive changes in temperature and relative humidity.

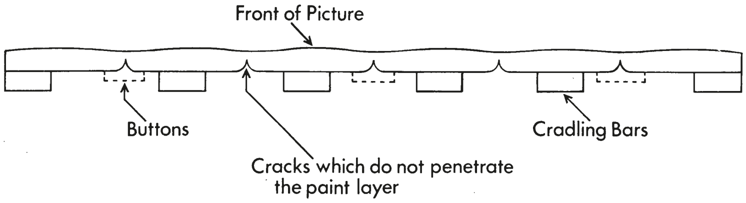


Figure 3 Diagram of the end grain of the panel, showing the cracks between the fixed vertical cradle bars.

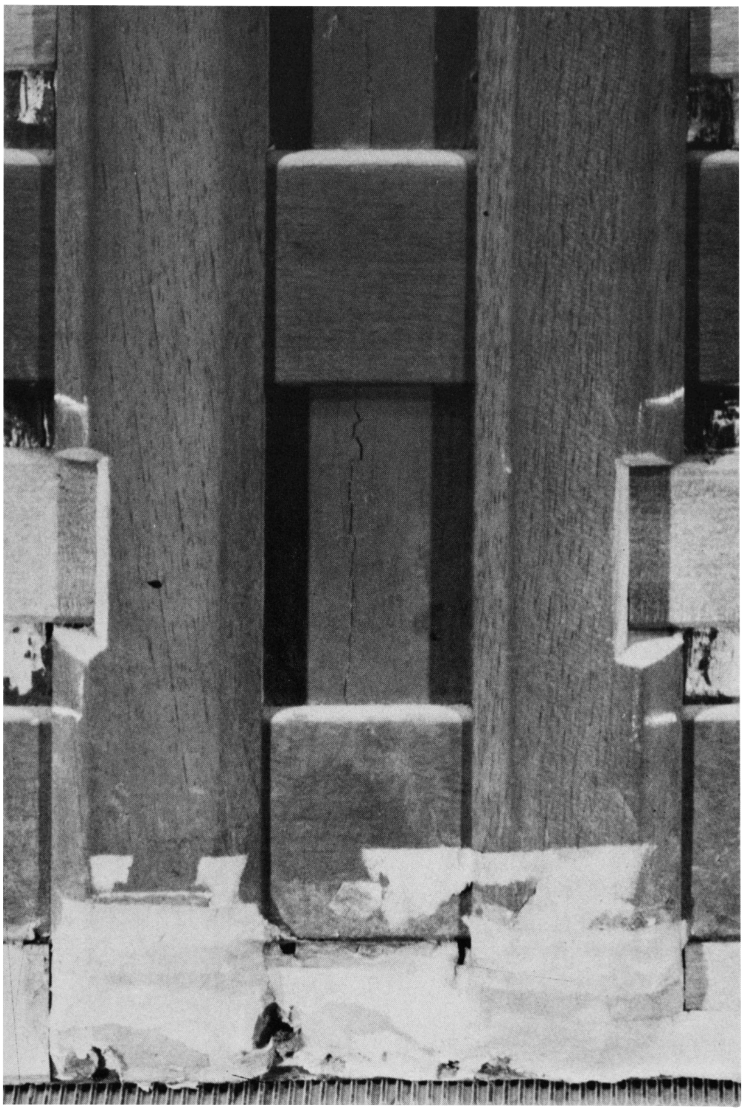
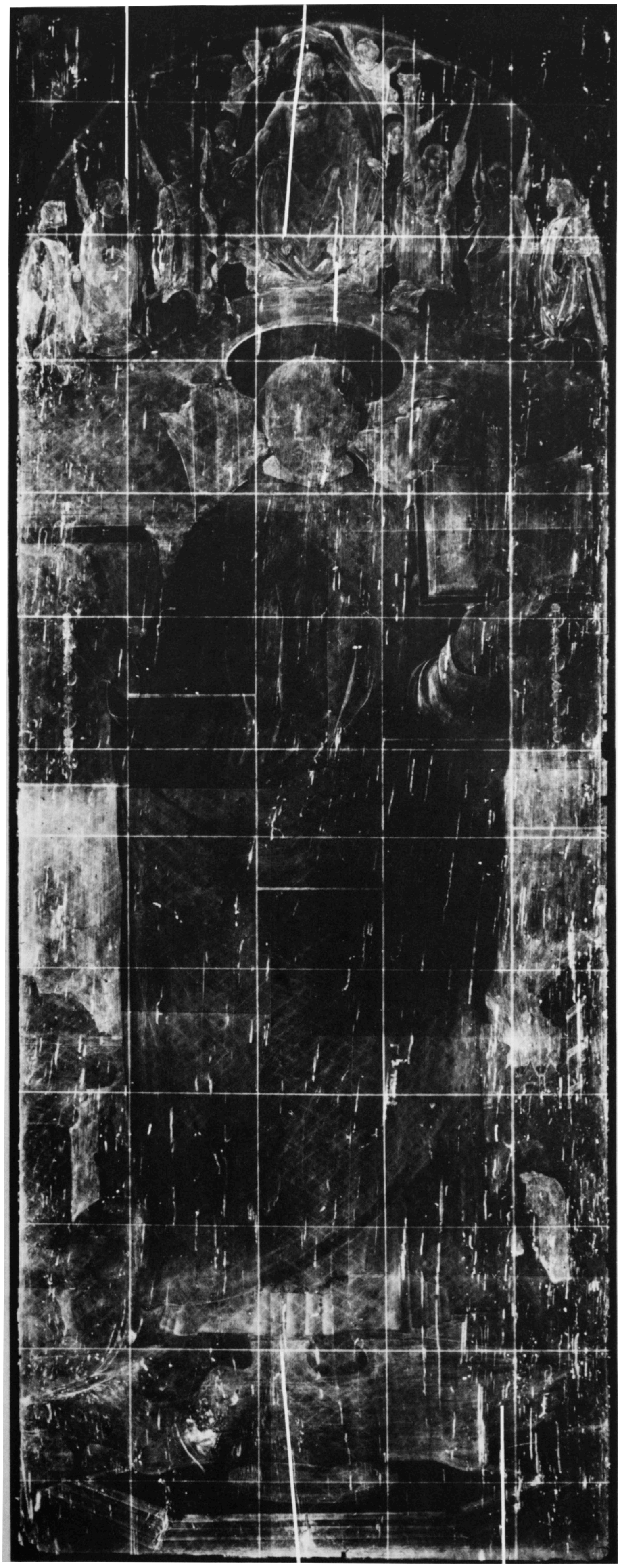


