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# Some Panels from Sassetta's Sansepolcro Altarpiece

Martin Wyld and Joyce Plesters

## The restoration of some panels from Sassetta's Sansepolcro altarpiece

Martin Wyld

On September 5, 1437, Stefano di Giovanni signed a contract to paint the high altarpiece for the Church of San Francesco at Sansepolcro. Stefano, who is now universally known as Sassetta, was to paint the altarpiece in Siena within four years, and then accompany it to Sansepolcro to repair any damage that might occur during the journey. The altarpiece was actually delivered in 1444, and Sassetta received the third and final part of the payment as laid down in the contract of 1437. The main parts of the altarpiece, although their exact arrangement is not clear, can be identified as being: *S. Francis Triumphant*, and full length figures of *S. John the Baptist and the Blessed Ranieri* (Berenson Collection); *The Virgin and Child* and the full length figures of two saints (Louvre); *The Marriage of S. Francis to Poverty* (Musée Condé, Chantilly), and seven more narrative scenes from the life of S. Francis (National Gallery Nos.4757–4763, Figs.1–8). The altarpiece was a double-sided pentaptych; the front consisted of *The Virgin and Child* flanked on each side by two full length saints, and the back of *S. Francis Triumphant* flanked on each side by four of the narrative scenes (the seven National Gallery pictures and that at Chantilly) in two rows.\* The original arrangement of the narrative scenes is not recorded, and is still the subject of research.

The altarpiece is said to have remained in the church or in the adjacent priory until 1810, after which date the parts were variously dispersed. The eight narrative panels changed hands several times, belonging amongst other owners to the Florentine dealer Carlo del Chiaro, and, some years before 1840, to Count Anatole Demidoff. In 1840 the Chantilly picture, *The Marriage of S. Francis to Poverty*, was sold separately, and some time before 1877 *The Legend of the Wolf of Gubbio* (National Gallery No.4762) was separated from the other panels, the remaining six of which were later acquired from a church in Corsica by Emmanuel Chalandon. Lord Duveen acquired these six pictures from Georges Chalandon in 1925, and the following year acquired *The Legend of the Wolf of Gubbio* from another source. In 1927 Duveen sold all seven pictures to Clarence Mackay of Long Island, from whom the National Gallery purchased them in 1934. The rather disingenuous part played in this purchase by Duveen as both a trustee of the Gallery and as a former owner of

the pictures is described very entertainingly in Lord Clark's autobiography.

Although much of the original frame of the altarpiece has been lost, and also possibly some predella and pinnacle panels, it is clear that the techniques used in its construction are in general those used in Italian painting in the fourteenth and fifteenth centuries. The poplar panels, which in this case were about 4cm (1½in.) thick, and the frame into which they were to be fitted, were gessoed and gilded before the actual painting was started. In the case of the eight narrative scenes, whose dimensions are each about 89×54.5cm (35×21½in.) including the unpainted edges covered by the frame, poplar planks wide enough not to need joining were used. The grain of the wood is vertical on all the surviving panels, and it has been suggested that each pair of vertically adjacent narrative scenes was painted on one plank, which would have made the construction more rigid. Owing to the way in which the panels have been treated since the altarpiece was broken up the evidence for or against this possibility is lost. The top corners of the eight panels, adjoining the trefoil, were decorated in pastiglio; the corners of the frames of the four pictures in the top row were a different shape, being cut away.

By the time the pictures arrived at the National Gallery, all seven had undergone several restorations, the most recent and drastic of which had probably taken place while they were in Duveen's possession in 1926–7. The painted parts of the panels had been sawn out of their frames (which by then were probably partly nineteenth century) reduced in thickness to almost ½cm from their original 4cm, and heavy cradles had been fixed to the backs of the panels. This left the pastiglio work of the top corners with its original thickness of panel attached to the frame. The painted parts of the panels were then replaced in their frames without regard for matching them with their original spandrels. This, together with the cutting away of the backs of the panels, destroyed almost all the evidence which might have shown how this part of the altarpiece was joined, and, by implication, the position of the various panels in it. All that can now be said with certainty is that four of the National Gallery pictures were in the upper row. The Chantilly picture has not been separated from its spandrels, nor has the panel been reduced in thickness, and because the top is square it must have been in the lower row. In corroboration, three of the National Gallery frames have rectangular tops and must have been in the lower row (Figs.9, 10, 11, 12).

It is recorded that the eight narrative panels were restored while they were in the possession of del Chiaro in the second decade of the nineteenth century, but no detailed description of the restoration exists, nor is it known whether they had been restored before. It is

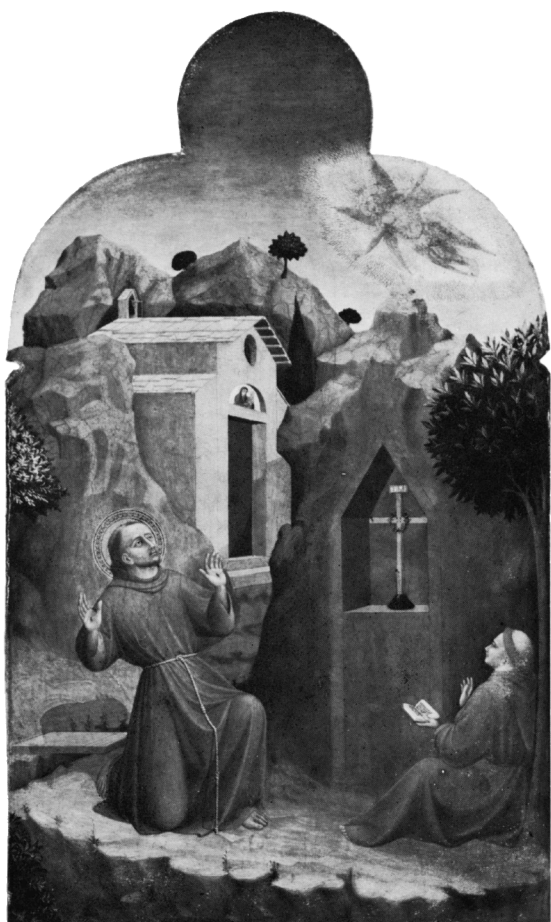
\* For a full account of the history of the altarpiece, see Martin Davies, *The Early Italian Schools*, Second Edition (revised) 1961.



**Figure 1**  
(Far left)  
N.G. No.4757  
*The Whim of the young S. Francis to become a soldier* (after cleaning and restoration).



**Figure 2**  
(Left)  
N.G. No.4758  
*S. Francis renounces his earthly father.* (after cleaning and restoration).



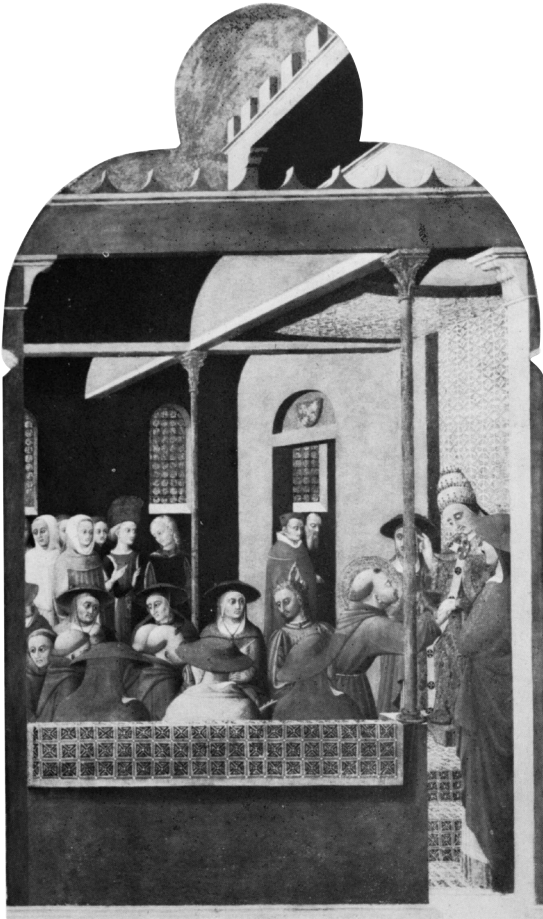
**Figure 5**  
(Far left)  
N.G. No. 4760  
*The Stigmatisation of S. Francis* (before cleaning).



