

Rembrandt's Simeon's Song of Praise, 1631:

PICTORIAL DEVICES IN THE SERVICE OF SPATIAL ILLUSION

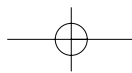
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Introduction

Simeon's Song of Praise is an excellent example of Rembrandt's detailed small-scale history paintings from the 1630s. Despite the greyed and blanched condition of several of the dark passages in the background, it still reveals his great gift for chiaroscuro (fig. 1).¹ To achieve this, Rembrandt had at his disposal a bag of tricks and devices, some new innovations, such as theatrical lighting effects, which he pioneered through his muted palette and textural effects. The carefully constructed composition, on the other hand relies more heavily on traditional devices, such as linear and atmospheric perspective, and his use of repoussoirs.



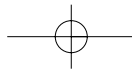
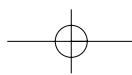


Fig. 1 Rembrandt, *Simeon's Song of Praise*, signed RHL. 1631 [RHL in ligature] lower right, oil on oak panel, 60.9 x 47.9 cm, Mauritshuis, The Hague, inv. 145, after treatment 2005

The way the various aspects are combined in a single painting to create a convincing illusion is highly innovative. Coupled with his personal interpretation of the biblical story of Simeon (Luke 2: 25-33) – the moment of Simeon's praise – a dramatic masterpiece of spatial ingenuity was created that must have been highly appreciated by the connoisseurs of the time. That it has now been established

that the picture belonged to the Stadholder Frederik Hendrik is therefore not surprising.²

Rembrandt painted *Simeon's Song of Praise* in 1631, around the time he left Leiden and moved to Amsterdam.³ The staged composition and the numerous details recall his teacher Pieter Lastman, with whom he apprenticed in 1624/25. In the centre, a concentrated shaft of light falls on



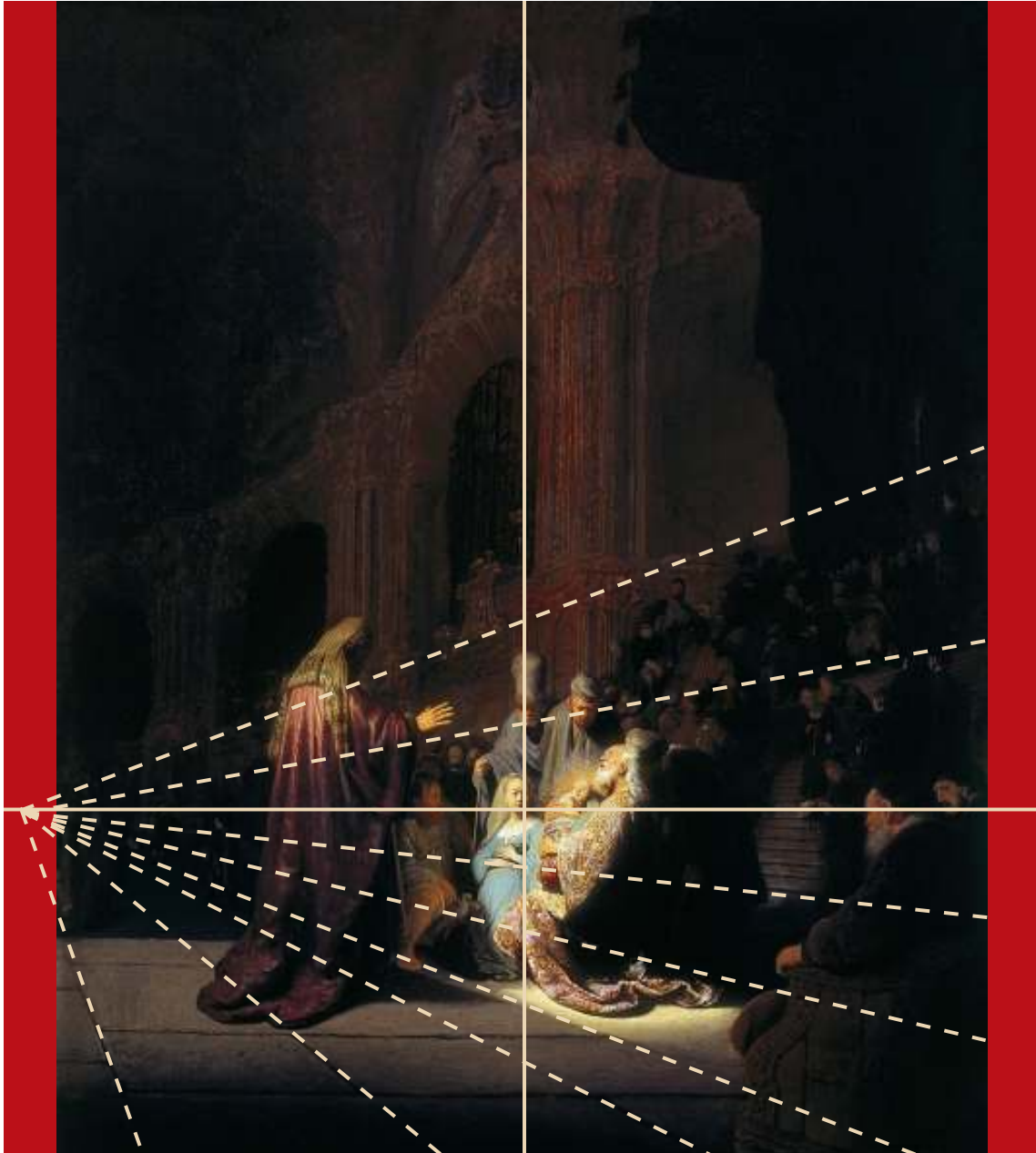
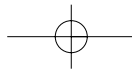
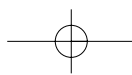


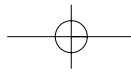
Fig. 2 Rembrandt used linear perspective to construct the composition. The orthogonals (dotted lines) and horizon dissect at the vanishing point to the left outside the picture

the central figure group, which serves to focus attention on the figure of Anna⁴ and Simeon holding the Christ child, and between them the kneeling Mary. The scene takes place in a monumental gothic church-like temple that is repeated in *A Woman taken in Adultery* from 1644 (National Gallery London) more than ten years later.

The recent varnish removal and restoration allowed close examination of the painting, which together with analyti-

cal research provides a better understanding of the painting's genesis and original appearance.⁵ This paper reports on the pictorial means Rembrandt used to create this work – particularly his combination of linear and atmospheric perspective. Unfortunately, the spatial depth that is so important in this painting is compromised by the formation of a greyish haze in several (dark) areas. The underlying causes that have led to this change in appearance were also investigated in order to better understand Rembrandt's original intention. Other aspects of the painting technique have been examined where possible.





Compositional devices

In the past, little attention has been given to the role of linear perspective as a means by which Rembrandt achieved spatial illusion in his paintings⁶, with perhaps the exception of *The Painter in his Studio* from c.1628 (Museum of Fine Arts, Boston).⁷ In *Simeon's Song of Praise* the use of orthogonals connecting many of the major details as well as the lines of the floor tiles that meet in a vanishing point to the left outside the picture, clearly points to the application of single-point perspective (fig. 2).⁸ Since the vanishing point lies outside the picture plane, no pin-hole would be expected to be found. Furthermore, not all orthogonals (such as those of the stairs at the centre right and the lit area on the floor) converge *exactly* to the same point. This can be explained by the fact that not all features of the painting were constructed as part of a geometrically rigorous whole, but evolved as part of the painting process, and serve to demonstrate that during painting Rembrandt was not interested in mathematical precision, but relied instead on an empirical manipulation of the light values to make the spaces work optically. The primary goal of the strong oblique recession was to lead our eye into the picture, so that we too feel as if we are witnessing this event. The combination with the horizontal recession created by the increasing width of the floor tiles from right to left, as well as the severe foreshortening of the ground plane, creates a feeling of great spaciousness. This is reinforced by the deliberately chosen low horizon line (as seen again and again in his paintings) that passes through Mary's and Christ's faces in the bottom third of the picture. This not only creates a strong vertical recession but imbues the scene with (unprecedented?) monumentality.

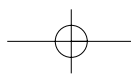
The strong recession of space in three dimensions creates a wide-angle view of the interior suggesting that Rembrandt was more interested in visual and atmospheric effects than in following the rules of linear perspective.⁹ This is also hinted at by the slightly curved lines in the upper part of the picture that connect the top of the windows and the capitals of the columns. Whether these lines should be seen as marginal distortions, perhaps even alluding to ideas at the time regarding optics and the nature of vision, or whether they are simply meant to describe the rounded interior of the temple of Jerusalem, as traditionally depicted, is ambiguous.¹⁰ In any event, the effect here is one of heightened realism, although this is clearly an imaginary church.

In this regard, Rembrandt may have taken inspiration from the real environment, though it is conceivable that the engravings of vault perspectives of Hans Vredeman de Vries, which will be discussed later, could also have

inspired Rembrandt's architectural interiors (a feature not only of *Simeon's Song of Praise*, but of many of his other paintings, and etchings), given Vredeman de Vries' wide-reaching influence. Probably already at this time Rembrandt possessed prints by well-known fifteenth and sixteenth-century masters, which also could have served as a point of departure.¹¹ Certainly the inventory of his possessions drawn up in 1656 lists numerous books of architectural prints.¹²

The combination of abrupt foreshortening with the numerous small figures and spacious foreground containing oversized repoussoirs is also a traditional device for rendering spatial depth known to painters at that time. Here, the placement of the rather small figures in the central plane makes space for large-scale repoussoirs of the seated man in the lower right and its baldachin with the enormous awning in the upper right. Their bold shapes not only enhance the suggestion of receding space and balance the strong oblique recession, but also force the viewer to focus on the central scene. The inclusion of the baldachin as a seemingly convincing architectural feature is remarkable, even though the overhead awning of the baldachin is too close to the viewer in relation to the curtain hanging further back in the background. This seems to be a deliberate visual intrigue, much like we observe in the hanging candelabras in the work of Pieter Saenredam, for instance. Rembrandt may have seen repoussoir curtains in works of the fifteenth and sixteenth centuries, as well as in paintings by contemporary Utrecht painters. A repoussoir curtain first appears in Rembrandt's easel painting in the initial stage of *Judas Repentant, returning the thirty pieces of silver* (Private Collection, UK) from 1629 that was subsequently painted out.¹³ Much later the curtain becomes a true *trompe l'oeil* (*Holy Family* from 1646, Staatliche Museum Kassel) as well as a device much used by painters from the Delft school including Vermeer.