Figure 4 Detail of the bottom of the panel, showing a split between the fixed vertical cradle bars.

Figure 5 *(Right)* X-radiograph of the whole picture, after treatment. The complete splits in the panel, through paint and ground as well as wood, are marked. The square grid of white lines represent the interstices between the balsa planks in-filled with 'wax cement'.



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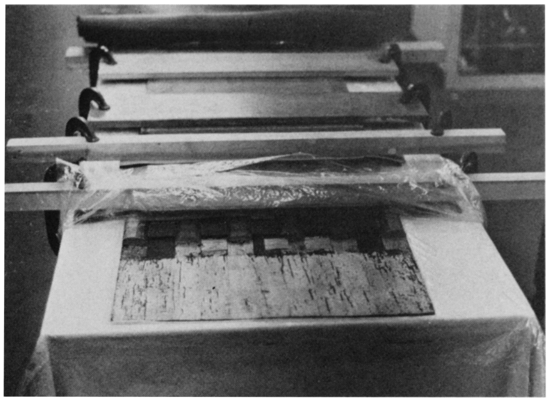

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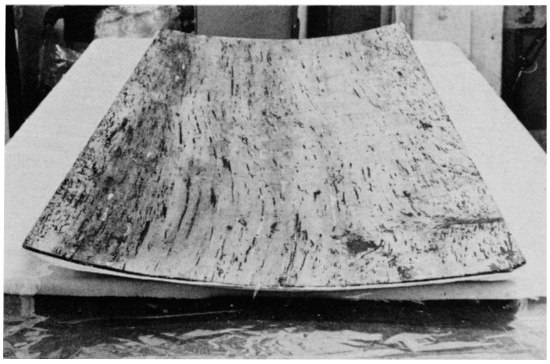

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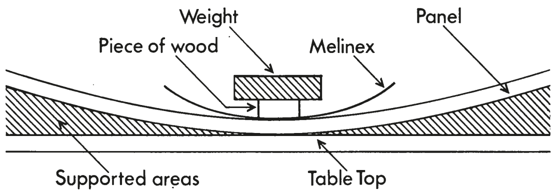

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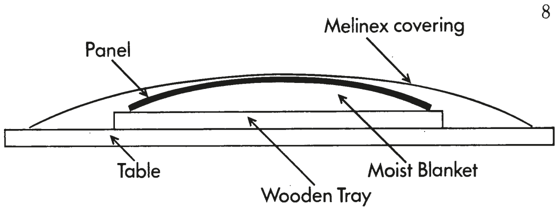

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Figure 6 The beginning of the removal of the cradle.