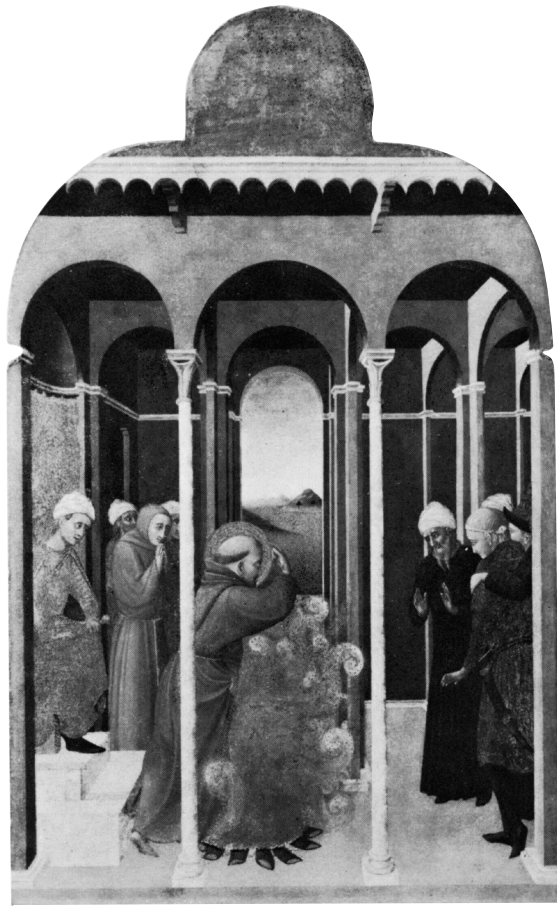
**Figure 6**  
(Left)  
N.G. No. 4762  
*The Legend of the Wolf of Gubbio* (before cleaning).



**Figure 3**  
(Right)  
N.G. No.4759  
*The Pope accords  
recognition to the  
Franciscan order*  
(after cleaning  
and restoration).



**Figure 4**  
(Far right)  
N.G. No.4761  
*S. Francis bears  
witness to the  
Christian faith  
before the Sultan*  
(after cleaning  
and restoration).



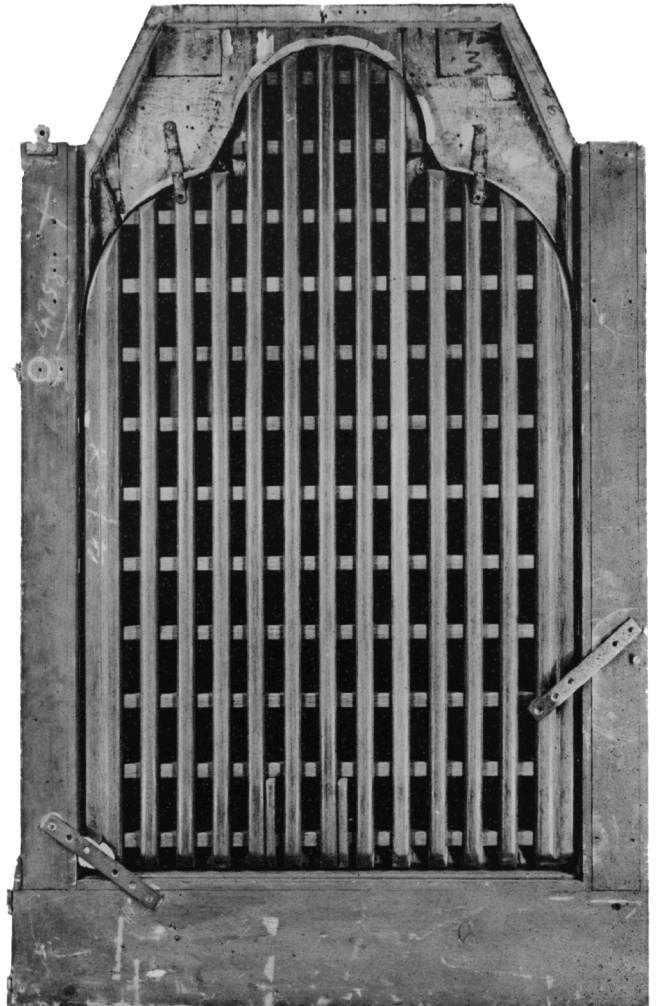
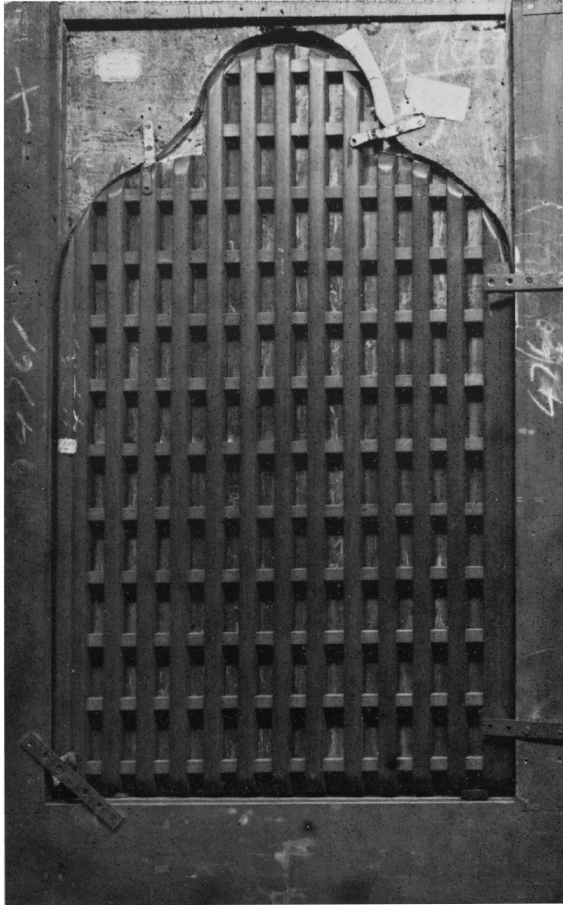
**Figure 7**  
(Right)  
N.G. No.4763  
*The funeral of  
S. Francis (before  
cleaning).*



**Figure 8**  
(Far right)  
Musée Condé,  
Chantilly,  
*The marriage of  
S. Francis to  
Poverty.*







**Figure 9** (*Top left*). The back of N.G. No. 4761, showing the cradled part of the panel and the original wood of the spandrels. The remainder of the frame is modern.

**Figure 10** (*Left*). The back of the Chantilly panel.

**Figure 11** (*Top right*). The original pastiglio work still attached to the Chantilly panel.

**Figure 12** (*Above*). The cut top corners of the spandrels suggests that they were in the top tier of the narrative panels; the picture in the frame, N.G. No. 4758, does not necessarily belong in it.



feasible that the altarpiece remained undisturbed in the church of San Francesco from 1444 until 1752, when it is said to have been dismantled and stored in the priory. No other restoration of any of the pictures is recorded, although there may have been several by the time of their acquisition by the National Gallery in 1934.