According to Van Mander's *Schilder-Boeck* (1604) in the chapter entitled *Van der Ordinanty ende Inveny der Historien* (Concerning the Arrangement and the Invention of Histories), repoussoirs were considered an important tool for history painters.¹⁴ Van Mander only mentions linear perspective in the chapter on landscape painting where he states that (landscape) painters must know how to place the vanishing point on the horizon. On the last page of the book, however, he says he regrets that he could not deal with all subjects, but that perspective and proportion had already been clearly described in separate publications.¹⁵ In a margin note he refers readers to books on geometry, perspective and architecture, including Pieter Coecke van



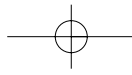
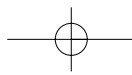


Fig. 3 Overall X-radiograph. The reserves for the main figures indicate they were clearly part of the composition from the beginning; the reserve for Anna's cloak is smaller than its present form, as is that of the bending figure to the right of Simeon. No reserve was made for Joseph



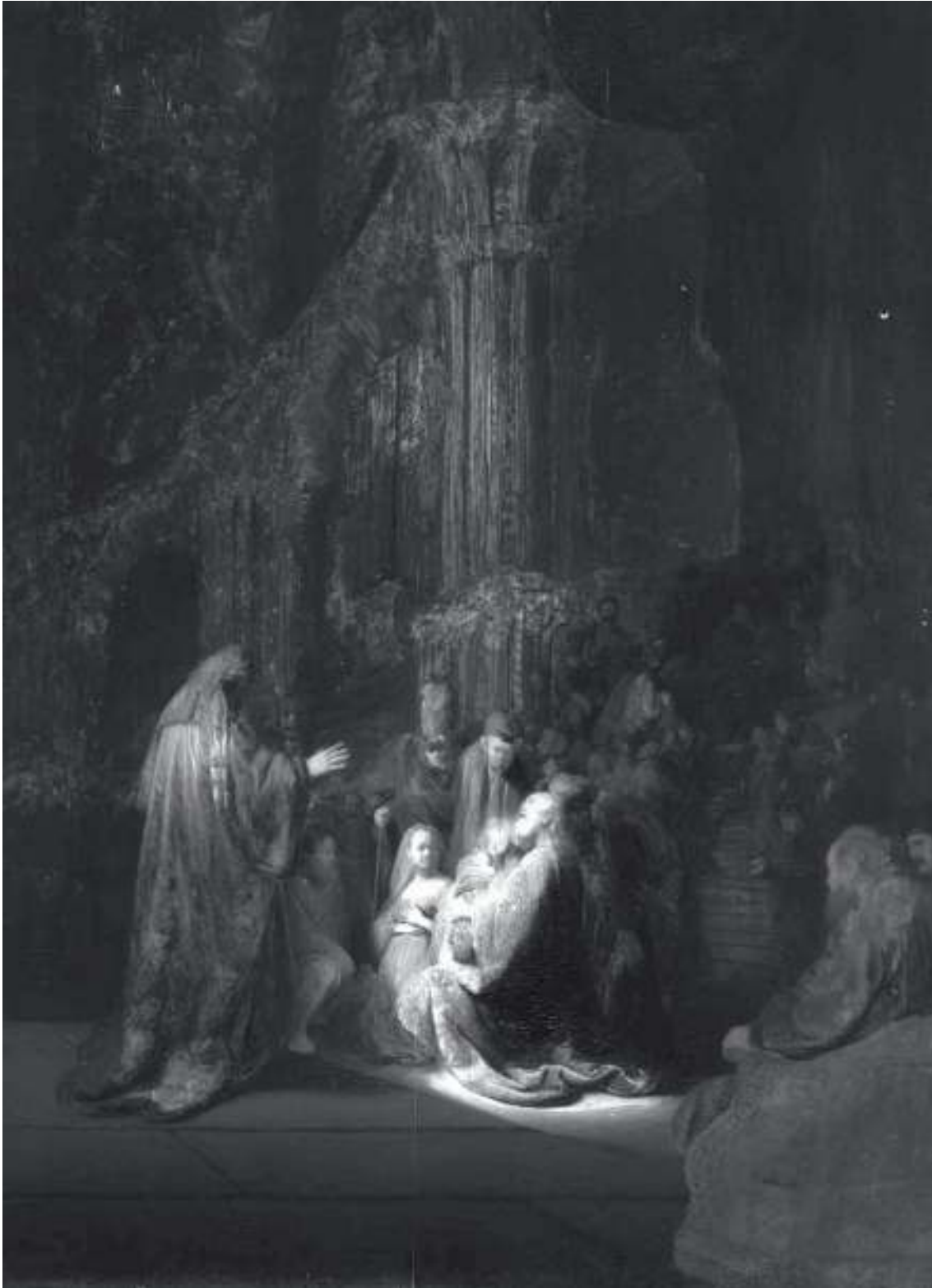
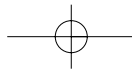
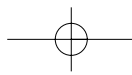
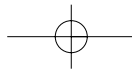


Fig. 4 Overall IR image (compilation of 36 images). Here, the sketch can be visualised because of the presence of carbon black. Note that the figure of Anna was made taller by extending the robe over the already painted floor





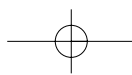
Aelst's (1502-1550) translation into Dutch (1539-1553) of Sebastiano Serlio's books on principals of perspective of Renaissance architecture.¹⁶ In the period 1560-1604, Hans Vredeman de Vries (1526-1607), painter, engineer and architectural designer, who worked in many cities all over Europe, produced a number of enormously influential illustrated books in Dutch, Latin, French and German.¹⁷ His important *Perspective*, published in 1604/05 in The Hague and Leiden and dedicated to the Stadholder Prince Maurits, contained illustrations of imaginary architectural interiors. In 1605, Simon Stevin, a mathematician-engineer in service to Maurits at the court in The Hague, published his own treatise on perspective, *De Deursichtighe*. According to Kemp, this was largely in response to the Stadholder's quest to understand the principle of pictorial representation. Stevin and his fellow mathematicians were concerned with developing a range of new technologies that included navigation, surveying, accounting and banking, not to mention optical instruments such as telescopes and microscopes. Samuel Marolois (c.1572 - c.1627), yet another important Dutch theorist, who also lived and worked in The Hague, published some ten editions of his treatise *Opera Mathematica*, between 1614 and 1662.¹⁸ Hendrik Hondius (1573 - c.1649), a pupil of Vredeman de Vries and tutor to Constantijn Huygens, who would become advisor to the next Stadholder, Frederick Hendrik, as well as Rembrandt's patron, also published several books, including in 1622 his own widely influential handbook, the *Institutio artis perspectivae*.

The treatises of De Vries, Stevin, Marolois and Hondius were largely geometrical in nature and included little reference to the developing ideas on the natural phenomenon of vision.¹⁹ Information on optics may have been introduced through the works of sixteenth-century theorists like Daniele Barbaro's *La Practica della prospettiva* published in 1569, Giovanni Battista della Porta's *Magia Naturalis sive Miraculis Rerum Naturalium* from 1558 and 1589 and Egnatio Dante commentary on Vignola's *Le due regole della prospettiva practica* of 1583. Della Porta's *Magia Naturalis*, which included experiments with optics, was extremely popular and widely distributed. It appeared in Italian, French, German, English and Dutch, altogether in more than fifty editions in the sixteenth and seventeenth century.²⁰ Andreas Vesalius' important *De humani corporis fabrica libri septem / The seven books of human anatomy*, which included the structure of the eye, was published in 1543. That Rembrandt was familiar with the ideas of Vesalius is suggested by the unusual emphasis given to the arm in *The Anatomy Lesson of Dr Nicolaes Tulp*, from 1632 (Mauritshuis, The Hague).²¹ Moreover, Johannes Kepler's important publication, *Ad Vitellionem Paralipomena* of 1604, in which he

correctly defined vision for the first time as a function of the eye as 'brought about by the picture of the thing seen being formed on the concave surface of the retina' was an important discovery.²² His theories were further developed by René Descartes (1596-1650) who lived in The Hague from 1628-1650, publishing his book, *La Dioptrique* in Leiden in 1637. Since most artists would not have had much theoretical schooling, the practical nature of the perspective handbooks, which were republished several times until after mid-century, must have appealed to artists, who could easily copy the perspective effects. Hondius' equally popular book from 1622 clearly describes and illustrates the distance-point method of perspective. He also mentions Dürer's glass frame as an aid to painting and explains how some artists would hold the frame at an angle enabling them to record vertical recession as well as recession into depth.²³ It is compelling to think that this group of illustrated books can be directly linked to the fervour of activity surrounding developments in technology and science taking place in the new Republic and to what extent the young Rembrandt was influenced by these theories.²⁴

The technological revolution that took place under sponsorship of Maurits must to some degree also account for the growing popularity of architectural painting that occurs in The Hague at the time. The decorative and illusionistic qualities of the works of Bartholomeus van Bassen (c.1590-1652), Hendrick van Steenwijck II (c.1580-c.1649) and Dirck van Delen (1605-1671), constitute what has been referred to as a Court style that not only appealed to the Stadholders and their circle, but to the reformed, wealthy and socially prominent.²⁵ Van Bassen, one of the most important architectural painters of the first half of the seventeenth century, settled in The Hague in 1622, later becoming city architect of The Hague between 1639 and 1652. In particular his early works (1620/30) contain some common features including the use of oblique recession and naturalistic lighting effects that we see in Rembrandt's *Simeon's Song of Praise*.²⁶ Rembrandt must have been acutely aware of the popularity of these architectural painters given the close proximity of The Hague to Leiden, and especially from 1628 onwards after his contact with Constantijn Huygens, intellectual, connoisseur and advisor to the Stadholder, who was extremely active in promoting the arts and the new sciences.²⁷ It was around this time that Rembrandt painted *The Painter in his Studio*.²⁸ Notably, his works prior to this painting show little interest in linear perspective as a means to create spatial illusion.