Figure 7 The panel after the removal of the cradle showing worm damage. The warp shows the tension the panel had been under while cradled.

Figure 8 Diagram showing how the panel was supported while the cracks were being glued.

Figure 9 Diagram showing the panel on a moisture tray.

Figure 10 The panel, relaxed to a flat configuration after the moisture treatment, while wax and resin are brushed onto it.

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Figure 11 Wax and resin being ironed in to impregnate the worm channels and secure the open net hessian. Anthony Reeve (left) and David Thomas of the Conservation Department at work on the panel.

Figure 12 The first layer of balsa wood, its grain in the same direction as that of the panel, being pressed into the 'wax cement'.

Figure 13 The first layer of balsa wood is complete, covered with Melinex and weighted overnight.

Figure 14 The panel with a flat metal sheet on it to maintain even pressure over its whole area.

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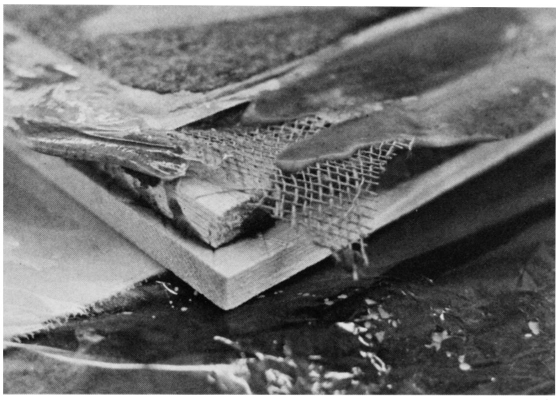

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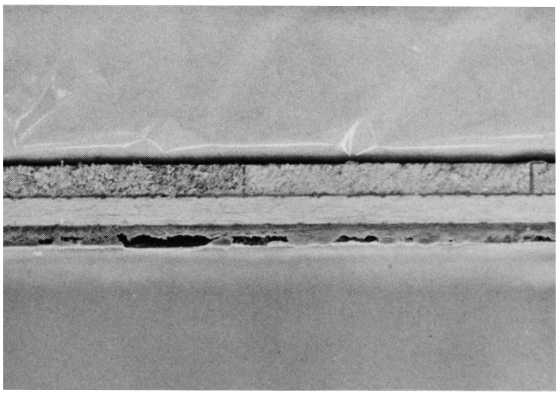

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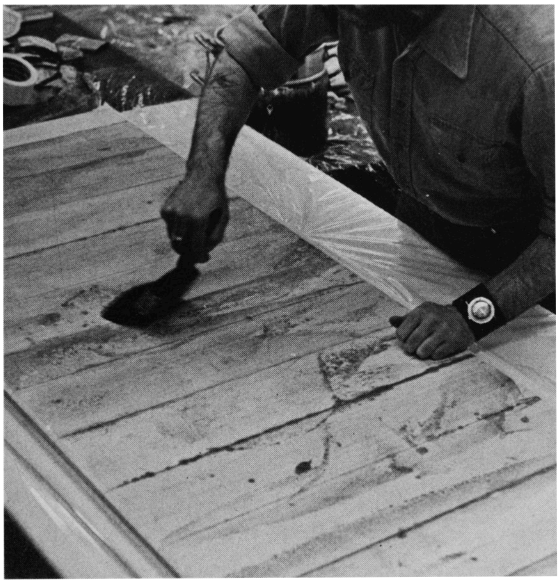

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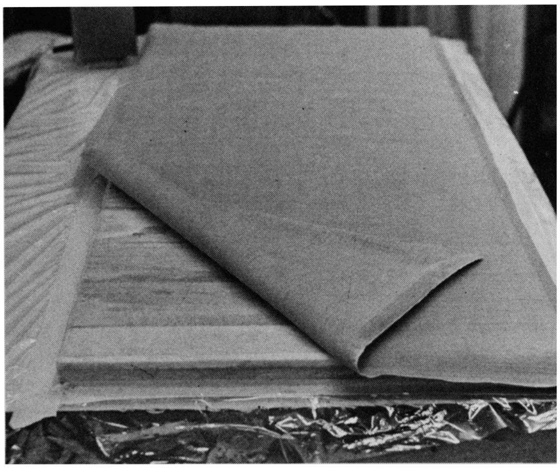

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Figure 15 The clamps used to ensure even pressure.

Figure 16 The second layer of balsa wood, across the grain of the original, is applied.

Figure 17 The front of the panel, still with its facing, after both layers of balsa wood have been applied.