On their arrival only one of them, *The Legend of the Wolf of Gubbio*, was thought to be in sufficiently bad condition to require treatment. According to the National Gallery Manuscript Catalogue 'The picture was cleaned by Holder, the old varnish being more or less removed according to the amount of original and new paint underneath. In general, the top half was nearly stripped, but the figures still retain much of the former varnish. Thereafter many old stoppings uncovered by this process were tinted in by Holder and the whole varnished. Finished 25 March, 1935.'

Looking at this picture in 1974, when the possibility of cleaning the seven panels was under consideration, it was easy to understand Holder's piecemeal approach. There were a few small damages in the sky, but the lower part of the picture was badly disfigured by darkened retouchings, which obviously covered substantial paint loss (Fig. 13). Further distortion was caused by the old varnish left by Holder during his partial cleaning being very discoloured, whereas the new varnish applied by him had not yellowed much, making the sky very bright in comparison to the landscape and figures. Had *The Legend of the Wolf of Gubbio* been the only panel from the Sansepolcro altarpiece which the National Gallery possessed, cleaning would not have been considered. However, even a superficial visual examination made it clear that none of the other six panels had suffered so much damage, three of them being in very good condition. It may be useful to summarize here the factors which, after much discussion, influenced the decision to clean the seven Sassettas.

1. The soft resin varnishes used by previous restorers had discoloured and also sealed in layers of surface dirt which further obscured the original colours.

2. The varnish layer had become so thick that it disguised the texture of the paint, and the difference between thickly and thinly painted areas (e.g. the thick paint of the trees in *The Stigmatization* as opposed to the thin paint of the surrounding landscape) was lost. Also deprived of any impact were S. Francis' gilded haloes and the gold decorations in the fire into which the saint steps to prove his faith to the Sultan. The lines incised into the gesso as a preliminary underdrawing, and which caused slight depressions in the paint, were either accentuated by being filled with dirt, or, if not, made invisible by the varnish.

3. The old retouchings had discoloured, covered original paint in good condition as well as damaged areas, and in places were so inept that they seemed to undermine Sassetta's intentions, e.g. a damaged capital in S. Francis before the Sultan had been restored in a sort of reversed perspective.

With most early Italian pictures it is comparatively easy, even through a thick layer of discoloured varnish, to form a reasonably clear idea of the condition of the paint by straightforward visual examination in good light. With rare exceptions, the texture of the retouch-

ings is so unlike that of the original paint that they are easily distinguishable. This was in general true of the Sassettas, and further examination in raking light, under low magnification and with a stereoscopic microscope at 15×–40× magnification provided very accurate information about the state of the paint surface and the extent of the retouchings. This sort of information can be recorded and augmented by photography and by laboratory analysis. X-radiographs were taken of the more damaged areas of the pictures, but were not in this case as illuminating as they often are. Sassetta did not use much white lead, so there was little to interrupt the X-rays on their way through the picture, and the cradles on the backs of the panels confused and blurred the X-radiograph image. The latter difficulty could have been overcome by removing the cradles, but this would only have been justified if there had been serious doubt about the condition. Infra-red and ordinary black and white photography were more useful for recording the condition of the pictures before cleaning, and particularly of the extent of the old retouchings (Fig. 14). The laboratory work carried out at this time by Joyce Plesters is described later in a separate section.

It is unusual if the circumstances in which old pictures have been damaged are known, and the Sassettas are no exception to this. The only physical treatment which will be documented is that currently being completed, long after the cutting down of the backs of the panels and the flaking of paint from the front. The work carried out on the panels, apart from destroying evidence about the original construction of the altarpiece, was probably quite unnecessary. The Chantilly panel, and the surviving spandrels of the National Gallery pictures, are well preserved; there is no tendency to warp and neither are there joins in the panels which could open. The National Gallery panels have been slightly attacked by woodworm, which can be treated without too much difficulty, but not by dry rot, and the remaining planed-down wood is in good condition. The cradles themselves are remarkable in that all the cross members still move easily. This may be because so much of the backs of the panels are covered by the cradles that they are unable to react to changes in temperature and humidity. Because the panels have remained stable for at least the forty years they have been at the National Gallery, and because they will always be kept in a controlled environment, the cradles have been left, the only treatment carried out being the cleaning of the movable cross members.

The paint surface of the pictures has suffered from one major and one minor kind of damage. The majority of the losses are due to the paint and ground together flaking away from the panel; this can be attributed to the glue in the gesso ground slowly decomposing after prolonged exposure either to damp or to frequent changes in temperature and humidity, and is not the result of a defect in the paint layer itself. It is not easy to say why one picture should suffer so much more than another from this sort of damage when as far as is known they have been identically treated. While it is true that *The Legend of the Wolf of Gubbio*, which was separated from the other panels, is the most damaged, there is no obvious reason why *S. Francis before the Sultan*, for



instance, should have flaked badly whereas *The Stigmatization* has not. It may be that panels in the lower row in the original altarpiece flaked more than those in the upper, or vice versa, but the real explanation is probably more mundane.

The minor cause of paint loss is due to an aspect of Sassetta's technique. In all the National Gallery pictures, except for *The Stigmatization*, he made use of silver leaf as well as the more conventional gold leaf, mainly as an underlay for ultramarine or crimson coloured garments. In particular, the areas where the silver leaf was glazed with a crimson coloured lake pigment have not survived. This can be seen most clearly in the robe which S. Francis is wearing in his two appearances in the first picture in the series (Plate 3, page 16), and which his irate father holds over his arm in the second (Figs. 14–16). Because of the damage that has occurred, the sequence of the painting process is clearly visible; the gesso ground, orange-red bole, silver leaf and the remains of the crimson glaze. Since all the areas where this method is used are damaged in a similar way, and since silver leaf is known to be unsatisfactory when painted over owing to its tendency to corrode, it is reasonable to assume that the damage is a result of a defect in the painter's technique or to his use of an unstable material. This sort of damage is essentially different to those areas where the paint and ground have flaked away together in that it is confined to the silver

leaf and the paint layer above it; the gesso ground and the red bole generally survive. A fuller description will be found in Miss Plesters' contribution. It is worth noting that Sassetta made substantial use of silver leaf in the central panel of the front of the altarpiece, *The Virgin and Child* (Louvre), and that the silver is similarly damaged to that in the National Gallery pictures.

Until recently, restorers almost automatically retouched any damaged areas in pictures, and, if the damages were large, had no qualms about re-inventing the missing parts. This had resulted, in the case of the Sassetas, in some peculiar effects which were fortunately hidden by the old discoloured varnish. Figs. 15 and 16 are details of the robe, mentioned in the previous paragraph, which S. Francis' father is holding over his arm. Fig. 16 shows exactly what is left of the original picture, that is to say, the red bole, the remains of the silver leaf, some of the underdrawing and a few minute scraps of the crimson glaze. Fig. 15 shows the same detail before cleaning; a previous restorer has reconstructed the robe, vaguely following the underdrawing, in a dull red colour with no silver underneath it. This re-painting, quite different in effect from the original transparent crimson glaze over silver leaf, has made the robe unrecognizable as the one which S. Francis is wearing in the previous picture in the series (Plate 3). The narrative content of this scene from the Saint's life is obscured by the old restoration.





The most difficult decision to be made after the removal of the old varnish and retouchings is how much, if any, retouching should be done. The general principles employed in the restoration of the Sassettas were:

1. To retouch only where there could be no reasonable doubt about what was missing, e.g. the many losses in the background architecture of *S. Francis before the Sultan* were restored. By contrast, the damages in the Sultan's robe in the same picture, where gold leaf and painted decoration had flaked away, were simply toned down to match the colour of the original red bole.
2. To retouch only where all the original paint layers were missing, e.g. where all that remained was the panel or gesso ground. Thus there was no question of trying to restore S. Francis' damaged robe (Figs. 14–16) because traces of the original underlayer remained; restoration in this case was, of course, also precluded by the amount of invention that would have been necessary.