The relationship of the figure to the space in these early architectural interiors, however, is very different to what



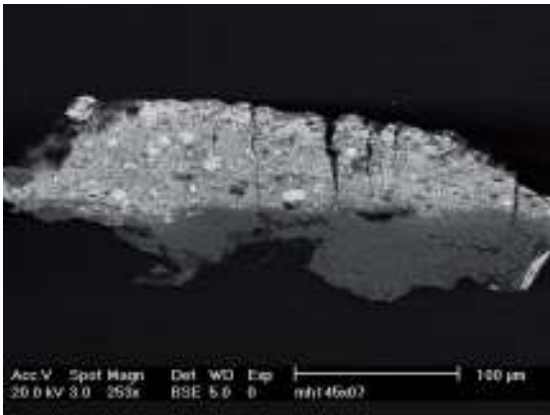
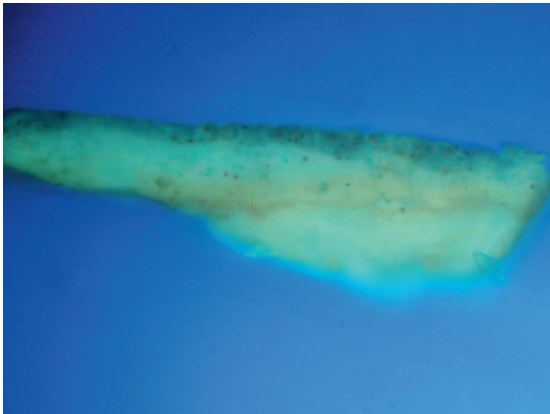
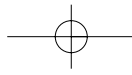


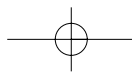
Fig. 6 Paint cross-section from Mary's cloak (145x07) showing two layers of finely ground azurite mixed with lead white and a little red earth, on top of light ground layers. Rembrandt used this fine grade of azurite to achieve a subdued greyish blue tonality. Normal light (A), UV (B) and SEM image (C)

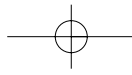


Fig. 5 Detail central figure group showing Simeon with the Christ child and Mary and two onlookers. Note the contrast between the rough handling of Simeon's robe and the smooth paint of Mary's cloak

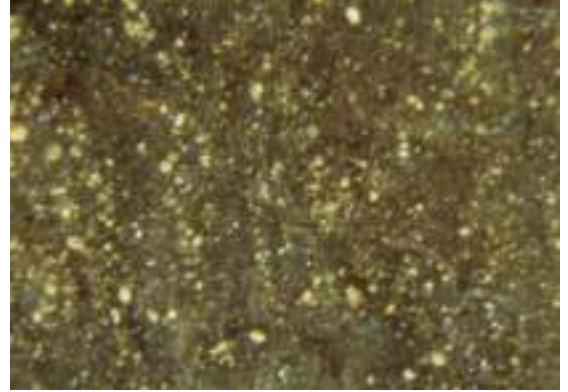


Fig. 7 Detail of the purplish robe of the prophetess Anna. Here Rembrandt has also reinforced the contours on the shadow side with blackish outlines. The modelling is now distorted by greying of the thickest most raised areas





A **Fig. 8** Detail of Joseph's jacket showing minute yellowish lumps, possibly orpiment (A), and microphotograph (original magnification 20 x) (B)



B



Fig. 9 Detail of upper right showing well-preserved green glaze used to unify the background figures

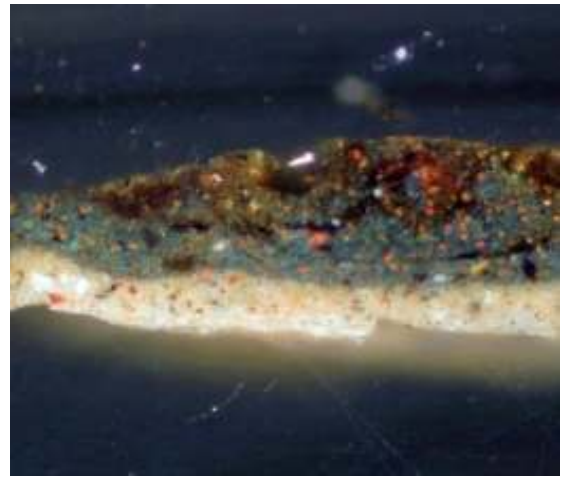


Fig. 10 Paint cross-section 145x08 from green glaze in background figure to the right behind Joseph. Here the yellowish oil, was applied directly onto the wet azurite on the painting itself to create a green glaze

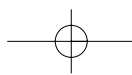
Rembrandt set out to achieve. This is perhaps not strange since architectural painters usually collaborated with specialist painters who would add the figures. In *Simeon's Song of Praise* the figures were clearly part of the composition from the beginning (fig. 3). In this regard, Rembrandt's *Simeon's Song of Praise* seems to owe more to sixteenth-century prints,²⁹ particularly in terms of the treatment of space and light where forms are thrown into relief by a strong directional light, such as seen for example in the etchings of Dürer.³⁰ From the 1656 inventory of Rembrandt's possessions, it is known that Rembrandt owned Dürer's influential book on proportion that included woodcut illustrations, which were highly esteemed by Van Mander (1604). For perspective Van Hoogstraeten (1678) also refers readers to [amongst others] the books of Dürer.³¹ According to Wheelock, the failure of images created by linear perspective alone to conform to visual experience was a general problem encountered by many Dutch artists.³² Clearly, Rembrandt understood the shortcomings of linear

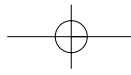
perspective and strove for a more realistic perception. In his *Anatomy Lesson of Dr Nicolaes Tulp* from 1632, painted a year later (Mauritshuis, The Hague), Rembrandt already moves away from linear perspective in favour of light and atmospheric effects to articulate architectural space. His use of surface texture, colour value and contrast shows he was well aware of other factors that affect the relative distance at which objects are perceived. These aspects will be taken up in the section on atmospheric perspective.³³ Whether he arrived at these solutions intuitively, out an interest in art theory, or from the new findings about optics, or a combination of factors, is unclear.

The preparatory ground and paint layers

The ground layers

Rembrandt's *Simeon's Song of Praise* is painted on an originally rectangular oak panel measuring 60.9 x 47.9 cm.³⁴ The format, which is essentially intact, falls into a cluster of





standard size panels – known as *salvators* – from the Leiden period which have roughly the same size.³⁵ Unfortunately, in the eighteenth century the upper corners were rounded when an arched top was added to the picture.³⁶ The ground layers, which up until now have eluded proper description, consist typically of a compact whitish chalk ground (EDX: Ca) followed by a cream-coloured *imprimatura* or priming layer (fig. 14).³⁷ The combination of a chalk ground and a light priming layer is considered standard practise, not only for Rembrandt's panels, but for seventeenth-century Dutch panels in general. The *imprimatura* consists of large aggregates as well as fine particles of lead white (EDX: Pb), with additions of chalk (EDX: Ca), earth particles (EDX: Fe, Si, Al) and fine carbon black. The thickness of the priming layer varies between 6 and 30 μm though in general both layers are thin enough to permit the structure of the oak panel to be discerned on the surface.³⁸ The light ground plays an important role in the appearance of the painting. Rembrandt exploits it in the sparsely applied background, especially in the capital and columns of the architecture where it appears and shimmers through the overlying thin brown surface paint to form lively golden tonalities.

Painted sketch

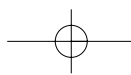
Previous technical studies have confirmed that for both panels and canvas with a light ground Rembrandt used a translucent brown sketch to set down the main forms and principal shadows.³⁹ Here too, Rembrandt has begun his painting by roughly sketching in the architectural elements with translucent blackish brown paint that was then worked up with lighter and darker tones. Parts of this streaky brown layer have been left uncovered to function, for instance, as a half-shadow in the jacket of the figure bending over to the right of the Christ child. It was also left exposed along the extreme bottom margin where it is not completely covered by the dark grey foreground paint. The painted sketch can be visualised in IR because of the presence of carbon black and good contrast with the light priming (fig. 4).⁴⁰ Logically the sketch does not extend below the light areas of the painting: Simeon, the Christ Child and Mary.⁴¹

In cross-section, this layer appears a warm medium brown with a maximum thickness of about 10 μm . In addition to large rounded particles of carbon black (EDX: C), it contains a little brown umber (EDX: Fe, Mn), bone black (EDX: Ca, P), dispersed lead⁴² along with a large amount of chalk (EDX: Ca).⁴³ The large proportion of chalk identified in the layer, however, is thought to account for the translucency. Chalk may have been added as filler and to improve the brushability of the sketch paint.

