THE ZIBBY GARNETT TRAVELLING FELLOWSHIP

Report by Katharine Waldron

Twentieth-century oil paint recipes by Talens, and issues in modern oil paintings.

At Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency), Amsterdam, The Netherlands.

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1. INTRODUCTION

My name is Katharine Waldron and I am in the second year of my Postgraduate Diploma in the Conservation of Easel Paintings at The Courtauld Institute of Art, London, UK. I am 24, British and from Norwich, Norfolk, UK. My course provides practical training in the conservation of easel paintings and supporting theory, including the ethics and history of paintings conservation. It will give me the skills and knowledge base to go on to gain further practical experience or a research degree in paintings conservation, after which I intend to work towards ICON accreditation and work as a paintings conservator, either privately or in a museum or gallery. Students on my course are encouraged to gain further practical experience in the summer holidays. In my first year of study I was introduced to the importance of interactions between centres of conservation research – nationally and internationally – for the sharing of problems, ideas and resources. I was keen to gain first-hand experience of this at the Cultural Heritage Agency of the Netherlands, which has collaborated with the Courtauld conservation department on a number of projects. I had only visited Amsterdam once before, briefly, and I hoped that this would be an opportunity to explore the city and its superb collections and learn about the day-to-day workings of a conservation science department in another country. My tutors alerted me to the Zibby Garnett Travelling Fellowship.

2. AIMS OF STUDY TRIP

I spent most of my time at the headquarters of the Netherlands Institute for Conservation, Art and Science (NICAS), based at the Ateliergebouw next to the Rijksmuseum in Amsterdam (figs. 1 and 2). On two days I travelled off-site to the factory and archive of Royal Talens, the Dutch manufacturers of artists' paints and materials, in Apeldoorn (figs. 4 and 5).

Amsterdam, the busy capital of the Netherlands in the province of North Holland (figs. 3 and 4), is home to a number of world-renowned museums and galleries and boasts an impressive collection of modern and contemporary works. A significant body of research carried out at the centre in Amsterdam concerns issues arising during conservation of these. A number of disturbing degradation phenomena have become apparent in recent years on unvarnished paintings made using 20th-century commercially-manufactured oil paints, posing practical and ethical problems for conservators; one issue, for example, is water-sensitivity, which inhibits the surface cleaning of these paintings using the usual range of aqueous methods. The technical study of modern paints in relation to these problems is a key area of current research, and links have been proposed between the additives present in the paints of certain 20th-century manufacturers and the water sensitivity of paintings by artists known to have used them.

Work is ongoing in the Netherlands to build a database of reference material relating to Dutch 20th-century paint manufacturers, to include extant recipes and the results of technical analysis on tube paint samples. A similar resource exists for Winsor & Newton recipes and is proposed for the art supplier Charles Roberson & Co. The digitisation of historical paint recipes has benefits for conservation research and practice concerning 20th-century oil paintings; the information can reveal, for example, which additives in the paints might be responsible for particular degradation phenomena. During my time in the Netherlands, I would be focusing on recipes of the manufacturer Royal Talens. As well as contributing to the database, I aimed to identify whether these paints could have been used in several works from the 1950s by the Dutch artist Karel Appel, which exhibit a number of degradation phenomena referred to above and described below.

I envisage that my later work will bring me to work on paintings of a range of different ages and media, including modern and contemporary works where the materials and their degradation may be unpredictable or new to me. I consider a scientific understanding of the chemical composition and change of artists' materials to be as important as my building of practical experience at this stage. I hoped that this placement would provide me with experience and contacts that would enhance my awareness of the latest questions, problems and developments in the conservation world, which has a growing range of analytical techniques at its disposal to study the processes of deterioration in paintings.

The Trust awarded me the generous sum of £1200 towards my trip. I was also employed for a short time in a private studio in the weeks beforehand and was able to contribute £100 from my savings.

3. MY PROJECT

The NICAS works in collaboration with the Rijksdienst voor het Cultureel Erfgoed (the Cultural Heritage Agency of the Netherlands, hereafter referred to as the RCE) and the University of Amsterdam. The Institute combines expertise in state-of-the-art scientific analysis, art history and conservation to conduct research into the techniques and materials of artists and craftspeople, and the chemical and physical changes that occur in objects over time. I was able to meet academics, students and interns and get a glimpse of the myriad of projects – which were not limited to paintings – taking place around me. I was supervised by Dr Klaas Jan van den Berg, a senior researcher at the RCE who specialises in the chemical and physical composition of paint films and the changes that occur in them over time and in relation to their conservation. Dr van den Berg has taken a leading role in the recent investigations in the deterioration and conservation of unvarnished modern paintings, and he was supervising a number of other students working on related projects.