Figure 18 Detail of the corner, showing hessian, 'wax cement' and the two layers of balsa wood.

Figure 19 Detail of the edge.

Figure 20 Wax and resin being brushed onto the back of the balsa wood.

Figure 21 Canvas being applied to the balsa wood to protect it.

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Figure 22 The canvas being secured with heat to the wax and resin.

Figure 23 The wax and resin securing the canvas being chilled.

Figure 24 The support treatment is completed and the panel turned face up.

Once the panel was in a flat and relaxed state, wax and resin were applied to the back (Fig.10). This stage of the treatment has to be done without a break as the critical stage is building-up and maintaining the panel in its new configuration without allowing it to revert to its previous distorted state. Then a layer of open-net hessian, slightly larger than the picture, was laid over the back, lightly brushed over with wax and resin which was then ironed in (Fig.11). This layer gives a 'key' for the balsa wood and wax cement and is a suitable release layer if the panel should move again. This layer is designed to be reversible and will break away from the panel in the event of any movement, rather than the panel itself splitting again. Immediately following the application of the hessian a molten mixture of wax, dammar resin and sawdust ('wax cement') was applied liberally. The planks of balsa wood were laid immediately on the first layer always running with the grain of the original (Fig.12). (Balsa wood is available in many different widths and lengths; in this case planks of ½ inch in thickness and 5 inches in width were used.) They were prepared beforehand by scoring them in a criss-cross pattern to make a 'key', and warmed immediately before application. The whole of the first layer was applied by sliding the planks from side to side on contact to spread the 'wax cement' evenly and to remove air bubbles. When the layer was completed, the back was cleaned of excess 'wax cement' and covered in Melinex (Fig.13). A board of substantial thickness and slightly larger than the picture was placed over the back and, in this case, an ⅛ inch sheet of metal (Fig.14) to spread the pressure evenly when the panel was to be clamped to the table (Fig.15).

Figure 25 *(Left)* After removal of the facing, showing a few old damages and the bare wood in the spandrels.

Figure 26 *(Right)* Detail of top right corner showing one of the two unpainted areas probably originally covered by part of the frame (see p.45).

The following day the clamps were released and another coat of 'wax cement' applied. A second layer of balsa wood planks scored only on the underside and this time at right angles to the grain were then secured (Fig.16). The iron was also used at times to spread the 'wax cement'. When complete the second layer was again secured overnight in the same way as the first, using the Melinex, board, metal sheet and clamps. The cross-bars under the clamps in this case were of metal and more rigid than wood. Wood can be too pliable for this part of the treatment though the essence is not in the use of a great amount of pressure but in maintaining an even pressure over the whole panel while the 'wax cement' cools.

The picture was then turned over (Fig.17) and kept in this position for a few days to make sure that it had stabilized. The sides were then completely coated with wax and resin.

Fig.18 gives a good idea of the structure of the support before the edges were trimmed, and Fig.19 shows it after trimming. Wax and resin were then applied to the back of the balsa wood and then a fine linen canvas is laid over, the wax ironed through and chilled (Figs.20 – 23). The canvas was turned over the sides in the same way and then trimmed, completing the treatment of the back and sides (Fig.24). Figs.25 and 26 show the picture, after removal of the facing and after cleaning but before restoration. Cleaning is normally done before the treatment of the support in case old fillings prevent the realigning of the cracks. The basis of the support treatment using balsa wood and 'wax cement' originally stemmed from the research of the late R.D. Buck.

It must be said that the treatment described above was chosen as suitable for the picture in question though obviously variations and modifications or even completely different methods may be more suitable in other cases [1]. A very large number of the fifteenth and early sixteenth century Italian panels made of poplar have been planed-down and cradled before they came to the National Gallery Collection. This form of panel treatment seems to have been very common in England in the nineteenth century. The problems caused by the planing-down and cradling vary from panel to panel but it leaves almost all the panels vulnerable in that they are liable to splitting. Thirty years' experience of removing cradles, rejoining splits in the panels and securing them by the method described above has shown that, provided the pictures are then kept in a reasonably well-controlled environment, the panels will remain stable.

Reference

1. Some alternative approaches are described in the 'Preprints' of the IIC Congress on wood conservation, held in Oxford in September 1978. See 'Panel Paintings: Treatment' in N.S. Brommelle, A. Moncrieff and P. Smith (eds.), *Conservation of Wood in Painting and the Decorative Arts,* IIC (London 1978), p.149ff.