Tonal values, textural effects and differentiated contours in the service of atmospheric perspective

Rembrandt clearly understood the optical principle that the eye of the observer could be tricked into focusing onto something by means of lighting, stronger contrasts and tactile surfaces. By juxtaposing bright related colour harmonies and heightened impasto in the central figure group, with monochrome darkish tonalities and schematic handling in the background, he makes light and space tangible. His diminution of colour values, contrast, texture, detailing and contours as a function of receding illusionistic space is highly characteristic. Painters had long discovered that colours, textures, shadows and contours soften and become more diffuse with distance. This phenomenon, known as aerial perspective or *houding* plays a paramount role in his creation of perceptible three-dimensionality.⁴⁴ In this way, the rough surface structure of the figures of Simeon and the Christ child in the centre, which at first glance does not seem obvious, engages the eye while the smooth glazes of the multitude of tiny figures makes them recede into the space (fig. 5). Rembrandt went to considerable effort to achieve these textural effects. For the rich heavy brocade of Simeon's robe Rembrandt applied layers of contrasting colours and then scratched into the light wet surface paint with a blunt tool to reveal the various colours below. In the light areas, he first seems to have applied a light mauve (lead white, fine bright red, red lake) with a purplish brown tone in the shadow areas. This was followed by lighter mauve touches and a deep yellowish layer that is more brownish in the shadow areas. The application of white and pale pink on top of the still wet yellow layer accounts for the pale yellow- and pink lights, with final dabs of pure lead-tin yellow and lead white used to heighten the luminous and rich effect of the elaborate pattern. The dark shadow side of Simeon's robe is one of the most built up areas; here the thickly applied blackish strokes are unfortunately distorted by localised greying of the surface and heavy cracking. Simeon's head and hands are created with tiny animated dabs and strokes in shades of warm pink, grey and white.

In contrast, the flesh of the Christ child and Mary are paler and more smoothly painted. The mat greyish blue of Mary's cloak was applied while the flesh paint of her hands was still wet. Painted from light to dark, with additional white added wet-in-wet in the lit areas, the shadows were applied on top with strokes of darker blue/grey. Final blackish contour lines were added when the paint of the dress was dry, in order to reinforce the contrast with her hands and Christ's similarly coloured greenish grey blanket. The extremely fine, 2-3 μm -diameter azurite particles, are so tiny they can hardly be distinguished by the stereo



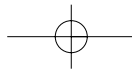


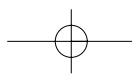
Fig. 11 Johannes Pieter de Frey (1770-1834), after Rembrandt, *Simeon's Song of Praise*, etching 1829-39, 484 x 308 mm (Rijksprentenkabinet, Rijksmuseum, Amsterdam)



Fig. 12 Detail of baldachin upper right showing greyish haze localised to this area

microscope (fig. 6). A cross-section demonstrates two layers of finely ground azurite (EDX: Cu), mixed with lead white (EDX: Pb) along with a little fine red earth (EDX: Fe, Si, Al).⁴⁵ The top layer consists of the same pigments that are finer and more compact.⁴⁶ The splintery appearance as well as the tiny size, as visualised in the SEM image, indicates the pigment was finely ground. From this we can conclude that Rembrandt deliberately used this fine grade of azurite to achieve a subdued greyish blue tonality. Certainly the use of fine azurite must have also afforded a smoother surface and easier handling, especially given the addition of lead white, as well as a paler more greyish tone instead of the normally much brighter blue of coarser azurite (fig. 6).⁴⁷ The dark reddish purple of Anna's robe appears to have been built up in numerous layers given the thickness and pronounced crack pattern. Rembrandt seems to have made several modifications, as a bright red layer is evident lower down in the cracks. The figure was also made taller by extending the robe over the already painted floor (here grey is visible in the cracks). This enlargement, which is clearly evident in the X-radiograph (fig. 3) and the IR image (fig. 4)⁴⁸, not only enhances the importance of Anna iconograph-

ically, but also serves to increase the monumentality in the picture, as well as unifying the central figure group. Here, Rembrandt has reinforced the contours on the shadow side of the heavy robe with black outlines. Unfortunately, the modelling in the robe is disturbed by localised greying of the surface of the raised areas, while the paint in the hollows retains its original dark translucent reddish purple (fig. 7). Although the shadowed face with its (hairless) broad square-shaped chin seems masculine, thick undefined diagonal ridges of paint extending up to the ear tend to suggest a chin-cloth as depicted in an image of Anna in the etching of the same subject from c.1639 (Museum Het Rembrandthuis, Amsterdam).⁴⁹ The raised and splayed wrinkled hand caught in the full light is painted in great detail with small dashes of white paint depicting the veins of the hands and highlights of the fingernails. Behind Mary and the Christ child, two old men look curiously on. The old man, or beggar directly behind the Christ child and Simeon, bears a strikingly well preserved opaque light green garment that is a mixture of lead white (EDX: Pb), fine azurite (2-4 μm in diameter) (EDX: Cu) and red and yellow earth (EDX: Fe, Al, Si).⁵⁰



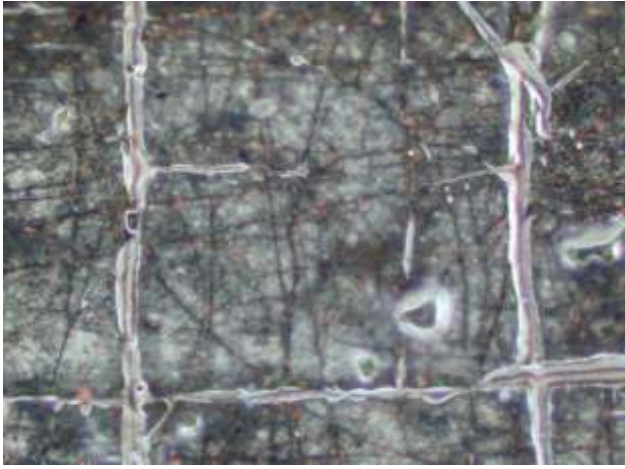
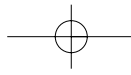


Fig. 13 Detail of the paint surface from baldachin under the light microscope (original magnification 100 x) showing the presence of tiny whitish particles

The presence of yellow particles of orpiment may account for the unusual speckled effect in the otherwise dark greyish green garment of Joseph (fig. 8) kneeling discretely holding the two sacrificial doves in the shadows to the left of Mary. Although here it was not possible to take a sample, the characteristic surface appearance of orpiment is very similar to that observed in other paintings where sampling was possible. One orangey yellow particle of orpiment (EDX: As, S) was by chance identified in a sample along the contour of the light green garment mentioned above, where it is most likely present due to contamination from Joseph's garment given its close proximity.⁵¹ Whether this curiously speckled effect was intended is unclear though perhaps it was used to suggest light emanating from the Christ child on his roughly textured dark garment.⁵² Sheldon et al. recently found two examples where orpiment was used to brighten half shadows.⁵³ This represents not only an unexpected use of orpiment, as postulated by Sheldon et al. but a significant new finding in the palette of the young Rembrandt.

In contrast to the pink and purple harmonies of the central figure group, the tiny background figures that inhabit the receding space surrounding the central figures (fig. 9) are more schematically and subduely painted. A remarkably glossy green glaze was liberally used to heighten the garments, hats and sacrificial objects providing a visual cohesiveness to this mass of 40-odd figures. This green is exceptionally well preserved and crack free since here, the blue pigment azurite (EDX: Cu) was used, not mixed with a yellow lake, as might be expected, but as a lower layer on top

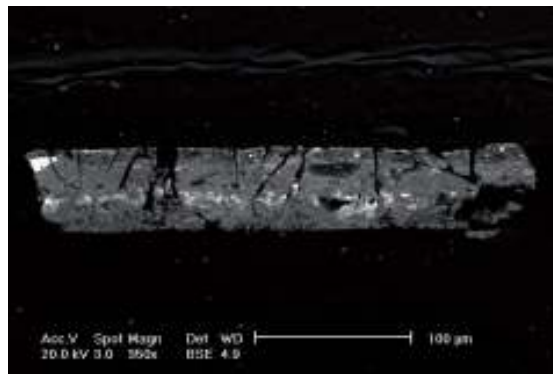
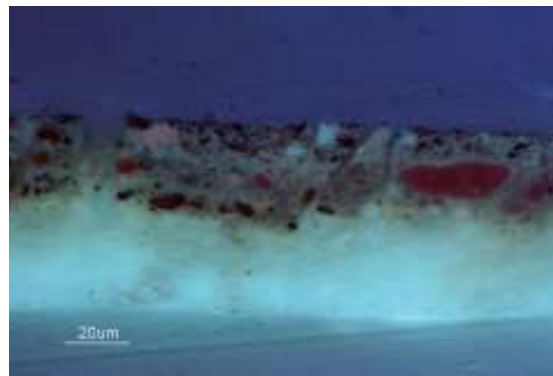
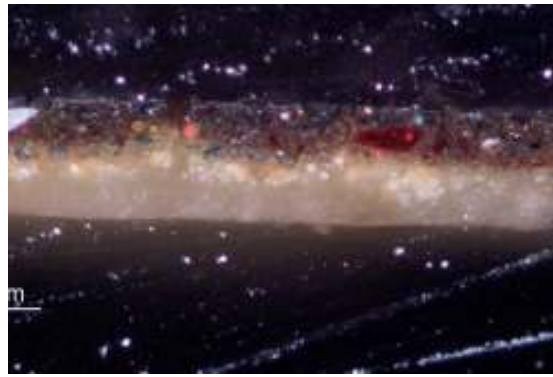
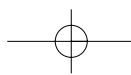


Fig. 14 Paint cross-section 145x04 from the baldachin showing the paint build-up and surface haze. Here the paint consists of two similar layers of dark reddish brown over the lighter brown sketch layer and light ground layers layers, consisting of a cream-coloured priming on top of a chalk ground. The SEM image reveals almost complete saponification of the lead white particles in the priming layer. Normal light (A), UV (B) and SEM image (C)