3. To use materials which, as far as present knowledge allows, do not discolour or become insoluble. The varnish used was MS2A, and retouching was carried out in egg tempera (over an isolating layer of varnish) glazed with Paraloid B72.

The aim of the retouching is not to make the picture appear 'whole' again but to enable the well-preserved parts to be easily visible without either damages or retouching distracting attention from them.



(From left to right)

**Figure 13.** Detail of N.G. No. 4762. The lighter rectangle is a cleaning test, and the dark spots in the landscape are old retouchings.

**Figure 14.** Detail of the infra-red photograph of N.G. No. 4758, before cleaning. The dark areas e.g. on the cloak and legs of S. Francis' father are old retouchings.

**Figure 15.** Detail of No. 4758 before cleaning. The robe over S. Francis' father's left arm is entirely the work of a restorer, covering what can be seen in Fig. 16.

**Figure 16.** Detail of No. 4758 after cleaning and restoration. The overall tone is the red bole; the lighter spots are the remains of the silver leaf.

## A technical examination of some panels from Sassetta's Sansepolcro altarpiece

Joyce Plesters

The restoration described above of the seven Sassetta panels (National Gallery Nos.4757–4763, Figs.1–7) provided an opportunity to examine them in ideal conditions and to take a limited number of samples. Most of the samples were from the first panels to be treated, No. 4757 *The Whim of the Young S. Francis to become a Soldier* and No.4758 *S. Francis renounces his Earthly Father*, because the problems of condition and technique encountered in these two were for the most part repeated in the other five panels.

Large gilded polyptychs were a feature of fourteenth and fifteenth century Italian painting. In the Sienese School the most distinguished antecedent of Sassetta's Sansepolcro altarpiece is Duccio's *Maestà* for Siena Cathedral, which like Sassetta's is painted front and back (the National Gallery has three small predella panels from the back). It happens that a detailed account of the restoration and examination of the *Maestà* has been published (1) and although over 130 years and considerable stylistic differences separate the two altarpieces, their materials, construction and painting technique have much in common. The greatest technical advances during the intervening period were in perspective, modelling and effects of light, reminding us that Alberti's *Della Pittura* was written, albeit in Florence, almost ten years before Sassetta's altarpiece was completed. No documentary source of Sienese origin has come to light describing painting methods of the time. The nearest we can get is Cennino Cennini's treatise on painting which, although written in the early fifteenth century, harks back to Florentine practice of the fourteenth. Perhaps Florence and Siena were less far apart technically than artistically, for many of the features noted in the Sassetta *S. Francis* panels are described with such striking accuracy in Cennino's treatise that it seems worthwhile to quote some of the relevant passages (2).

In the account given below an attempt is made to interpret the results of technical examination in terms of the artist's methods and materials. Space does not permit a detailed analytical report of every sample. The layer structure of the paint was studied and the pigments identified by methods of optical and chemical microscopy (3) supplemented by laser microspectral analysis (see p.23) and X-ray diffraction analysis (4).

### The wood panel supports

Lens examination of the end grain of the wood along the lower edge of each panel, combined with microscopical examination of thin transverse sections confirmed that all seven panels were of poplar wood. The wood of the top corners of the panels, still attached to the frames and retaining the original thickness, gave an identical result.

It is unfortunate that on the X-radiographs the image of the wood grain of the original panels is practically

obliterated by those of the paint film and the heavy mahogany cradles on the backs, so that it is impossible to tell if initially any pairs of the panels were painted on a single vertical plank.

### The gesso ground

The moderately thin white gesso ground can be seen in some of the cross-sections of samples in Plate 2. The white inert, identified chemically as calcium sulphate, was confirmed by X-ray diffraction to be anhydrite ( $\text{CaSO}_4$ ) with a small proportion of gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ).

### The drawing of the design on the gesso ground

Cennino describes drawing with charcoal and ink on the gesso and in fact in cross-sections from a few samples (e.g. Plate 2,) some grains of black are seen between gesso and paint. In the infra-red photograph (Fig.14) black drawing shows up in the head-dress of S. Francis's father and it is also found under flesh paint. To delineate areas to be gilded Cennino recommends incising the outlines in the gesso with a needle and this method Sassetta has used extensively and not confined to gilding. A very fine needle has been used. The verticals and horizontals of the architecture have been ruled with a straight edge and not only the haloes, but also the curves of the arches and vaults done with compasses. That the outlines were scratched in the gesso before painting began is demonstrated by the fact that they show white on the radiographs. The wet paint has run into the channels and made the incised lines more opaque to X-rays than the surrounding area. Sassetta may have been attracted by the precision of the incised line. A disadvantage is that it cannot easily be obliterated, as compared with the drawn or painted line, either by rubbing out or painting over. Not unexpectedly some *pentimenti* occur between the drawing and painting stages. For example in No.4757, *The Whim of the Young S. Francis*, the arch farthest to the right of the balcony has been drawn in perspective but never painted; in No. 4763, *The Funeral of S. Francis*, a pattern of incised intersecting arcs can be seen representing an earlier and alternative arrangement of the roof vaults to that actually painted. The most unexpected use of the technique is in No.4762 *The Wolf of Gubbio*, where the flight of birds, an enchanting feature of the picture, follows exactly the curve of an incised line, faintly traced with an unfaltering hand. It implies, incidentally, that the flight of birds was not a last-minute fancy, but envisaged in the earliest stages of the composition.

### The application of bole and gilding to the panels

In earlier Italian altarpieces, for example the Duccio *Maestà*, figures, and even landscapes, are set against a background not of sky but of burnished gold, a deliberate anti-naturalistic device. Four of the Sassetta panels have gold backgrounds, though confined to a small area of the trefoiled top. The other three and the Chantilly panel (Fig.8) have blue skies. No.4761 *S. Francis before the Sultan*, presents the contradiction of blue sky seen



through an arch within the building and gold leaf above the rooftop. Beside the gold background and frame, gilding was incorporated in the main area of the painting for haloes, jewellery and other objects of precious metal, and particularly for gold-brocaded drapery. Once the gesso ground had been laid, the next step was to apply bole and metal leaf to all areas featuring gold, tin or silver (these last two being used comparatively rarely). The technique of gilding is well-known and need not be described in detail here, except to say that in the Sassetta panels water-gilding, as distinct from oil-gilding, is used. In water-gilding, common practice, even to the present day, is to use the glue medium of the bole as the adhesive for the gold leaf. Cennino, however, specifies egg white. In the course of comparing gilding on the panels of the Sassettas with that on their frames (see p.17) the medium of the various samples of bole was analysed. In every sample the medium was identified as animal glue, not egg protein (5). The bole on the Sassetta panels, large areas of which are exposed where gilding and paint has been lost, appears unusually red, almost vermilion in hue, but laser microspectral analysis gave the principal elements as Al, Fe and Si, indicative of the usual type of red clay. When a particular feature is to be gilded the bole and gold applied usually extends a little beyond the contours, the surplus gold leaf being either scraped off or else subsequently covered by the paint of the surrounding area. The gold leaf of the Saint's halo in No.4760 *The Stigmatization*, continues under the paint of the rocky landscape for a few millimetres. Unfortunately paint sticks very badly to gold, as many losses on the Sassetta panels testify. An interesting discovery was that along the periphery of the painted surface of each panel there runs a narrow (1–2mm) band of bole and gold leaf between gesso ground and paint layer. The likely explanation is that the gessoed panels were already fixed in their (gessoed) frames and the gilding of frame and panel done in a single operation. This was the case with the Duccio *Maestà*, except that additionally frame and panel were gessoed as one.