Cossa's 'S. Vincent Ferrer': A note on the materials and technique

Ashok Roy

The conservation treatment of the central panel of Francesco del Cossa's altarpiece depicting S. Vincent Ferrer provided a welcome opportunity to collect data on the painter's technique by selective sampling. Cossa's painting methods are of interest to us from two points of view. Firstly, very few Ferrarese School paintings of the fifteenth century have been examined by the Scientific Department in any detail, and so the technical features of this panel will serve as some basis from which other Italian School paintings of the later part of the fifteenth century may be compared. Secondly, the last quarter of the fifteenth century in Italy is a period when technical innovation, particularly in paint medium type, might be expected, but also a time when traditional painting practices are likely still to be highly influential. In the absence of several comparable paintings to examine it is difficult to assess how typical the precise technique and choice of materials are of the picture's school and date; in any event the elements of technique recorded here may prove of use in reinforcing the connection of the National Gallery panel with paintings of *S. Peter* and *S. John the Baptist* in Milan which are thought to be the two flanking panels from the altarpiece of S. Petronio [1] (see also Fig.1, p.46).

Vasari records *S. Vincent Ferrer* as a tempera painting [2], and this appears to be correct (see below). Apart from the need for full-scale treatment to the panel (described above by Anthony Reeve), the painting is in remarkably good condition, such losses as there are being mainly attributable to problems arising from the condition of the support, or to poor adhesion of paint to the gilded background within the arched top. The picture demonstrates well the characteristics of tempera paint in many of the passages — edges are sharply defined, the paint has a rather 'dry' look and the colour tends to be bright and crisp. In common with other works in egg tempera the overall appearance of the paint surface is matched by its microstructural character, the paint having been applied in thin, flat layers. However, certain parts of the picture are considerably more thickly painted than is common in egg medium. For example the paint of the Saint's face and hands is made up of between four and five layers, one or two fairly thick, presumably in order to introduce a greater degree of modulation of light and shade than could normally be achieved in the tempera technique; anticipating the effects which were to become so successful with the development of oil painting. By contrast, the flesh paint of Christ and the angels is a great deal thinner with a simple two-layered structure; moreover here it is depicted in the traditional manner with a green-tinged underpaint in the shadows, a feature lacking from the Saint's more naturalistically painted flesh.

The panel bears a thick gesso-glue ground. In this case the gesso was found by X-ray diffraction analysis (XRD) to be wholly of unburnt gypsum

($CaSO_4.2H_2O$), a composition recorded for two other Ferrarese paintings of similar date [3]. Key details of the design, for example the elaborate system of folds in the Saint's cloak, are incised into the gesso and these scored lines are still clearly visible on the picture and as fine light lines on the X-radiograph [4]. Incised lines are also discernible in the gilded upper portion of the panel, clearly carried out after the application of gold leaf to this area. The gilding itself appears to be of a completely conventional kind, with the usual thin orange-red bole beneath the gold leaf.

Less totally conventional in technique is the way in which the sky has been painted. The bright blue surface layer is executed with greater or lesser amounts of natural ultramarine mixed with lead white, and is underpainted with a very thin pale greenish blue layer containing minute flecks of a dark blue dyestuff (Plate 13a, p.44). This dyestuff which appears to 'stain' the white pigment with which it is mixed, unfortunately was present in the layer in insufficient quantities to allow it to be isolated and fully identified, but its microscopic appearance and susceptibility to bleaching by aqueous sodium hypochlorite suggests the pigment to be indigo or some similar material. Indigo which may be extracted from a number of plants of the genus *Indigofera,* in the fifteenth century could have been of European or imported origin. It seems to occur infrequently on easel painting at this time [5], probably because of its tendency to fade on exposure to light, but on the Cossa panel the layer containing the blue dyestuff is completely protected from photochemical degradation by the overlying opaque sky paint. This underlayer seems to have been laid in as an initial means of developing the tonal gradation seen on the picture, from an intense blue at the top to the very pale blue of the horizon. Beneath the lightest areas of sky, the blue dyestuff is present only as scattered grains of pigment between the gesso and upper paint layer. The ultramarine in the body paint of the sky is of high quality containing a proportion of lazurite particles large enough to be visible on the picture with a hand-lens. The paint here has a noticeably gritty texture. A final glaze of pure ultramarine, unmixed with white pigment, forms the surface layer of the most intense blue area over a thicker layer of ultramarine and white.

