seen in abraded areas along the tacking edges. Probably Mignon started with a double ground, much the same as the ground on De Heem's Festoon with Fruits and Flowers. Presumably dissatisfied with the result he applied a third layer to obtain an even smoother surface.

The cross-sections, taken mainly from the flowers, reveal a thin grey layer with fine lead white and a fine black pigment. Before being restored, this grey layer was visible, with some variation of the grey tone, in lacunae in the upper paint layers, as in the yellow fox rose (Rosa x cultorum) and the pink Province rose (Rosa x provincialis L.). Mignon appears to have applied an underpainting in grey hues which was sometimes used, as the pink Province rose reveals, to achieve a delicate bluish effect, creating the translucent petals characteristic of this flower. He subsequently applied the basic colours of the flowers, before blocking in the background, apparently a common practice. This is mentioned in several sources, including the Memorandum Book in which Jacob Bogdani's method is described: 'He designs the loose manner of his Flowers with a Chalk on the Cloth out of his Head then he paints all his Roses and Guiflowers and Tulips on the Cloth with Stalks one by one leaving the Ground of the Cloth'.

This order was also recommended by Willem Beurs: 'A flower painter may well paint his flowers and leaves, the ones in the sun light and then the ones in the shade; then the bottle or pot; after which one can start with the table and [back] ground [...], as the wetstand of his flowers (or also fruits), which is his first priority, will permit'.

A paint sample from the orange marigold (Calendula officinalis L.) in the centre of the composition reveals a remarkable structure (figs. 1a and b). Over the triple ground and thin grey underpainting, is a blue layer containing indigo covered by a layer consisting of lead white, and some yellow lake followed by a layer identified as realgar (fig. 2). Lights were executed with a yellow pigment. The blue layer seems odd as a base for an orange flower. However, the flower may have been painted over a planned leaf. Gerard de Lairesse describes the so-called taschelenbinnen in his Groot Schilderboek (1707) in the chapter on flower still lifes. These are the small flowers added to balance the strong colours of the main composition: 'The taschelenbinnen [flowers-in-between] [...] are added on top of the green or the background in the working-up stage'. The marigold in Mignon's painting may well be a taschelenbinnen, painted over an existing leaf.

The layer structure encountered in the cross-sections of the red and yellow flame tulip, the pink Province rose and the blue convulvus (Convolvulus micans L.) is rather straightforward, demonstrating the work of an experienced artist who knew how to obtain an optimal effect with a simple technique. The paint sample of the yellow and red flame tulip shows this, since Mignon simply covers the triple ground and the grey underpainting with a thin bright red layer composed of red lake pigment.

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Fig. 1
EDX spectrum of the orange top layer in cross-section form marigold: the presence of arsenic (As) and sulphur (S) indicate an arsenic sulphide pigment like realgar or orpiment; calcium (Ca) and potassium (K) refer to the substrate of the yellow lake.

Fig. 2
Paint cross-section of sample (R 50.4) from orange coloured marigold: bright, field, incident light (1) magnification 50x, and SE M-b组织领导 electron image (2b), scale bar is 100 mm.

2. Second ground: agglutinate rates of lead white, carbon black, earth pigments.
5. Yellow and white paint layer: lead white, orpiment, realgar.

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2. M. Bijsma, 'De Groene Rondeboek van 1691' (unpublished), Amsterdam, Koninklijke Bibliotheek
3. Identification of pigment is based on peaks for arsenic and sulphur in SEM/EDS measurements and a good match of the XANES pattern with JCDPS (file 8-0473). The yellow pigment is not identified, SEM/EDS spectra did not show peaks for Ca, this would indicate the expected leady yellow.

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In 1639, Abraham Albright (1640-1692) was born in Leipzig, the son of a painter, and by the age of seven he had already shown a talent for drawing and painting. His early life was spent in the studio of his father, where he received a solid grounding in the fundamentals of art. In 1664, he entered the studio of the famous Dutch painter, Jan van der Heyden, who was known for his skill in depicting flowers and landscapes. Albright's paintings were characterized by a deep sense of color and composition, and he quickly gained a reputation as a talented artist.