### Embellishment of the gold and silver leaf

An intriguing aspect of Sassetta is that parallel with his keen interest in such Renaissance topics as perspective, he still succumbs to that passion for richly-decorated and gilded surfaces and two-dimensional pattern which had dominated Siennese painting in the previous century. It reached its furthest point perhaps in Simone Martini's *Annunciation* of 1333, now in the Uffizi Gallery. A comparison with Duccio shows that whereas the latter's speciality is the emphasizing of the edges and folds of draperies with a thin line of gold in the Byzantine tradition, Sassetta's predilection is for the adornment of surface areas with gold patterns (though there is nothing new in this—Florentines such as Orcagna were exponents of it long before). In using such techniques Sassetta is carrying on a long tradition while at the same time following the same current trend of International Gothic as Pisanello and Gentile de Fabriano. Whatever Sassetta's artistic intention, the actual techniques of gold and silver work to be seen in the seven *S. Francis* panels, and detailed below, are all described

by Cennino, who holds that branch of the painter's craft in the highest esteem. The lengthy account given below may serve to explain how what are now some of the most damaged parts of the paintings were once its great glory:

#### (a) Tooling

Haloes are obvious examples of tooling without addition of paint. Saint Francis in each of the seven panels (and in the Chantilly one) wears a rather plain halo consisting of concentric inscribed circles (drawn with compasses) enclosing an inner circlet of punched double rings joined by dots. For this a stylus and two ring punches would suffice. In tooling gold leaf a desirable skill is generally considered to be to indent the surface of the still slightly-yielding gesso without breaking the 'skin' of gold, but it looks as if the tooling of S. Francis's haloes went clean through to the bole. Even that is difficult to judge in the present condition where much of the bole lies bare. Tooling of gold leaf produces facets at different angles which reflect the light giving sparkle and interest to the flat surface. For example, the frame of S. Francis's bed in No.4757 is 'seeded' or punched all over with little dots to give it texture.

#### (b) Coloured glazes over metal leaf

A technique going back to the eighth century (6), early descriptions constituting some of the first mentions of the use of drying oils for mixing with pigments. In the Sassetta panels there were found three different coloured glazes—crimson, blue and green—over gold or silver.

*Crimson over silver:* While investigating the worn and patchy state of the dark red garment which the Saint wears in both scenes in No.4757, and which his father holds in No.4758, it was discovered that although much of what we now see is bare red bole, in places where the top crimson paint layer has survived it has beneath it silver-coloured metal leaf. A cross-section of a sample of paint from one of these areas in No.4757 can be seen in Plate 2a. It shows gesso ground, orange-red bole, a thin line of silver-coloured metal petering out to black, and finally a thick dark crimson paint layer. Laser microspectral analysis of a tiny detached sample (approx. 0.2mm across) identified the metal leaf actually as silver, not tin. Some hitherto inexplicable black patches of the dark red draperies were blackened silver. In order to protect silver from further tarnishing after the old discoloured varnish had been removed during cleaning, the areas in question on all the panels were immediately revarnished. The artist's original intention must have been for the silver to shine through a crimson glaze. The crimson pigment present was identified from its spectral transmission curve (see p.41) as a lake pigment of an organic dyestuff and of an insect- and not a plant-dyestuff, probably *kermes*. It is a suitably transparent pigment for glazing. Analysis of the medium of the red paint by gas chromatography (see p.58) indicated egg tempera, not oil. Now glazing in an aqueous medium such as egg tempera can never achieve the transparency, gloss or depth of colour of an oil glaze. Although oil glazes are described in full by Cennino, he does give alternative instructions for glazing in egg tempera under the heading 'How to design gold brocades in various colours... if you want to make the

cloth red, lay in with vermilion over this burnished gold. If you need to put any dark on it, put it on with lac; if you need to put on lights, put them in with red lead; *all tempered with yolk of egg*' (the present author's italics). Lac is, of course, a red lake pigment similar to that from kermes. Where in the Sassetta panels a crimson glaze has been laid over silver it has become so dull, dark and opaque that it obscures the metal surface it was meant to enhance. A slightly better idea of the artist's intentions may be gained from a similar dress worn by the figure with the sword at the extreme right of No. 4761, *S. Francis before the Sultan*. The crimson glaze still has traces of an incised brocade pattern revealing silver beneath. In the same figure the sword has been depicted by leaving part of the silver leaf of the garment free from red glaze and adding blackish modelling.

*Blue over silver*: silver leaf, again practically invisible to the unaided eye, was detected, for example, under the dark blue of the robe of S. Francis's father in No. 4758 and the upper part of the drapery of the man who touches the Saint's wound in No. 4763 *The Funeral of S. Francis*. In each case the blue pigment is natural ultramarine, highly suitable for glazing. Cennino describes its application over silver leaf, but with glue size as the recommended medium, even less successful for this purpose than egg. In fact solubility tests indicate that in the Sassetta samples the medium of the ultramarine over silver is more likely to be egg than glue. It may be noted that cross-sections of both blue and red glazes over silver show some blackening of the silver leaf under the glaze in addition to where it is exposed to the atmosphere. This may have been caused by sulphur compounds in the egg tempera medium, and it is even possible that discolouration and deterioration of the glazes themselves may come from some interaction of the glaze with the silver, especially since elsewhere in the picture blue and red glazes are found in excellent condition.

*Green over gold*: Cennino's instructions for green and gold brocade drapery are: 'Gild the ground; draw on it the subject you want; lay in the grounds with verdigris in oil. . . .' This technique appears to have been used in the Sassetta panels but unfortunately almost all the areas concerned have become so discoloured that J. Pope-Hennessy (7) could be excused for referring to the 'brown bedspread' in No. 4757 and to the bishop wrapping his 'brown cope' round the Saint in No. 4758. Yet both areas must originally have appeared as a clear, bright green glaze over gold. Copper was shown to be present in high concentration in samples of the brown glaze from both, and known brown pigments absent. Beneath the surface of each sample pockets of unchanged green glaze are visible and one or two green crystalline particles of low refractive index which look like verdigris. There was not sufficient sample for gas chromatography, but solubility tests indicated an oil medium rather than egg. Some small spots of green glaze have been miraculously preserved on the embroidered edge of the bishop's cope in No. 4763 *The Funeral of S. Francis*, and on the triptych depicted in the same panel. The bedspread of the Saint's bed in No. 4757, far from being brown may once have been exotically coloured, for a sample of the glaze under the microscope revealed both

pink and blue underpaint which were probably meant to be visible in some parts.

(c) *Patterns using opaque paint layers over gold leaf*:

Under the heading 'How to execute gold or silver brocades', Cennino describes how, having applied a coat of paint of the required colour so as to cover your gold leaf entirely, you draw on the painted surface the pattern of the brocade, then 'with a little style of birch, or hard wood or bone . . . with a point . . . at one end; and a little edge at the other, for scraping', you scrape away the paint from whichever parts of the brocade you wish to appear gold, whether background or pattern. Comparatively well-preserved examples in No. 4757 are the canopy of S. Francis's bed where ultramarine blue paint has been scraped away in the shape of stars to show the gold leaf beneath, and the exquisitely tooled white brocade pillow on which his head rests. In the same panel, in the midst of such highly sophisticated techniques, is a rather naive touch. The angel's pink dress is painted over gold leaf then the whole surface covered with tiny vertical scratches into which a crimson glaze seems to have been rubbed. The intention appears to have been to represent some pile fabric such as velvet. Cennino Cennini does describe 'How to do velvet' instructing that the 'cut threads' should be painted in oil paint with a brush (instead of first incised as here) but also advising the artist to 'make the cut threads rather coarse'. So coarse and widely-spaced are they on the angel's robe in No. 4757 that they look more like bristles than velvet, added to which the strokes all run vertically, independent of the movement of the drapery or the modelling of the figure. A similar effect is seen in the Saint's bedspread and in drapery on other of the panels. Initially the mandorla of the figure of Christ in No. 4760 *The Stigmatization* and the fire through which the Saint prepares to walk in No. 4761 *Saint Francis before the Sultan* were made more vivid by vermilion on top of the gold, but its impact is now diminished by wearing and by the surrounding red colour of the exposed red bole where gold and paint are lost. The curious punched dots in the flames of the fire may mark the site of more convincing sparks, perhaps done in the same way as the gold stars on the bed canopy. The device of imitating the glow of a fire with red paint over gold leaf can be seen in another Sienese predella panel of about the same period, National Gallery No. 5453, Giovanni di Paolo, *The Birth of S. John the Baptist*.