A second feature of Cossa's choice of materials also proved of note. The very dark green of the foreground, both left and right, was found to have been painted as a moderately thick (*c.* 100μ) single layer containing pale to mid-green pigment in the form of crystalline spherulites (Plate 13b, p.44). The X-ray powder pattern of the pigment proved to correspond exactly with that of malachite (basic copper carbonate, $CuCO_3.Cu(OH)_2$) [6]. Malachite of this particle form has now been identified in five *quattrocento* panels belonging to the National Gallery [7], and appears to be a type distinct from the usual irregular mineral fragments which characterize natural malachite when ground as a pigment. Two possible interpretations for the observed pigment form seem reasonable. One possibility is that the malachite is of natural origin and has undergone reaction and partial dissolution in the paint medium causing the irregular surface form to have been lost. (Reactions of this type involving both malachite and verdigris in proteinaceous media have been reported to have taken place with complete reaction of the pigment on illuminated manuscripts [8].) Alternatively, the pigment is an artificial malachite prepared by precipitation, the globular particle form being a consequence of its mode of formation from solution [9]. The weight of evidence seems to favour the second explanation. By transmitted light under the microscope, the globules can be seen to consist of aggregates of needle-shaped crystallites which radiate from a common nucleation centre to form a roughly spherical particle. This internal structure is particularly apparent when the particles are viewed between crossed polars [10], and it is a particulate type consistent with quite specific conditions of precipitation [11]. A fair proportion of the green pigment in the Cossa (as well as in the other examples cited in Note 7) was found to be in the form of *twinned* spherulites, with two incompletely spherical particles fused at a common face. Aggregates of more than two particles similarly united are also present in the paint sample; a feature which accords well with the particle characteristics of some recently prepared examples of green verditer (artificial malachite) [12], in which twinned spherulites and larger groupings are common. It seems very improbable that the particle structures just described could arise from the interaction of natural malachite with the paint medium (see below and [13]).

Malachite of spherulitic particle form was also found to be the pigment of the angels' dark green drapery and to be present in the pale green underpaint for the flesh tones of the small figures in the sky. It appears, in fact, to be the only pure green pigment used on the panel [14].

Perhaps the most unusual of Cossa's choice of pigments proved to be that of 'mosaic gold' [15], used to depict the horizontal rail from which the amulet and rosary hang. Although no further samples were taken, it is clear from the surface quality and colour of the paint that the same pigment had also been employed for the legs of the podium on which the Saint stands, the edges of the book, the small clouds which border the lower edge of the gilded background, and for the mandorla enclosing the figure of Christ. Mosaic gold is synthetically produced tin (IV) sulphide (SnS_2). Microscopically it consists of golden-yellow crystalline platelets with a bronze-like metallic lustre (see Plates 12 and 13c, p.44). In transmitted light the pigment is a deep golden-orange and weakly birefringent. The material used by Cossa was shown to be tin disulphide by XRD and laser microspectral analysis (LMA) [16]. So far as we know, no occurrence of this pigment has previously been reported on an easel painting, although Cennini mentions its use, somewhat disparagingly, for panels. Recipes for mosaic gold were fairly common in the fourteenth century, involving a seemingly arcane chemical process, but the material appears to have been regarded mainly as a substitute for real gold in manuscript illumination and miniature painting [17]. On *S.*

Vincent Ferrer it is unlikely that mosaic gold was used to mimic genuine metallic gold, since true gilding forms a significant part of the composition; more probably its unique quality was thought desirable in its own right. Some additional evidence for this conclusion is provided by Cossa's use of thin highlight lines of opaque yellow in conjunction with most of the areas painted in mosaic gold. Together the effect can be compared to the combination of brown earth pigments with lead-tin yellow highlights so favoured by the Early Netherlandish School painters to depict objects wrought in metal [18]. In the Cossa, these yellow highlights are painted in pure lead-tin yellow (demonstrated by XRD to have the crystal structure designated 'type I' [19]), and show clearly as fine white lines on the X-radiograph against a dark background where mosaic gold, which has a low absorbence for X-rays, alone is present.

In addition to the more unusual pigments discussed above, the following were also identified:
Vermilion (red mercuric sulphide, HgS), used alone for the rosary beads; in mixture with lead white for the flesh of Christ and the angels; and in combination with earth pigments, white and black for the multilayered paint of the Saint's flesh.
A red lake pigment used on its own as a moderately thick glaze over a thin lead white underpaint to depict the cloth draped over the podium. The substrate for the lake pigment was shown by LMA to be hydrated aluminium oxide, and it is hoped that the red dyestuff will be identified at some future date by thin-layer chromatography.
Lead white, confirmed by XRD to be of the normal basic lead carbonate composition, in the light grey stone plinth for the podium.