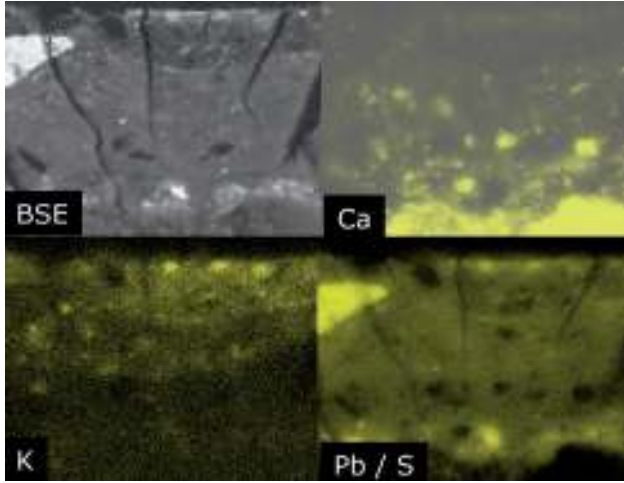
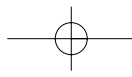


Fig. 15 BSC image, Pb, K, S, Ca EDX maps of cross-section 145x04 from the baldachin showing distribution of elements associated with the surface haze (fig. 14)

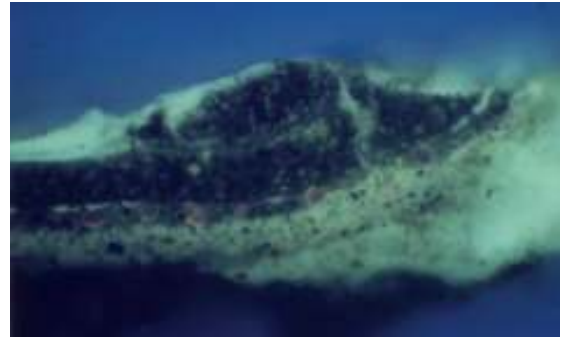
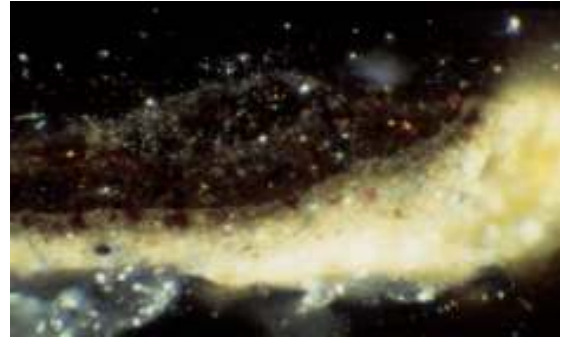


Fig. 17 Paint cross-section 145x05 from blanché and cupped paint lower right edge. Here the paint is built up in two layers of dark brown consisting mostly of organic brown earth pigment, possibly Cologne earth, in addition to a little red earth, on top of the lighter brown sketch layer. What appears to be a varnish layer separates the two brown layers. Normal light (A), UV (B) and SEM image (C)



A **Fig. 16** Detail of the chair in lower right showing blanché and cupped paint around the lower and right edges (A) and corresponding microphotograph of paint surface (original magnification 20x) where cross section 145x05 was taken (indicated by the circle) (B)

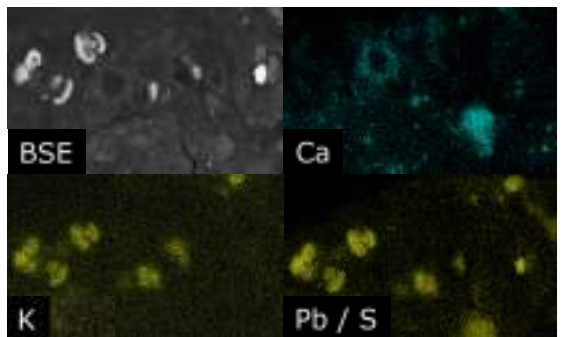
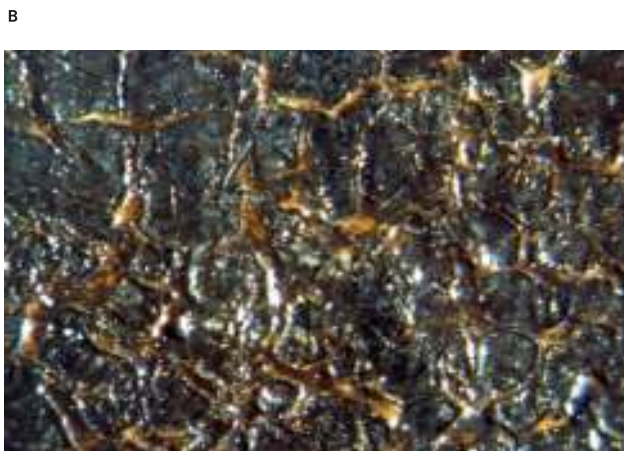
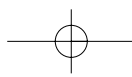
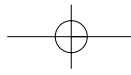


Fig. 18 BSC image, Pb, K, S, Ca EDX maps of cross-section 145x05 (fig. 17) from lower right edge showing distribution of elements associated with surface haze





of which a large amount of lead-siccativized oil⁵⁴ containing a little fine yellow and red earth particles (EDX: Fe, Si, Al) was applied wet-in-wet (fig. 10).⁵⁵ The use of leaded oil, rather than a yellow-pigmented paint, explains the good state of preservation, apart from possible darkening. This identification of an oil glaze represents a significant new insight in Rembrandt's materials.⁵⁶

The schematic forceful brushwork of the underlying blackish brown sketch plays an important role in the sparsely applied background, its vague contours and muted tonalities aiding in the convincing illusion of three-dimensional space. In lighter areas of the background, Rembrandt allowed the light ground to be exposed or to shimmer through the final paint creating details and warm golden tonalities. This is particularly obvious near the central figure group and in the capitals of the columns.

The addition of warmer and cooler finishing touches creates convincing effects of light and shadow in the shadowy interior. In the upper part of the architecture an opaque greyer brown effectively suggests the correct position of the vaults high in the space, though, unfortunately, patchy lighter grey discolouration severely disrupts their legibility both in terms of detail, as well as their intended place in the spatial arrangement. Although some caution has to be exercised, it is interesting to compare the present lack of legibility in this area to the clearly defined vaults and baldachin depicted in a drawing and print made after the painting in the early nineteenth century (fig. 11).⁵⁷ This could suggest that degradation, as discussed in the next section, was less advanced in the nineteenth century.

Changes in appearance: blanched degraded paint layers⁵⁸

In several areas of the painting, the original colour, and therefore position in the spatial arrangement, is severely distorted by blanching or greying of the paint.⁵⁹ It is particularly disturbing in the large baldachin in the upper right, where its original dark reddish brown colour is obscured by a vaguely perceptible haze (fig. 12). Examination of the paint surface under the light microscope (normally reserved for study of paint samples) indicates the presence of tiny whitish particles (fig. 13). It can be concluded that the haze is a result of these white particles.

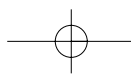
Cross-section analyses of a sample from the baldachin shows that the paint layer build up is relatively straightforward, revealing two (or three) almost identical layers of a dark reddish brown over the (lighter) brown sketch layer (fig. 14).⁶⁰ The dark brown paint layer contains, in addition to large rounded particles of carbon black (EDX: C), red lake

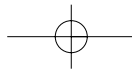
(EDX: Al, S, K from the substrate), large particles of orangey manganese-poor umber (EDX: Fe, Mn), some earth pigments (EDX: Fe, Si, Al), lead white and probably chalk. EDX mapping shows an even distribution of lead throughout, possibly pointing to the migration of lead soaps (fig. 15). In cross-section, the haze appears as a thin greyish crust, about 1 µm thick. It is better observed in the SEM backscatter image (fig. 14C) due to its higher contrast compared to the rest of the paint. EDX demonstrates the crust is rich in lead and potassium, as well as a little calcium and sulphur.

Blanched grey areas are also evident in the stairs in the centre right background, and in localised areas of the grey floor in the foreground and near distant left background. These patchy lighter grey areas severely compromise the intended depth in the painting. Analyses of the paint cross-sections reveal that the paint compositions are similar to that of the baldachin.⁶¹ Again, in both the light microscope and SEM back scatter images a (whitish) deposit is visible on the surface that is rich in lead, potassium, sulphur and calcium and phosphorous pointing to similar degradation as seen in the other samples.

The dark reddish brown paint of the seated spectator in the lower right corner is also greyed and blanched, though here it is partly related to light scattering from the severely cupped and cracked paint layers (fig. 16). Samples from cupped and non-cupped areas, show that the paint layer build up is relatively straightforward, revealing two layers of dark brown consisting mostly of organic brown earth pigment, possibly Cologne earth (EDX: C, Al, Ca, K, Fe, Si), and a little red earth and dispersed lead on top of the lighter brown sketch layer (fig. 17).⁶² In the sample from the cupped paint, what appears to be a varnish layer separates the two paint layers. Interestingly, spherical-shaped crystals (EDX: Pb, K, S) have formed in the surface varnish residues, corresponding in composition with whitish deposits found on the surface in samples from blanched areas.

The causes for the greying of the surface in the various areas of the painting are due to the formation of an insoluble whitish deposit. The degradation products in this deposit have consistently been shown to contain the elements lead, potassium, sulphur and calcium and are probably a mixture of lead-potassium sulphates and various calcium compounds such as sulphates, oxalates etc.⁶³ The results are comparable with blanching problems studied in other (Rembrandt) paintings that also have (bone) black, lakes, smalt and/or earth-containing paint layers that are rich in binding medium and appear to be full of lead





soaps.⁶⁴ The present hypothesis is that the lead soaps result from the dissolution of lead white in the same layer or in underlying layers, in this case the priming layer. The dissolution of lead white can be recognized in the SEM backscatter images by their (greyer) less dense amorphous appearance, as compared to the well-defined highly scattering intact pigment particles. The potassium is thought to come from various possible pigment sources, such as the lakes or the earth pigments, or smalt if present. That the severe state of saponification of the priming layer could be a source of leachable lead carboxylate components seems to be confirmed by the amount of lead detected throughout the paint layers.⁶⁵ These components are thought to migrate to the surface where they undergo reactions with elements, calcium and sulphur from the environment, though whether the calcium also derives from the paint layer is still under investigation. The new insight into the nature of these insoluble blanched layers will hopefully provide information as to whether it may be possible, for this or other paintings, to remove them. Naturally this depends on how intimately bound the white deposit is with the paint.