The canopy and backcloth of the bishop's throne in No. 4758 is now much of it bare bole, but near the top a small patch of crimson paint survives, a cross-section of a sample of which is shown in Plate 2c. On top of the gold leaf are no fewer than three layers, first lead white, then vermilion and lastly a thick crimson glaze. This suggests that all three of the techniques (a), (b) and (c) described above were combined, the paint scraped through to different levels to reveal the various colours, so producing a lavish gold, white, scarlet and crimson brocade of which the arabesque design can still be seen incised in the red bole.



## The painting proper

Only after all the painstaking and detailed gold and silver work had been completed could the painting proper be proceeded with:

## The pigments

In addition to the usual lead white, yellow, brown and red ochres and carbon blacks, the following pigments were identified:

### Blues

*Natural (lapis lazuli) ultramarine* was the only blue pigment identified, occurring throughout in drapery, architecture and skies. The subtle gradation of the blue skies depends not only on increasing the proportion of ultramarine to lead white for the deeper shades, but also on increased particle size of the ultramarine (in the deepest blue, individual ultramarine particles can be distinguished on the surface of the pictures with a 10× lens).

### Greens

*Malachite* (basic copper carbonate,  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ ) was the principal green pigment, identified in drapery, architecture, foliage and landscape. Its identification posed initial problems. Chemical tests showed a high concentration of copper ion and effervescence with dilute mineral acids indicating copper carbonate. Particle characteristics were, however, unlike those of reference samples of the ground natural mineral or its synthetic equivalent (green verditer), having globular particles instead of broken crystalline fragments (Plate 2d). The refractive index seemed high compared with Canada balsam, suggesting malachite rather than verdigris, but the rounded particles made measurement of refractive indices difficult by the usual immersion methods. Finally, X-ray diffraction confirmed that the crystal structure was that of *malachite*. A tentative explanation for the rounded particles was that of interaction between pigment surface and medium (copper pigments are well-known for reacting with organic material). An alternative explanation came from a recent study with the scanning electron microscope of particles of natural and synthetic malachite, which showed that in some samples of the artificial variety the particles were in the form of spherulites, like the Sassetta samples (8). Although numerous recipes from the twelfth century onwards exist for the preparation of artificial azurite (the equivalent blue copper carbonate mineral) (9) there seems to be none for the green before the seventeenth century, though its preparation would have presented little difficulty. Cennini's *verde azurro* seems to correspond to malachite mineral.

*Verdigris* (basic or neutral copper acetate) was deduced to have been the green pigment present originally in the browned glazes over gold described above.

Green earth (*terre verte*) was not identified. The muted greens of the landscape in No.4760 *The Stigmatization* were combinations of brown and yellow ochres, lead white and carbon black, sometimes with malachite. Since the Sassetta panels still retain the green underpainting for flesh, to be seen for example in the Duccio

*Maestà*, one sample of greenish flesh paint was examined (from the forearm of the poor knight in No.4757). The green underlayer was not green earth, but lead white with yellow ochre and black, the mixture Cennino terms *verdaccio*.

### Reds

*Vermilion* (red mercuric sulphide,  $\text{HgS}$ ) is prominent in draperies, particularly the costumes of the cardinals in No.4759 *The Pope Accords Recognition to the Franciscan Order*. It was also identified in two samples of flesh paint. *Crimson coloured lake pigments* were present in pink and red draperies, both mixed with lead white and used alone in glazes. As previously mentioned the lake pigment of the deteriorated crimson glaze over silver was identified as deriving from scale insect, not plant, dye-stuff, possibly *kermes*. Laser microspectral analysis detected the aluminium of the aluminium hydroxide substrate in two samples tested.

The pale pink of the architecture in No.4758 consists of lead white, red lake pigment and a scattering of very finely-ground vermilion.

### Yellows

*Lead-tin yellow* (lead-tin oxide,  $\text{Pb}_2\text{SnO}_4$ ). Chemical tests and laser microspectral analysis established the presence of lead and tin in samples from the opaque canary yellow of the carpet in No.4758 and the ceiling vaulting in No.4763 *The Funeral of S. Francis*. X-ray diffraction confirmed that the pigment was lead-tin yellow Type I (formula given above) of the two types defined by H. Kühn (10). Lead-tin yellow seems to correspond to what Cennino calls *giallorino*.

The marbling on the architecture of No.4763 and the deeper yellow of the carpet in No.4758 are both produced by translucent yellow glazes over the paler opaque lead-tin yellow. Similar glazes were noted in samples from parts of the rocky landscape of No.4760. Laser microspectral analysis of the top surfaces of two minute samples from the carpet and architecture referred to above, both bearing yellow glaze, gave lead and tin but no aluminium and negligible calcium, indicating the absence of aluminium hydroxide or calcium carbonate, the essential substrates for any yellow lake pigment. On the same spectrum plate, a minute sample of the pale yellow background (no glaze) of the lunette over the door of the chapel in No.4760, *The Stigmatization*, exhibited lead, some aluminium but no tin. The presence of lead white having been established previously, an admixture of yellow lake on an aluminium hydroxide substrate is presumed. To return to the identity of the pigment of the yellow glaze mentioned above, likely candidates would be gamboge or saffron, either of which may be used with medium without being made into a lake pigment. Unfortunately a sample sufficient for analysis by thin layer chromatography could not be taken, but it might be possible to identify the yellow glaze pigment in an existing paint cross-section from its transmission curve (see pp.38–42) once the reference curves for known yellow pigments have been obtained.

**Plate 1** The Master of S. Giles

Photomicrographs of paint cross-sections, photographed by reflected light at a magnification of 220x, magnification on the printed page as scale illustrated.

**(a)** *The Mass of S. Giles*

Dark green shadow on curtain to the left of the altar.

1. Chalk ground.
2. Trace of black underdrawing.
3. Translucent underpaint: malachite (partially dissolved in the paint medium) + black + a few particles of lead-tin yellow and possibly lead white; this layer is not clearly separated from the layer above.
4. A slightly greener layer, containing mainly malachite + a few particles of lead-tin yellow and lead white.
5. Malachite + a little lead white, and possibly a trace of lead-tin yellow.
6. 'Copper resinate' glaze, containing some black pigment particles (trace only on left hand side of cross-section).

**(b)** *The Mass of S. Giles*

Greenish-yellow highlight on fold of same curtain.

1. Chalk ground.
2. Trace of black underdrawing; note also trace of greenish translucent material between ground and lowest paint layer.
3. Light green underpaint: malachite + lead-tin yellow.
4. An extremely thin layer of mid-green paint, containing mainly malachite + a little lead-tin yellow, which is only with difficulty distinguished from the layer above.
5. An equally thin layer of similar composition.
6. Lead-tin yellow + a little malachite.
7. Layer of lead-tin yellow paint forming the highlight.

**(c)** *The Mass of S. Giles*

Orange banner covering window, just to the left of the crucifix, visible through cusped arch.