In 1668, Albright moved to Amsterdam, where he continued to develop his skills as a painter. His work was well-received, and he soon became one of the leading artists in the city. In 1673, he was invited to the court of the Dutch East Indies Company, where he was given the opportunity to travel and paint in the East Indies. During his time there, he created a number of beautiful landscapes and still-life paintings, which were highly prized by collectors.

In 1680, Albright returned to Amsterdam, where he was elected a member of the Royal Academy. His work was now in high demand, and he soon became one of the most successful artists in the city. In 1692, he died suddenly, leaving behind a legacy of beautiful paintings that continue to inspire artists and art lovers to this day.
The stunning beauty and diversity of 17th-century Dutch still-life painting raises many questions about developments in style and technique.

What materials did artists use to produce these works? How were they made? Did all the still-life painters of this period use the same methods and materials? If they did, why are there so many striking differences? And if they used different materials, or the same materials in different ways, can we relate this to differences in style?

These questions have been explored by conservators and curators of the Amsterdam Rijksmuseum and scientists attached to the Molart project. (Molecular aspect of ageing in art) in an examination of a score of paintings from the museum collection. This clear and accessible presentation of their results provides an insight into the techniques of famous masters such as Jan Brueghel, Balthasar van der Ast, Jan Davidz de Heem, Willem Kalf, Rachel Ruysch and Jan van Huysum.

Arie Wallert is curator of paintings at the Rijksmuseum Amsterdam and participant in the Molart project.
and vermilion (which appears to be present in the yellow flower). A thicker, bright layer was subsequently added for the yellow flowers, presumably after blocking in the background. A single layer of the red lake was next, followed by the pink and red lakes. A remarkable feature of the painting is the yellow fox grey underpainting, which is revealed in the painting process. The flower looks rather flat, lacking the depth of the original work. The presence of ultramarine blue is noted in the underpainting, but it is not clear if it was used as a pigment or as a binder. The painting also reveals the use of carbon black and red ochre. The yellow lake is seen over the ochre, suggesting the use of yellow ochre in the painting process. The underpainting is revealed in the painting process, with the artist using a variety of pigments and techniques. The artist also used a combination of tempera and oil paint, with the oil paint applied over the tempera layers. The final result is a rich, vibrant, and detailed painting, with a strong sense of depth and spatial relationships.
tion. In the Middle Ages, the use of pigments for miniatures and especially their combinations were bound to
strict rules recorded in codicologies of colours. Each
basic colour had a prescribed darker colour that was
used for shading and modelling, and a specific lighter
colour used to highlight. Modelling with a darker hue
highlighting with a lighter tone was called matirage.
The interactions were the equivalent of seventeenth-century
painters such as De Lairese. The three-step method came to play a central
role in the theory of the French academicians. There, the
first sketch, the ground, would receive highlights and
shadows as the paint layer was built up. After a few
months, or strokes were made. In the French academy,
the process became codified, or rather standardized, into a fixed
and rigid system. At its best, it could result in the elusiveness of Mignons
originals, but mechanical and uninteresting paintings.
A suggestion of this division of labour can also be inferred from a document in the inventory of the factory of Lucas van Leyden, preserved in the Hamburger Kunsthalle. The factory was described as a 'manufactory' in the 15th century, producing works of art using a variety of techniques, including dead-colouring and gold leaf. The use of dead-colouring was classified as a 'fashionable' technique, and the artists were known for their skill in creating intricate designs using gold leaf and other materials.

In the 16th century, dead-colouring was used extensively in the decoration of textiles, furniture, and other objects. Artists such as Pieter de Hooch and Jan Vermeer were known for their skill in creating realistic and detailed works using dead-colouring. The technique involved the application of dead colours to a wet surface, allowing the colours to blend and create a smooth, seamless finish. The use of dead-colouring was also popular in the decorative arts, where it was used to create intricate patterns and designs.

Most underpainting was painted with a soft brush to create an even and smooth surface from which to proceed. A brush of badger hair was used to spread the dead-colouring evenly over a single piece of vellum or paper. The work was then dried before being painted with the next layer of dead-colouring. Once the underpainting was complete, the surface was ready for the final layer of oil paint, which was applied with a soft brush to create a smooth and even finish.