Conclusion

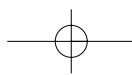
Ingenious compositions like this were luxury items produced for a small class of sophisticated patrons who must have appreciated the intensity of the human expression and the spatial illusionism. Whether Constantijn Huygens, secretary to Frederik Hendrik, bought the picture directly from Rembrandt for the Stadholder's collection or whether Frederik Hendrik commissioned it, is not known. Given that optics and perspective were important topics among Dutch scholars and connoisseurs, it is plausible to think that the painting can be directly linked to interests in the rationalization of sight and pictorial representation taking place at that time in the new Republic. Although it is clear that Rembrandt had a good understanding of linear perspective, he was certainly able to bend the rules, empirically combining traditional perspective and visual phenomena in a single painting to satisfy his artistic goals.

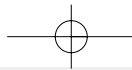
Rembrandt's interest for linear perspective constructions that developed around this time seems to diminish after he settled in Amsterdam. Preoccupation with the relationship between light and space would eventually result in new pictorial solutions where the use of light and shadow, vague contours and limited colour range ultimately manifest itself in his late rough manner of painting. It seems fitting that one of Rembrandt's last paintings found in his studio after his death, is a *Simeon in the Temple* (National

Museum, Stockholm).⁶⁶ While the 1631 picture evokes the carefully staged composition and numerous details of his paintings of the 1630s, the 1669 picture is executed completely in the rough manner of his late style, where it would seem that Rembrandt finally achieved his painterly goal where paint and matter - art and nature - became one.⁶⁷

Analyses of the pigments and the paint layer build-up have revealed new information about how Rembrandt achieved his painterly effects. The possible identification of orpiment could represent a significant discovery in the palette of the young Rembrandt. The use of extremely finely ground azurite to create subdued greyish blue points to a discriminating use of materials. Likewise, the use of leaded oil applied directly onto the still wet azurite to create a unifying green glaze in the background provides new insight into his methods and materials and demonstrates how efficient his painting technique could be.

Unfortunately, the spatial depth that is so important in this painting is compromised by a greyish haze, which was found to be due to the formation of a localised insoluble white deposit on the surface. Analysis of this thin surface deposit has shed new light on degradation processes, particularly the development of typical surface crusts encountered in many paintings by Rembrandt and other seventeenth-century artists that was found to relate to the composition of the paint layers.





Acknowledgements

We are grateful to Anna Tummers (Amsterdam University) and Quentin Buvelot (Royal Picture Gallery Mauritshuis) for their comments, as well as the valuable support and help from colleagues in the Mauritshuis. We also wish to thank Jørgen Wadum (Statens Museum for Kunst, Copenhagen) who carried out the IR imaging; Jaap Boon for interpretation of the DTMS data and Jerre van der Horst for DTMS measurements (FOM-AMOLF, Amsterdam). The analytical research took place as part of the Open Laboratory agreement between the FOM Institute for Atomic and Molecular Physics (FOM-AMOLF, Amsterdam) and the Mauritshuis.

Notes

1 Though imperfectly preserved in the background and slightly mutilated at the two upper corners, this is nonetheless an undoubtedly major work from the end of the Leiden period, reliably signed and dated 1631. J. Bruyn, B. Haak, S. H. Levie, P. J. J. van Thiel, E. van der Wetering, *A Corpus of Rembrandt paintings*, vol. 1, (The Hague, 1982), 331-337, no. A34.

2 The picture was auctioned in Leeuwarden on 17 April 1697 as part of Frederik Hendrik's daughter's (Albertine Agnes) estate. See K. J. A. Jonckheere, *Kunsthandel en diplomatie: De veiling van de schilderijenverzameling van Willem III (1713) en de rol van het diplomatieke netwerk in de Europese kunsthandel*, (Amsterdam, 2005), 166. We are grateful to Quentin Buvelot for this information. See also P. van der Ploeg and C. Vermeer, *Princely Patrons: The Collection of Frederick Henry of Orange and Amalia of Solms in The Hague*, M. Enklaar ed., [exh. cat., Mauritshuis, The Hague] (The Hague, 1998), 68, 188-191, and A. B. de Vries, M. Tóth-Ubbens, W. Froentjes, *Rembrandt in the Mauritshuis*, (The Hague, 1978), 76-78.

3 Broos refers to this painting as 'a kind of farewell to his Leiden Period'. B. Broos, *Intimacies and Intrigues History Painting in the Mauritshuis*, (The Hague/Ghent, 1993), 248.

4 According to Tümpel, the emphasis given to the prophetess Anna in the depiction can be seen as a direct reference to a published sermon of Luther (1483-1546) that Rembrandt must have known. See C. Tümpel 'Traditional and groundbreaking: Rembrandt's iconography', in E. van de Wetering, *Rembrandt: Quest of a Genius*, [exh.cat., Museum Het

Rembrandthuis, Amsterdam] (Zwolle/Amsterdam, 2006), 130-132.

5 Varnish removal was carried out by Jørgen Wadum in 2004; treatment was completed by Petria Noble in 2005, at which time the present technical investigation was carried out. The analytical research was carried out in collaboration with FOM Institute AMOLF, Amsterdam, as part of the 'Open-Laboratory' agreement. Microscopy was done by Petria Noble in the Mauritshuis using a Nikon Optiphot-2 light microscope (magnification up to 400x), with normal light provided by a 100 W Halogen projection lamp. An Ostram Mercury Short Arc HBO 103 W/2 lamp and Nikon filter V-2A (excitation 380-425 nm, emission >430 nm) were used for fluorescence microscopy. SEM-EDX analysis was performed by Annelies van Loon and Petria Noble at FOM Institute AMOLF, on a FEI XL30 SFEQ high vacuum electron microscope and EDAX detector. FTIR analysis was done by Annelies van Loon using the Biorad FTS Stingray 6000 system. DTMS analysis was carried out by Jerre v.d. Horst, Annelies van Loon and Jaap Boon, using a JEOL JMS-SX/SX102A 4 sector double focusing mass spectrometer.

6 According to Van de Wetering, Rembrandt was indifferent towards perspective preferring to rely on more subtle means to suggest space. E. van de Wetering, *Rembrandt The Painter at Work* (Amsterdam, 1997), 256-257. In 1968, Emmens wrote that Rembrandt's interest in perspective progressively lessens. J. A. Emmens, *Rembrandt en de Regels van de Kunst*, (Utrecht, 1968), 103-105.

7 L. D. Couprie, 'De Jonge Rembrandt in zijn atelier, 1629: Een perspectivische analyse van een paneeltje in het Museum of Fine Arts Boston', *Jaarboekje voor Geschiedenis en Oudheidkunde van Leiden en Omstreken*, (Leiden, 1994), 69-96.

8 Linear perspective is briefly mentioned in the entry of the painting in *Corpus of Rembrandt Paintings*, where it states that it is dealt with 'unusually consistently'. Bruyn et al. 1982, 335.

9 For optics and perspective in seventeenth century painting see for example M. Kemp, *The Science of Art: Optical themes in western art from Brunelleschi to Seurat*, (Yale University, 1990); S. Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century*, (Chicago, 1983); A. K. Wheelock, Jr., *Perspective, Optics, and Delft Artists Around 1650*, (New

York, 1977). W. A. Liedtke's review of A. K. Wheelock's, Jr., *Perspective, Optics, and Delft Artists Around 1650*, *The Art Bulletin*, LXI, no. 3 (September 1979), 490-496. While perspective has been studied extensively by many authors, the focus has mostly been on architectural, landscape or Delft painters, in particular Vermeer. See for instance: A. Tummers, 'Aelbert Cuyp's Innovative Use of Spatial Devices', in M. van den Doel ed., *The Learned Eye: Regarding Art, Theory, and the Artist's Reputation, Essays for Ernst van de Wetering*, (Amsterdam, 2005), 87-98; See the articles by J. Delsaute, J. Wadum and D. Bomford in *Vermeer Studies*, I. Gaskell and M. Jonker eds., (Washington, 1998); and contributions by R. Ruurs, J. Giltaij and D. Bomford in *The Paintings of Pieter Jansz. Saenredam (1597-1665): Conservation and Technique*, J.R.J. van Asperen de Boer and L. Helmus eds., (Utrecht, 1998); J. Wadum, 'Johannes Vermeer (1632-1675) and his use of Perspective', *Historical Painting Techniques, Materials, and Studio Practice*, A. Wallert, E. Hermens and M. Peek eds., *Symposium preprints*, (Getty Conservation Institute, 1995), 148-154; R. Ruurs, *Saenredam: The Art of perspective*, (Amsterdam, 1987).

10 The circular nature of vision depicting the horizon in the form of a circle, was illustrated in Vredeman de Vries' *Perspective*, published in 1604, the same year as Kepler's theory of retinal images. Samuel van Hoogstraeten in his *Inleyding tot de Hooge Schoole der Schilderkonst ...*, Rotterdam 1678, (1969), 34, suggested artists should sometimes strive to duplicate true space by using curved lines. See also Wheelock 1977, 82; Kemp, 109-110. In the course of the seventeenth century departures from linear perspective in the form of curved orthogonals or horizon lines appear in many artists' works. See e.g. J. Elkins, "Das Nusslein beisset auf, ihr Kunstler!" *Curvilinear perspective in seventeenth century Dutch art*, *Oud Holland*, 103 (1988), 257-276.