The paint medium of No.597 has been investigated by gas-chromatographic analysis (GC) and the results reported in summary on p.67. Analyses obtained by GC were supplemented by staining and heating tests. In the areas sampled for GC, egg was found to be the binding medium in the Saint's black cloak, his grey frock, and in the pale blue paint of the sky. A sample of the green containing 'spherulitic' malachite as the pigment gave a chromatogram with a very large peak for palmitate but low in azelate, and this suggests a medium of yolk of egg. The relatively high lipid content was also detectable with the oil stain, Sudan black. Staining reactions using amido black 10B at varying pHs suggested the presence of egg proteins in the grey paint of the plinth, in the white drapery of the angel at the top right edge, and in a sample of mosaic gold [20]. The staining intensities were found to be at a maximum for a low pH staining reagent and this has been interpreted as indicating a medium rich in egg yolk [21]. Egg was similarly shown to be the medium for the red lake glaze of the cloth covering the podium, and this perhaps accounts for its rather turbid appearance in a cross-sectional sample.

It was pointed out at the beginning of this note that Cossa's *S. Vincent Ferrer* although an egg tempera painting is in parts fairly thickly painted. The rather richer, thicker technique is confined to the central subject, in particular the Saint's flesh and black cloak. The paint of the cloak comprises two layers — an undermodelling layer consisting of lead white and carbon black, and an upper layer of carbon black alone, apparently very rich in egg medium. Although the final layer cannot strictly be described as a 'glaze', the paint has a translucency and glossiness as a consequence of the high proportion of medium present in the film [22]. *S. Vincent Ferrer* can thus perhaps be regarded as a work in which egg tempera paint has been pushed to the limits of the optical effects of which it is capable.

Notes and references

1. DAVIES, M., *National Gallery Catalogues: The Earlier Italian Schools* (London 1951), p.116.
2. VASARI, G., *Le Vite de più Eccellenti Pittori Scultori ed Architettori,* Gaetano Milanese (ed.), Vol. III (1878), p.133.
3. GETTENS, R.J. and MROSE, M.E. 'Calcium Sulphate Minerals in the Grounds of Italian Paintings', *Studies in Conservation,* **1**, 4 (1954), p.183.
4. For an explanation of why incised lines appear white on an X-radiograph, see PLESTERS, J., 'A Technical Examination of Some Panels from Sassetta's Sansepolcro Altarpiece', *National Gallery Technical Bulletin,* **1** (1977), p.10.
5. Cennino Cennini refers to indigo in a number of contexts. The most notable occurrence of indigo in a fifteenth century Italian picture in the National Gallery is in the blue paint of the blue and gold background of the Virgin's throne in Crivelli's 'Altarpiece: The Virgin and Child with SS. Francis and Sebastian' (No.807).
6. See ASTM data card No.10 – 399.
7. In addition to the present panel, 'spherulitic' malachite has been identified in two Sassetta panels from the Sansepolcro altarpiece (Nos.4757 and 4758); Bellini's 'Blood of the Redeemer' (No.1233); and Giovanni di Paolo's 'SS. Fabian and Sebastian' (No.3402), see *National Gallery Technical Bulletin,* **1** (1977), p.13 and Plate 2d, p.15; **2** (1978), p.23, Plate 7, p.47, and p.65. The pigment has also been noted in a small panel given to Botticelli belonging to Glasgow Art Gallery ('The Annunciation').
8. FLIEDER, F., 'Mise au Point des Techniques d'identification des Pigments et des Liants inclus dans la Couche Picturale des Enluminures de Manuscrits', *Studies in Conservation,* **13**, 2 (1968), p.62.
9. The earliest recipes for green verditer (artificial malachite) seem to date from the mid-seventeenth century, whereas those for blue verditer (artificial azurite) appear much before this. There is no reason why green verditer should not have been manufactured and used as a pigment quite early, but it is possible that the basic procedure was so well-known that there was no need for the recipes to be recorded. It is probable that the green product was quite variable in its properties, and often too fine-grained and pale-coloured to make a good artists' pigment. The globular particle variety because of its relatively large