Fig. 17
A combination of a sample of the pigment used in the underpainting, as well as a close-up of the oil paint on a small sample of canvas, are shown in this image. The underpainting is composed of a mixture of oil, pigment, and ground, and is applied in a thin, even layer to create a smooth surface. The oil paint is then applied over the underpainting, creating a rich and glossy finish.

In summary, dead-colouring was a popular technique in the 16th century, used in a variety of applications. The technique involved the application of dead colours to a wet surface, allowing the colours to blend and create a smooth, seamless finish. The use of dead-colouring was also popular in the decorative arts, where it was used to create intricate patterns and designs. The technique was used in the underpainting of paintings, where it was applied with a soft brush to create an even and smooth surface from which to proceed.
Underdrawing requirements of the subject matter were addressed in the painter's studio according to the basic principles of painting. When the subject was drawn in the studio, the underdrawing was then transferred to the final painting. The underdrawing was used as a guide for the final painting, helping to define the outlines and shapes. The underdrawing was then covered with a wash or ground before moving on to the final painting. The underdrawing was an essential step in the process of painting, helping to guide the painter in creating a successful final artwork.
precise underdrawing, the painting was based on a loose sketch in a dark, almost black, paint under a dark imprimatur, as in Willem Kalf's Still Life with Silver Jug (cat. no. 10; fig. 11).

IMPRIMATURA

If oil paints were used directly on the chalk ground of a panel, the absorbent ground would soak up the binding medium of the paint. This would result in poor adhesion of subsequent paint layers. The ground and underdrawing were therefore covered with a thin, insulating layer of lead white bound in oil - thin enough to show the underdrawing. The lead white provided a bright reflective surface for the subsequent paint layers. This primerscler or imprimatur was often given a little tone with the same function as the second ground layer on canvases. Since this insulating layer was required to dry rapidly, pigments containing cobalt, copper, lead or manganese were often added. A toned ground also offers the advantage of providing a middle or dark tone to serve as a basis for the highlights. This would be particularly useful for painters with a more quick and painterly approach, rather than descriptive and linear. In other words, Kalf (cat. no. 10) and Van Beieren (cat. no. 8) would have profited more from such a layer than Bosschaert (cat. no. 3), Mignion (cat. nos. 11 and 12) or Van Haysum (cat. no. 18).

Examination of imprimaturas occasionally reveals mixtures of several different pigments. This suggests that remnants of paint, the dregs from the put used to clean the brushes for example, or the scraps of palettes, were re-used for this purpose. The seventeenth-century painter Charles le Brun offered an explanation of this practice:

The pinceauere is a vase in which the brushes are cleaned with oil. And of the mixture is made a grey colour, for certain purposes, such as to lay on the first coats, or to prime the canvas.  

Retaining the visibility of this dark underlayer affected the tone of the following paint layers. When, for instance, a light ochre or lead white is brushed, or scumbled over the canvas so that the lighter paint only takes the tops of the canvas weave, the dark underpaint shimmers through in those areas where the light paint has not caught. In this way, the painting builds up from dark to light. To achieve this, dabs or strokes would be applied in a relatively dry, 'short' paint, giving the texture of the paint an open, broken appearance. The dark tone of the imprimatur thus contributed to the transition of the shadow and so to the overall impression.

BINDING MEDIUM

In each painting examined here, the binding medium of the upper layers seems to have been a drying oil, its primary function being to bind the individual pigment particles thereby enabling the pigment to adhere to the surface. This oil would be obtained by pressing plant seeds. The most common sorts were linseed, walnut and poppyseed, which produced drying oils containing various triglycerides. The principal unsaturated fatty acids among these triglycerides are linolenic acid and linoleic acid. When drying, these relatively small units grow into larger networks by oxidative polymerisation processes. These networks are therefore able to bind the pigment particles. The oxidative processes are accelerated by certain metal ions from the pigments. Copper, cobalt, lead, and manganese ions affect the drying of oils in particular. They may also play a role as centres for coordination complexes, eventually developing into a completely hardened paint film.