11 B.P.J. Broos, 'Rembrandt borrows from Altdorfer', *Simiolus*, 4 (1970), 100-108. See also B.P.J. Broos, *Index to the formal sources of Rembrandt's art*, (Maarssen, 1977).

12 The following books of architectural prints, including Albrecht Dürer's *proportie* book with woodcuts prints, are amongst the possessions listed in the 1656 inventory: 'een perspectief van Lucas van Leijden.' (fol. 30v) 'een boeck met hout printen van

Lucas van Leijden.' (fol. 33v) 'een dito met kopere printen van Lucas van Leijde soo dubbelt als enckelt.' (fol. 34) 'een dito vol Turcxen gebouwen Melchior Lorich Hendrick van Elst en andere meer, uijtbeeldende het Turcxen leven.' (fol. 35) 'een dito vol teeckeningen van alle Roomsche gebouwen en gesichten, van alle de voornaemste meesters.' (fol. 35) 'een dito vol printen van architectuur.' (fol. 35v) 'een dito vol printen vande architectuur.' (fol. 35v) 'proportie boeck van Albert Durer, houtsnec.' (fol. 36) W. L. Strauss and M. van der Meulen, *The Rembrandt Documents*, (New York, 1979), 348-387. Also see online: <http://gemeentearchief.amsterdam.nl/schatkamer/rembrandt-prive/rembrandt-van-rijn/rembrandts-inboedel.html>

13 This is visible in the x-radiograph of the painting. See Van de Wetering, 1997, 77. One of the drawn studies for this painting, *Three scribes*, c.1628/29, also shows a large schematic repoussoir curtain. See E. van de Wetering and B. Schnackenburg, *The Mystery of the Young Rembrandt*, [exh.cat. Rembrandthuis, Amsterdam/ Staatlichen Museen, Kassel] (Kassel, Amsterdam 2001), 226-231.

14 Karel van Mander, *Den Grondt der Edel vry Schilderconst*, 1604, H. Miedema ed., (Utrecht, 1973), 130-131 and Broos 1993, 249.

15 'Ik wil wel dat je let op het verkorten en verkleinen, zoals men dat in de natuur ziet. Al is het geen architectuur, waarvoor nauwkeurige regels nodig zijn, toch moet je goed je oogpunt of vluchtpunt kunnen zetten op de horizon, dat wil zeggen op de bovenste lijn van de water. Alles wat daaronder is ziet men dan [van] boven af en het andere ziet men onder op.' [Miedema Dutch transcription] in Van Mander 1606 (Miedema 1973), fol. 35, 206-207, and on perspective, 286-287.

16 In Italy, France and Germany a dearth of important publications on perspective already existed. The first northern treatise, *De Artificali Perspectiva* by Jean Pélerin, published in French and Latin, and illustrated with various perspective constructions, was very popular appearing in four editions: 1505, 1506, 1521 and 1635. Albrecht Dürer's *Underweysung der Messung* of 1525 played an important role in disseminating this knowledge in the Netherlands in the seventeenth



century. For a survey of treatises on perspective published south and north of the Alps, as well as treatises published in the Netherlands see e.g.: J. Wadum, 'Vermeer and spatial illusion', in *The scholarly world of Vermeer*, T. Brandenburg and R. Ekkart eds., [exh. cat., Museum van het Boek/Meermannoo-Westrenianum, The Hague] (The Hague, 1996), 31-49.

17 For Hans Vredeman de Vries' career and wide-reaching influence see *Tussen Stadspaleizen en Lucht kastelen*, H. Borggreffe, T. Fussenig, B. Uppenkamp eds., [exh. cat., Koninklijk Museum voor Schone Kunsten Antwerpen] (Antwerp 2002), and *Hans Vredeman de Vries und die Folgen*, Studien zur Kultur de Renaissance, Bd. 3, H. Borggreffe and V. Lüpkes eds., (Marburg 2005).

18 Kemp 1990, 112, 114.

19 Wheelock 1977, 123-124, 132-152 and Kemp, 1990, 110.

20 For Della Porta also see A. Wallert, 'A peculiar emblematic still-life painting from Johannes Torrentius', *ArtMatters*, 4 (2007), 54-67.

21 Since the normal procedure in anatomical dissections was to begin with the torso, the depiction of the arm is considered a direct reference to Vesalius' discoveries on the anatomy of the arm (Vesalius is depicted on the frontispiece of his 1543 treatise with a forearm). That it could also reflect the wishes of Tulp or the Amsterdam Surgeons' Guild who commissioned the portrait though cannot be ruled out. N. Middelkoop, J. Wadum, P. Noble, B. Broos, *Rembrandt under the scalpel*, [exh. cat., Mauritshuis, The Hague], (Amsterdam/The Hague, 1998), 22.

22 See for example, Alpers' chapter on Kepler, 'Ut pictura, ita visio', Alpers 1983, 26-71.

23 Wheelock 1977, 158, 159.

24 Kemp 1990, 109. On Rembrandt's early exposure to rhetoric and art theory see for instance Van de Wetering 2006, 91-99.

25 W. A. Liedtke, *Vermeer and the Delft School*, [exh. cat., Metropolitan Museum of Art, New York] (New York, 2001), 77-83, particularly 81, and J. M. Montias, 'Perspectieven in zeventiende-eeuwse boedelbeschrijvingen', in *Perspectieven: Saenredam en de architectuurschilders van de 17^e eeuw*, J. Giltaij and G. Jansen eds., [exh. cat., Museum Boymans-van Beuningen, Rotterdam] (Rotterdam, 1991), 19-29; in the same volume, W. A. Liedtke, 'De Hofstijl: architectuurschilderkunst in 's-Gravenhage en Londen', 31-42.

26 See e.g. Van Bassen's *The Tomb of William the Silent in an Imaginary Church*, 1620, (Szepmuveszeti Museum, Budapest) in Liedtke, 2001, 223 and A. Rüger and R. Billinge, 'The Design Practices of the Dutch Architectural Painter Bartholomeus van Bassen', *National Gallery Technical Bulletin*, 26 (London, 2005), 23-42.

27 Huygens is presumed to have already visited Rembrandt in 1628. See Van de Wetering and Schnackenburg 2002, 24. For Huygens, see in the same volume 'Constantijn Huygens on Rembrandt and Lievens', 396-399. Also Alpers' chapter, 'Constantijn Huygens and the New World', Alpers 1983, 1-25.

28 On the possible influence of Huygens and art theory regarding this picture, see B. van der Boogert in Van de Wetering and Schnackenburg 2002, 307. For analysis of linear perspective in this painting, see Couprie 1994.

29 W. A. Liedtke, *Architectural Painting in Delft*, (Doornspijk, 1982), 56.

30 For discussion of Dürer's perspective, space and light, see Kemp 1990, 53-61, 109.

31 Dürer's *proportie boeck* was the only practical handbook listed in the 1656 inventory. See Strauss and Van der Meulen, 1979, fol. 36, 376-7. See also note 12, as well as D. Bomford, J. Kirby, A. Roy, A. Rüger, R. White, *Rembrandt: Art in the Making*, (London, 2006), 15. Dürer's books on geometry, perspective and human proportion (*Instruction in Measurement of 1525*, and *Four Books on Human Proportion of 1528*), which appeared in a number of translations and editions, were highly influential in the seventeenth century. For Van Mander's high regard for Dürer see, Karel van Mander, *The Lives of the Illustrious Netherlandish and German Painters*, H. Miedema ed., vol. 1 (Doornspijk 1994), particularly fol. 208v, 92-93. See Van Hoogstraeten 1678, (1969), 276.

32 Wheelock 1977, 83, and 101, note 27.

33 Leonardo da Vinci's writings on painting seem very applicable to Rembrandt's painterly goals. Several authors have commented on the apparent relation of Leonardo's *Trattato* with Rembrandt. See e.g. J. Wadum, 'Contours of Vermeer', in Gaskell and Jonker 1998, 203-223; W. A. Liedtke, 'The "View in Delft" by Carel Fabritius', *The Burlington Magazine*, vol. 118, 875 (1976), 72-73 and Kenneth Clark, *Rembrandt and the Italian Renaissance*, (Glückstadt,

1966), 67-69, 213 note 13.

34 The panel consists of two radial-ly sawn, vertical, butt-joined planks measuring left: 23.5 cm and right: 24.5 cm in width. The oak is of Baltic origin, the left plank identical to a plank in Rembrandt's *The Prophetess Anna*, 1631 (Rijksmuseum Amsterdam). Dendrochronology gives the earliest felling date of 1605 (Dr. Peter Klein, University of Hamburg, 1995, Conservation files, Mauritshuis). The wood grain runs vertically and the panel maintains its original thickness varying between 3 mm (along the join) to 7/9 mm (at the left and right edges respectively). Tool marks can be made out on the reverse: on the back of the left plank, horizontal slightly curved saw marks, and on the back of the right plank, vertical marks from a plane.

35 This standard size has been also recognised in works by Rubens and Van Dyck, indicating its widespread use as a standard format. See Van de Wetering 1997, 13; also J. Kirby, 'The painter's trade in the seventeenth century: theory and practice', *National Gallery Technical Bulletin*, 20 (London, 1999), 20.

36 According to a royal inventory of 1757/1763, the upper corners were rounded off and an arched-top was added in 1733 by the painter/restorer Philip van Dijk when the picture became part of an interior scheme in Palace Het Loo. There it formed an ensemble with Gerrit Dou's, *Young Mother* (Mauritshuis, The Hague) on either side of Cornelis van Poelenburch, *The Annunciation of the Shepherds* (Gray, Musée Baron Martin). See Broos 1993, 247.