1. Chalk ground.
2. Whitish underpaint: lead white + a few tiny black particles.
3. Thin dark brown layer: black + a dark brown ochre + a little lead white.
4. Paint layer giving the colour of the stonework: lead white + a little dark brown ochre, black and one or two particles of a red lake pigment.
5. The reddish orange paint of the banner: vermilion + a little black and possibly a trace of lead-tin yellow. One or two glassy fragments of a blue pigment, possibly smalt, are also present.

**(d)** *S. Giles and the Hind*

Tan of King's boot, from crease just above the ankle.

1. Chalk ground.
2. Trace of black underdrawing.
3. Thin layer of malachite + one or two particles of lead white.
4. Thick layer of malachite.
5. Very thin layer of dark brown paint: vermilion + black + traces of dark brown iron oxide pigment, lead-tin yellow and red lake pigment.
6. Lead white + red lake pigment.
7. Lead white + an unknown (possibly organic) yellow pigment + lead-tin yellow + vermilion.
8. Yellowish glaze: the pigment has not been identified but may consist of a yellow natural dyestuff on a substrate containing a calcium salt.

**(e)** *S. Giles and the Hind*

Dark purplish shadow on sleeve of King's blue robe.

1. Chalk ground.
2. Yellowish underpaint: lead white + lead-tin yellow + vermilion + a red lake pigment + a few particles of azurite and black.
3. Purplish-red lake pigment, possibly containing a calcium salt in the substrate, + lead white.
4. Azurite + a trace of lead white.
5. Glaze: a red lake pigment.

**(f)** *S. Giles and the Hind*

Dark red shadow on shirt of man in group behind foreground figures.

1. Chalk ground.
2. Lead white + a little vermilion and red lake pigment.
3. Pink paint: a red lake pigment which may contain a calcium salt in the substrate + lead white.
4. The same, with a higher proportion of lead white.
5. Purplish-red lake pigment, probably containing a calcium salt in the substrate (possibly + a trace of lead white).
6. Glaze: a red lake pigment.

*Note.* A red lake pigment on a calcium salt substrate was positively identified in a sample from the red altar frontal in *The Mass of S. Giles*.

**Plate 2.** Sassetta's Sansepolcro Altarpiece

Photomicrographs of paint cross-sections photographed by reflected light at 150x magnification, magnification on the printed page as scale illustrated.

**(a)** No. 4757 *The Whim of the Young S. Francis to become a Soldier*

Dark red of S. Francis's robe, damaged area near horse's tail.

1. Gesso ground.
2. Orange-red bole.
3. Silver leaf.
4. Dark red glaze of crimson-coloured lake pigment in egg tempera medium.

**(b)** No. 4758 *S. Francis renounces his Earthly Father*

Blue from shadow of sleeve of the father's robe.

1. Gesso ground (trace).
2. Orange-red bole.
3. Silver leaf (fragmentary).
4. Blue glaze of natural ultramarine, probably in egg tempera medium.

**(c)** No. 4758 *S. Francis renounces his Earthly Father*

Fragment of crimson glaze from gold brocade backcloth of the bishop's throne.

1. Gesso ground (trace).
2. Orange-red bole.
3. Gold leaf.
4. Lead white.
5. Vermilion.
6. Thick red glaze (lake pigment).

**(d)** No. 4757 *The Whim of the Young S. Francis to become a Soldier*

Green of chest alongside S. Francis's bed.

1. Gesso ground (trace).
2. Thin line of granules of lead white.
3. Thick green layer of packed spherulitic particles of malachite.

**(e)** No. 4757 *The Whim of the Young S. Francis to become a Soldier*

Violet shadow of the blue garment S. Francis holds.

1. Gesso ground.
2. Greyish white layer (undermodelling?) of lead white with small scattered particles of black; some large fragments of charcoal black near bottom (drawing?).
3. Lead white underpaint.
4. Blue paint consisting of lead white with occasional large particles of natural ultramarine.
5. Dark red glaze (lake pigment).

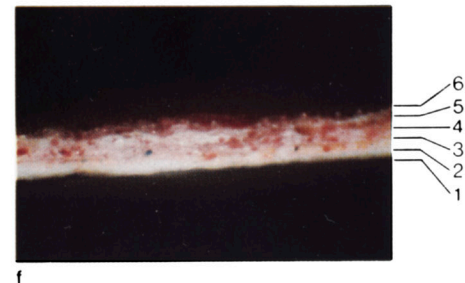
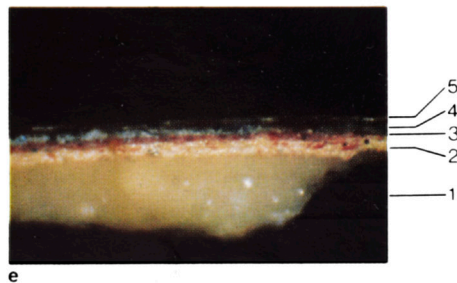
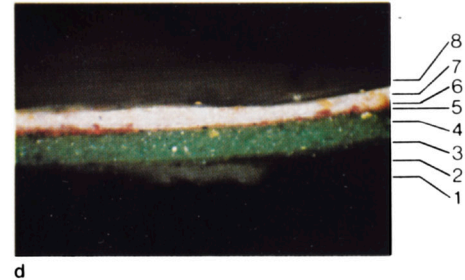
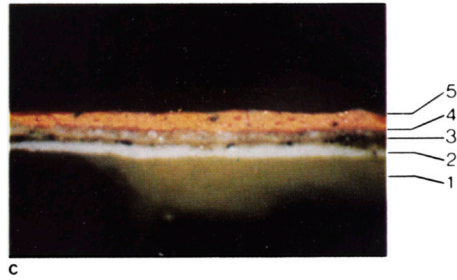
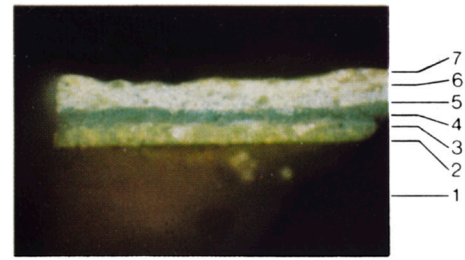
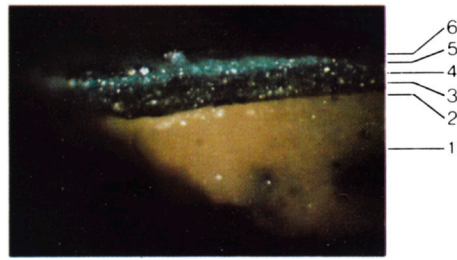
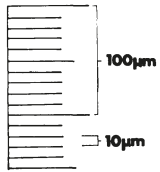
**(f)** No. 4757 *The Whim of the Young S. Francis to become a Soldier*

Deepest shadow of foliage of trees bordering the road.