In general, cold pressed oils are of better quality than hot pressed oils, which are darker and sometimes turbid. Poppeseed oil has distinct advantages over linseed oil in that it darkens, and yellows less. It was therefore the preferred medium wherever it was important to avoid yellowing. Painters used it to form the waxy yellow petals of a Viceroy tulip, or the cool light blue of a hyacinth. Theodor Turquet de Mayerne noted that Dutch flower painters such as Jaques de Gheyn II, used poppyseed oil extensively:

Mancop oil is a very white oil which is used in the Netherlands by painters, such as Jaques de Gheyn and his likes, who make very delicate works that require vivid colours, like vases with flowers.

This would explain the remarkable freshness of some of these early flower pieces. In the same note De Mayerne also mentions some of the disadvantages of poppyseed oil, it being a relatively poor dryer. To get the ground to dry, lead-rich glass was added, accelerating the process:

An Examination of Paintings from the Kiln museum

Still-Life Paintings: Techniques and Style

[Text continues on the next page]
with the original state. This involves a study of historic paint manufacturing and workshop practice that provides an insight into the nature of the materials and the original painting techniques.

The various contributors to this volume are identified by their initials below each text. Contributors from the Rijksmuseum include Martin Bijl [MB], Jolanda de Bruijn [JdB], Astrid van den Berg [AvdB], Michiel van de Laar [MvdL], Willem de Ridder [WdR], Gwen Tauber [GT], and Manja Zeldentust [MZ]; and from Molart, Klaas-Jan van den Berg [KvdB], Oskar van den Brink [OvdB], Margriet van Eikema Hommes [MvEH], Muriel Geldof [MG], and Erna Hermens [EH]. As a participant in both organisations, Arie Wallert [AW] kept the project on course. Joris Dik [JD] resident art-historian at the institute of crystallography of the University of Amsterdam, and Margreet Wolters [MW] from the Netherlands Institute for Art History (Rijksdienst voor Kunsthistorische Documentatie or RKD) contributed their own areas of specific expertise.

While most of the microscopy and micro-chemical tests were performed at the Rijksmuseum, Peter Hallebeek assisted with x-ray fluorescence and x-ray diffraction equipment at the Dutch Institute for Cultural Heritage (Instituut Collectie Nederland or ICN). Chromatography for the identification of organic colourants also took place at ICN. Fluorescence spectrometry for the identification of these colourants was done at the Getty Conservation Institute's Museum Services Laboratory. Cees Mensch, of the Shell Research and Technology Centre in Amsterdam did the scanning electron microscopy, combined with the energy dispersive analyses. Jerre van der Horst, at the Institute for Atomic and Molecular Physics (Amolf), operated the mass spectrometers. Jaap van der Weert did the FTIR microscopy. The photography was, as usual, in the experienced hands of Peter Mookhoek and Henk Bekker. The corrections to, and comments on our English texts by Tim Bedford and Gwen Tauber greatly improved the arguments.

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[AW]
assembled boards would then be planed to obtain level surface. The back edges were usually bevelled to allow the panel to fit into a frame. These bevels and other marks offer important clues about the origin of the panel (Fig. 1).

cishapers made panels for paintings in a range of standard sizes, known as the ‘rips’ and the amount they cost. They included frames, glass, and the 17th-century panel. This remarkably advanced standardisation related to local units of measurement. The dimensions of a panel from Leiden were in Amsterdam feet (3.8 m) and its height in Amsterdam zoll. Van Huysum's still life with flowers (cat. no. 18) measured 59.9 x 91.4 cm. Its standardisation is consistent in size with the rest of Van Huysum's other paintings. The relationship between problems of attribution and local units of measure is the subject of an ongoing investigation.

Canvas could be bought ready-made, but were also routinely stretched and prepared in the studio. Here too, the dimensions of canvases seem to have been based on local or regional standards since the size of the canvas was affected by the size of the looms on which the linen was woven. Linen was not specifically made for painting, but rather for bed ticking or sailcloth. The face seven-eighths of an inch thick was chosen, which is closely woven and is of equal quality in warp and weft and has few knots. Much of it was produced in the province of North Holland (sail cloth) and in the province of Twente and Over Friesland. The