37 A chalk ground with a little lead white in places. See De Vries et al. 1978, 75, 214-215. Broos 1993, 249, describes only a 'thin ivory-coloured ground'.

38 Both ground layers are visualised in four cross-sections from different areas in the picture. The priming is up to 30µm thick in sample 145x03 from the stairs at right edge. Here the priming layer seems to have become thicker due to saponification and subsequent expansion of the lead white particles. The SEM back scatter image reveals dissolution of the lead white particles in this layer.

39 For instance, Rembrandt's *Andromeda*, c.1630, panel (Mauritshuis, The Hague) has a translucent brown sketch layer applied on top of a cream-coloured priming layer. See J. Wadum, 'Rembrandt's erster "hässlicher Akt"', *Restaura*, 7 (2003), 498-499. Also

in *The Anatomy lesson* of Dr Nicolaes Tulp from 1632 (Mauritshuis, The Hague), which is painted on canvas, a translucent brown sketch was identified on top of the upper light grey ground. See Middelkoop et al. 1998, 66. Gifford also describes the use of an initial brown sketch: E. M. Gifford, 'Evocation and representation: Rembrandt's landscape painting technique', in C. Vogelaar and G. Weber eds., *Rembrandt's Landscapes*, [exh. cat., Staatliche Museen Kassel/Stedelijk Museum De Lakenhal Leiden] (Zwolle, 2006), 126-127. Also D. Bomford et al. 2006, 30.

40 Documented by Jørgen Wadum in 2004 with the Artist camera (Art Innovation, Hengelo) mounted with a CCD progressive scan image sensor (1360 x 1036 pixels) and a Schneider Kreuznach Xenoplan 1.4/23 mm CCTV-lens in NI2 with a long wave pass filter 1000 nm. The images were captured with Artist Software (release 1.2) and stitched with PanaVue Image Assembler.

41 The sketch layer is present in all three samples from the dark background: 145x02 (centre background, where it is very thin), 145x03 (stairs at centre right edge, about 10 µm and 145x04 (baldachin upper right, about 10 µm. It is also present in 2 samples, 145x05 and 0145x10 from the lower margin of the picture. In cross-sections from Mary's cloak (145x07) and the floor in the lower left corner (145x01A), no dark sketch layer is present. In the sample 145x06 from the chair at the lower right an intermediate layer consisting of organic red and brown is present.

42 The presence of dispersed lead is probably the result of lead soap formation in this layer or in the underlying priming layer. It is considered to be too much lead to be from the use of leaded oil.

43 De Vries et al. described a translucent brown intermediate layer, containing the pigment Cologne earth. De Vries et al. 1978, 73-81, 211, 214-215.

44 See E. van de Wetering, 'Rembrandt's manner: Technique in the Service of Illusion', in *Rembrandt the Master and his workshop*, H. Bevers, P. Schatborn, B. Wezel eds., [exh. cat., Gemäldegalerie Berlin/Rijksmuseum Amsterdam/The National Gallery London], (Berlin/London, 1991), 12-39, 37. Also 'Rembrandt's Brushwork and Illusionism; an Art-Theoretical Approach', in Van de Wetering, 1997, 179-190 and 'Young Rembrandt's "Rough manner"', in

Van de Wetering and

Schnackenburg 2001, 92-121.

45 Sample 145x07 is from a mid-tone in the blue dress.

46 De Vries et al. 1978, 75, 212 described the blue erroneously as strewn azurite [scattered onto a layer of lead white] though it is not clear how this determination was made.

47 M. Spring, 'The blue draperies', in S. Hodge, M. Spring, R. Marchant with Z. Veliz, 'The Santa Marina Retable from Mayorga, attributed to the Master of Palanguinos, c. 1490s', *Hamilton Kerr Bulletin*, 3 (2000), 27, note 18.

48 In IR several small changes to other figures are also evident: the right hand proper of the scribe holding a book in the lower right, was originally painted in a lower position. The second spectator in the lower right was also painted before the seated figure.

49 E. Runia and A. van Suchtelen, *Rembrandt in het Mauritshuis*, (Zwolle, 2006), 36.

50 Sample 0145x09 is from the opaque light green garment of the figure behind the Christ child.

51 Orpiment was also noted by the Mauritshuis restorer J. J. Susijn when the picture was consolidated in 1983 (Conservation files, Mauritshuis). In cross-section the natural orpiment particle in the green paint layer in sample 145x09 has a typical plate-like structure causing it to reflect light in a sparkly manner.

52 That it could also be a result of metal soap aggregates in lead-tin yellow cannot be excluded. See P. Noble, J. J. Boon, J. Wadum, 'Dissolution, aggregation and protrusion: Lead soap formation in seventeenth-century grounds and paint layers', *Art Matters*, 1 (2002), 46-61.

53 In an anonymous Flemish painting of the early seventeenth century and in *A winter Scene* by Aelbert Cuyp where it has been used mixed into the brown shadows. L. Sheldon, S. Woodcock, A. Wallert, 'Orpiment overlooked - expect the unexpected in seventeenth century workshop practice', Poster Summary, ICOM-CC 14th Triennial Meeting The Hague 2005, Vol. 1, I. Verger ed., (London, 2005), 529. See also: L. Sheldon, 'Blue and yellow pigments - a note on the hidden colours of light in Cuyp and Vermeer', *ArtMatters*, 4 (2007), 97-102.

54 The binding medium of the green glaze layer was determined

using Direct Temperature resolved Mass Spectrometry (DTMS). In the volatile region of the total mass spectrum, a high content of fatty acids was observed with characteristic peaks at m/z 256 and 284 of palmitic acid (C16FA) and stearic acid (C18FA) respectively. The spectrum also showed mass peaks for dammar and traces of pine resin, which is probably due to contamination from varnish in the sample. In the polymer region, the characteristic pattern of the pyrolysis products of the oil paint network was present. The inorganic fraction shows lead isotope peaks at m/z 206, 207 and 208. In the SEM backscatter image, tiny needle-shaped crystals rich in lead have formed in the medium-rich areas, probably as a result of lead soap formation and migration.

55 Sample 145x08 is from the dark green glaze from the small figure to the right behind Joseph.

56 A similar construction of colour consisting of a finely structured azurite underpaint and a surface glaze to produce a deep green tone, was also found in Rembrandt's *Saskia van Uylenburgh as Flora* (National Gallery London). See Bomford et al. 2006, 96-97.

57 A pencil drawing after Simeon's song of Praise, by N. Heydeloff (Curatorial files, Mauritshuis) also depicts the painting with its then semi-circular addition. See P. Noble, C. Pottasch and P. van der Ploeg, 'Rembrandt - Recent Restorations', *Mauritshuis in Focus*, 19, no. 3 (2006), 12, and Broos 1993, 247, fig. 1c.

58 'Blanching', a term which refers to the optical whitening of the paint surface, is related to a scattering of the light from a variety of causes: residues, formation of surface deposits, micro-voids in the paint surface or the fading/degradation of certain pigments.

59 See also Noble et al. 2006, 9-15.

60 Sample 145x04 is from the baldachin at the right edge of the painting.

61 Sample 145x03 is from the stairs at the right edge. Here the paint composition is very similar to that of the curtain, only lighter: carbon black, red lake, orangey umber, earth pigment, little lead white and chalk (applied in two layers).

Sample 145x01A is from the dark grey floor in the lower left background. The floor is built up in two layers: a thick compact greyish brown layer containing charcoal

black (EDX: C), lead white (EDX: Pb - mostly dispersed as lead soaps), earth pigments (EDX: Fe, Al, Si, Mn), as well as possibly a little red lake, followed by a thinner dark grey layer of a similar composition.

62 Two cross-sections were taken for analyses and comparison: sample 145x05 from cupped paint at the lower right edge and sample 145x06 from a non-cupped area in the chair.

63 Lead sulphates and lead potassium sulphates have been found as degradation products associated with medieval stained glass windows. J. Sterpenich, 'Cristallochimie des produits d'altération des vitreaux médiévaux: application au vieillissement des déchets vitrifiés', *Bulletin of Engineering, Geology and the Environment*, 61 (2002), 179-193. In smalt reconstructions carried out by researchers at the National Gallery London, potassium sulphates were also detected although they are water-soluble. In all these cases the source of potassium is the glass (potassium is added to glass to decrease the melting point). A variety of calcium degradation products, calcium sulphates, oxalates, phosphates etc. have been found in surface crusts depending on the conditions. Calcium oxalates are well-known surface degradation products on stone, glass etc. On paintings however, their occurrence has only been noticed recently, see K. Sutherland, B. Price, I. Passeri, and M. Tucker, 'A study of the materials of Pontormo's "Portrait of Alessandro de' Medici"', *Materials Research Society Symposium Proceedings*, 852 (2005), #OO2.2.1, and M. Spring, C. Higgitt and D. Saunders, 'Investigation of Pigment-Medium Interaction Processes in Oil Paint containing degraded Smalt', *National Gallery Technical Bulletin*, 26 (2005), 56-69 and in the same volume C. Higgitt and R. White, 'Analyses of Paint Media: New studies of Italian Paintings of the Fifteenth and Sixteenth Centuries', 88-97, particularly 93-94.

64 Blanching problems of dark paint layers are being studied in a number of seventeenth-century paintings. Annelies van Loon will present the results of this research in her forthcoming Ph.D. diss., *On colour changes and chemical reactivity in 17th-century oil paintings*, (Amsterdam, 2007).

65 Comparison of the paint layers

and the blanching problems in dark areas in Philips Wouwerman's *Stable interiors*, as discussed in the article by Verhave, Van Loon and Noble in this volume, shows a very similar build up of paint layers and comparable pigment mixture, with the use of both earth pigments and lakes.

66 S. Schama, *Rembrandt's Eyes*, (New York/ London, 1999), 686.

67 On late Rembrandt see e.g. Van de Wetering 2006, 56.