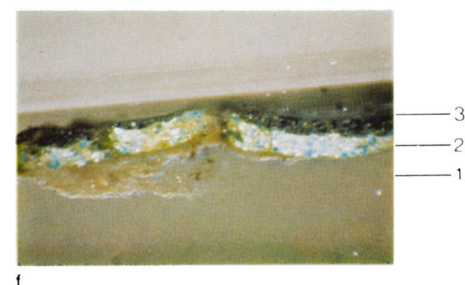
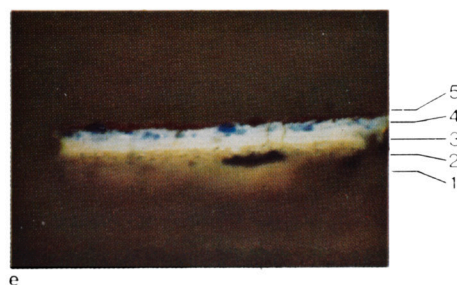
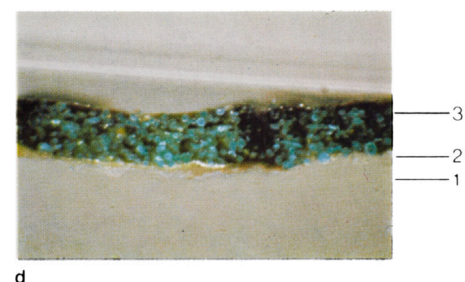
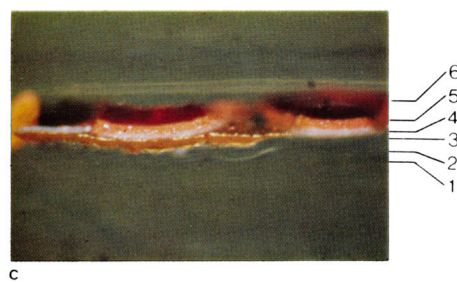
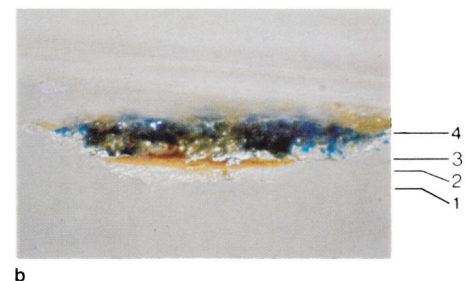
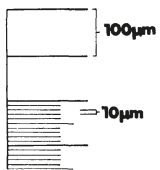
1. Gesso ground.
2. Green paint of malachite and lead white mixed.
3. Granular layer of carbon black.



**Plate 1.** The Master of S. Giles. (Full caption on facing page.) Magnification on printed page:



**Plate 2.** Sassetta's Sansepolcro Altarpiece. (Full captions on facing page.) Magnification on printed page:





**Plate 3 (Right)**  
Sassetta. *The Whim of the Young S. Francis to become a Soldier*. (N.G.4757). Detail after cleaning and restoration.

**Plate 4 (Far right)**  
Perugino. *The Virgin and Child with S. John*. Reconstructed, with its frame.





## The medium

Four samples of paint, all from No.4757, *The Whim of the Young S. Francis*, were analysed by gas chromatography (see p.58). They were: white of the right hand column; discoloured red glaze over silver (described above); blue of sky; green of the chest beside S. Francis's bed. In each case the fatty acid ratios corresponded to egg, an interesting result, for the pictures date from not long before oil painting was to displace egg tempera.

## The layer structure of the paint

As might be expected from their date, the paint is built up in an orderly system of comparatively thin flat layers. Glazes are used rather freely by Sassetta, in the painted areas as well as on gold and silver. The yellow variety has been mentioned. An example of a crimson glaze over blue comes from the violet shadows of the garment which S. Francis is holding in No. 4757, (Plate 3), of which a cross-section of a sample is shown on Plate 2e. Oddly enough the most complicated layer structure occurs in the painting of foliage, as in No.4760, *The Stigmatization*. The artist has evolved a system for adding half-tone, shadow and light in turn to each leaf which in fact gives the foliage a rather stiff artificial look. Some of the darkest greens, as in the trees along the road in No. 4757 (see Plate 3), are not the victims of discolouration of pigment or medium, as are the browned glazes over gold. They are deliberately painted dark. A cross-section from the darkest part of one of the trees just mentioned is seen (Plate 2f) to have a black layer painted over one of green malachite. In another example green was underpainted with black. Similarly the intensely dark green shadows of the chests beside S. Francis's bed in No.4757 are intentional. This clear-cut demarcation of light and shade is seen everywhere in architecture and landscape and combined with the intense blue of the skies produces the special quality of Italian light. Considering the comparatively small scale of the paintings it is remarkable the clarity with which even small details tell at some distance. Even the tiny stigmata on the Saint's body stand out in almost fluorescent brilliance, achieved in fact by thickly glazing vermillion with a crimson coloured lake. Cennino might like to have the last word on this: 'How to paint wounds . . . take straight vermillion; get it laid in wherever you want to do blood. Then take a little fine lac, well tempered . . . and shade all over this blood, either drops or wounds.'

## A note on the frames of the Sassetta panels

It has been explained by M. Wyld (p.3) how the seven National Gallery pictures were cut from their frames earlier this century. A brief examination of the frames produced a little new information. Whereas the panels themselves are of poplar (a diffuse-porous hardwood), all parts of the frames, including even the inner moulding of the trefoiled tops, are of softwood (conifer). Parts of the frames were not easily accessible for taking the several thin sections required for accurate identification of softwoods, but in a successful sampling (from one of the frames of which the decoration in the spandrels

matches that of the Chantilly frame) the wood was identified as *Abies* (fir), probably *Abies alba* (silver fir, common in Italy and elsewhere). A number of samples from the gilding of the various parts of the frame were also looked at. It had been assumed that the frames would have been regilded in the past, and expected that several layers of gilding might be found. In fact, with one exception which will be mentioned below, every sample had only a single layer each of gesso, bole and gold, beneath which was the surface of the wood. The 'gesso' was not in fact genuine calcium sulphate gesso as on the panels themselves, but shown by chemical analysis and X-ray diffraction to be calcium carbonate (chalk, or gilder's whiting). The *pastiglia* decoration in the spandrels was also composed of gilder's whiting and not calcium sulphate gesso (as specified for *pastiglia* by Cennini). The single exception, noted above, was a sample of gilding taken from the flat background of the *pastiglia* decoration of one of the frames of which the decoration matches the Chantilly frame. Beneath the gold and bole now visible and a layer of gilder's whiting was a lower layer of damaged gold leaf and bole with a thin coat of genuine calcium sulphate gesso attached to the surface of the wood.

No firm conclusions can be drawn from this until comparable data are available from the other panels of the Sansepolcro altarpiece, particularly the matching Chantilly panel, which seems never to have been separated from its frame. It could be, though, that the frames of the National Gallery's seven panels were stripped and entirely regilded before their acquisition.

## Notes and References

1. *Bollettino dell'Istituto Centrale del Restauro* (Rome), Vols 37-40 (1959) entire volumes.
2. The quotations from Cennino Cennini are taken from the edition and translation by Daniel V. Thompson: *Cennino d'Andrea Cennini da Colle di Val d'Elsa, Il Libro dell'Arte*, New Haven (1932).
3. J. Plesters, 'Cross-sections and Chemical Analysis in the Study of Paint Samples', *Studies in Conservation*, Vol. 2 (1956), pp.1-47. Since that time techniques have been modified and augmented.
4. The author wishes to thank Miss M. Bimson of the Research Laboratory, British Museum, for carrying out the X-ray diffraction analyses and Dr. M. Tite, Keeper of the Research Laboratory for kindly permitting the investigations to be done.
5. Analyses made by R. White of the Scientific Department, using a modified Ehrlich test for proteins followed by gas chromatography.
6. *Compositiones Variarum*, Bibl. Capitolare di Lucca, ms.490, published by L. A. Muratori in *Antiquitates Italicae Medii Aevi*, Milan (1738-42) 2, col. 365-392.
7. J. Pope-Hennessy, *Sassetta*, London (1939) pp.98,99.
8. R. J. Gettens, E. W. Fitzhugh, 'Malachite and Green Verditer', *Studies in Conservation*, Vol.19 (1974), pp.16, 17.
9. D. V. Thompson, 'Trial Index of Medieval Craftsmanship', *Speculum*, Vol.10 (1935), p.415.
10. Hermann Kühn, 'Lead-tin Yellow', *Studies in Conservation*, Vol.13 (1968), p.8.