particles is of fairly strong colour and may have been regarded as a satisfactory pigment, but might not have been a controllable product of precipitation.
See MACTAGGART, P. and MACTAGGART, A., 'Refiners' Verditer', *Studies in Conservation,* **25,** 1 (1980), p.37ff.
10. See CHAMOT, E.M. and MASON, C.W., *Handbook of Chemical Microscopy,* Vol. I, Johny Wiley (New York 1958), p.340 and p.395. A black-and-white photomicrograph of artificial basic copper carbonate between crossed polars is reproduced in GETTENS, R.J. and FITZHUGH, E.W., 'Malachite and Green Verditer', *Studies in Conservation,* **19,** 1 (1974), p.16.
There is a superficial microscopic resemblance between green verditer and the nineteenth century pigment emerald green (copper acetoarsenite), although the latter tends to be a more intense colour. To avoid possible confusion the presence or absence of arsenic in addition to copper should be established, or the pigments distinguished by XRD.
11. MACTAGGART, P. and MACTAGGART, A., *op. cit.,* p.39.
12. I am grateful to Peter and Ann MacTaggart for kindly supplying some of their specimens of blue and green verditer.
13. In one sample from Giovanni di Paolo's 'SS. Fabian and Sebastian' (see Note 7 above), spherulitic particles of malachite were found in mixture with lead-tin yellow. It is unlikely that in paint of this pigment combination sufficient reactive components of the paint medium (egg) would be available to partially dissolve the malachite.
14. Some thin brown glazes present on the background rocky landscape were initially assumed to be discoloured 'copper resinate'. However, LMA failed to detect any copper in either of two samples, although iron was present in the layers, and particles resembling earth pigments and charcoal were evident microscopically.
15. The origin of the name 'mosaic gold' (*aurum musicum,* and variants) is obscure. To compound the mystery Cennini unaccountably calls the pigment *'porporina'* (purple).
16. Tin was shown to be the only metallic element present in a sample by LMA, and the X-ray powder pattern was in very good agreement with that for tin (IV) sulphide (ASTM data card No.1 – 1010). The eight strongest lines in Angstroms of the XRD pattern for SnS_2 are: *5.9* (50), 3.15 (40), *2.78* (100), *2.14* (50), 1.82 (50), 1.74 (40), 1.66 (13), 1.52 (20). Relative intensities in brackets.
17. A detailed recipe for mosaic gold occurs in a Latin manuscript known as 'De Arte illuminandi', thought to date from the second half of the fourteenth century. See BRUNELLO, F. (ed.), *De Arte Illuminandi e altri Trattati sulla Tecnica della Miniatura Medievale* (Vicenza 1975), p.55.
No less than six separate procedures for making mosaic gold are recorded in the fifteenth century treatise known as the 'Bolognese Manuscript'. See Chapter VI of the 'Bolognese Manuscript', recipe nos. 141 – 5 and 168, in MERRIFIELD, M.P., *Original Treatises on the Arts of Painting,* Vol. II, John Murray (London 1849), p.459ff.
Methods for preparing tin disulphide continue into eighteenth and nineteenth century sources, usually for purposes connected with the decorative arts.
Two occurrences of mosaic gold use are cited in the literature: On vellum in the miniatures of a fifteenth century 'Flemish Book of Hours', see ROSS, J.L., 'A Note on the use of Mosaic Gold', *Studies in Conservation,* **18,** 4 (1973), pp.174 – 6; and on some early German playing cards, datable to about 1430, see RICHTER, E-L. and HÄRLIN, H., 'The "Stuttgarter Kartenspiel" ', *Studies in Conservation,* **21,** 1 (1976), pp.21 – 3 and fig.6b.
Janet Ross *(op. cit.)* describes the pigment as 'a golden-brown of medium intensity and value [with] a very subdued sparkle', and this succinctly captures its appearance on the Cossa.
It is interesting that mosaic gold should first have come to light on a Ferrarese painting since it has been noted that the art of manuscript illumination was a great Ferrarese speciality. André Chastel mentions a magnificent two-volume illuminated bible commissioned by Borso d'Este and kept at the Palazzo di Schifanoia. The palazzo was later decorated with frescoes by Cossa, and although we do not know whether mosaic gold was employed in the illuminated bible, it seems a possibility and Cossa would almost certainly have seen the work. See CHASTEL, A., *Italian Art* (trans. P. and L. Murray), Faber & Faber (London 1963), p.193 and p.195.
18. See for example, follower of van der Weyden, 'The Exhumation of S. Hubert' (No.783).
19. Lead-tin yellow 'type I' is Pb_2SnO_4. See KÜHN, H., 'Lead-tin Yellow', *Studies in Conservation,* **13,** 1 (1968), p.11 and p.31.
20. Mosaic gold would only be likely to display its characteristic, slightly lustrous appearance in aqueous media; in oil the pigment would probably merely seem 'muddy'.
21. MARTIN, E., 'Some Improvements in Techniques of Analysis of Paint Media', *Studies in Conservation,* **22,** 2 (1977), pp.63 – 5.
22. Black pigments do not normally appear really dark and fully saturated in egg tempera or other aqueous media. In this case Cossa may have sought a darker, more saturated richness for the Saint's cloak through a higher than usual proportion of egg medium or egg yolk content in the paint.