My project was centred on the results of previous analysis carried out on six paintings by the 20th-century Dutch artist Karel Appel (three of which are shown in figs. 6, 7 and 8). These paintings are important because they all exhibit specific degradation phenomena and/or water sensitivity in certain passages and colours. Appel's technique throughout the 1950s is characterised by violent, frenzied paint application that often involved applying paint directly from the tube; many of the colours analysed are thought to be tube paints and the degradation problems, outlined below, have largely been attributed to the range and combinations of ingredients that manufacturers were using in the mid-20th century.

The aim of this project was to identify any parallels that may exist between the materials identified in the paintings and the recipes for oil paints produced by the Dutch manufacturer Royal Talens between 1951 and 1961. The study undertaken by a previous Courtauld student, in which Talens tube paints in the archive collections at the RCE were dated using the catalogues and their contents analysed and compared with the recipes, provided invaluable analytical data on the Talens tube paints and guidance for interpreting the recipe cards.[1] Where possible, inorganic and organic analyses of the tube paints from this and other sources were taken into account in this project, because

[1] Bayliss, S., '20th Century Oil Paints', Project report, RCE (2013).

several instances had been noted before where the results of analysis did not entirely reflect what was written in the recipe. It was hoped that my work may help establish whether or not Appel was using Talens paints, and whether certain additives in the recipes may be associated with the degradation issues observed in the paintings.

3.1 Modern oil paints

In the twentieth century there was a marked increase in the mechanised mass-production of artists' materials and the range of products available. In particular, paints could be adulterated with various materials to alter their properties. Modern oil paints are usually a combination of:

A pigment*.* Inorganic pigments include earths and natural minerals. Organic pigments are based on carbon and include dyes, and are less lightfast. Pigments might be derived from nature or synthetically made.

An oil binder*.* This can be one or a combination of oils derived from seeds, nuts, pulses or vegetables. The oil might be thickened first by heating, and resins or waxes might also be added, to alter the handling properties of the paint. Some oils (e.g. linseed oil) are drying oils, while others (e.g. poppyseed oil) are only semi-drying and take longer to completely dry.

An extender*.* Often a colourless, inorganic substance such as calcium carbonate (chalk), barium sulphate, aluminium hydrate, magnesium carbonate, etc. This adds bulk or improves the handling properties of the paint, and might reduce the amount of pigment required.

Additives. These often take the form of stearates (e.g. alumimium stearate, zinc stearate), which are often added to improve the dispersion of the pigment in the binder; some pigments do not mix very easily with oil.

3.2 Karel Appel and degradation

Karel Appel was a founding member of CoBrA, an avant-garde group that existed between 1948 and 1951, of artists primarily from Copenhagen, Brussels and Amsterdam. The artists took inspiration from primitive and children's art, creating abstract works characterised by bold colours and shapes and expressive mark-making. The works of Karel Appel in the 1950s exhibit particularly violent, frenzied paint application with evidence of various implements: brushes, palette knives, the artist's hands and, most importantly, directly from the tube. This means it is possible to take samples of what is likely to be pure tube paint from these paintings, and the information thus gained can be used to understand more about the paints Appel was using. A number of the degradation phenomena outlined below occur in these 'pure' passages and have been attributed to the range and combinations of ingredients that manufacturers were using in the mid-twentieth century.

Medium separation. The binder in the paint forms a skin on the surface (for example, fig. 10). In some colours this leaves friable dry pigment beneath. In others the medium is a yellow colour and drips down the surface and appears to originate from cracks in the film. This has been linked to the presence of non-drying oils or stearates in the paint film. Storing a painting in the dark in the early stages of its life has also been linked to this phenomenon.

Matte, wrinkled and shrunken surface (for example, fig. 11). Caused by the paint on the surface drying more quickly than the paint beneath. One possible cause is the manufacturers' addition of driers to the paint.

White surface crust or 'efflorescence'. Analysis often reveals to be magnesium sulphate heptaydrate (epsomite). This is known to form when magnesium carbonate, present in the paint as an extender, reacts with sulphurous gases in the air, and it is proposed to be a common cause of water sensitivity in 20^{th}-century paints.

Paint not fully dried. This occurs in thickly-applied paint films. The paint remains sticky (for example, fig. 9). One proposed explanation for this is the presence of metal stearates to tube paints, which are thought to prevent the binder from drying.

3.3 The paintings

I compiled a spreadsheet summarising the results of all analysis previously done on the six paintings (fig. 12). This made it easier to make comparisons between the colours analysed in each painting. The data was obtained from several published and unpublished sources. Most of the paintings had been analysed with both inorganic and organic techniques, enabling the analysts to identify pigments, extenders, additives and binding media present. One or two, though, had only the results of inorganic analysis, and so the binding media and presence of certain additives, such as stearates, was unknown. It was possible to compare the constituents and degradation phenomena of a given colour between paintings. For example, ultramarine blue in *L'homme*:

Painting	Colour	Problem/degradation phenomena	Composition of paint, determined from analyses
L'homme (1953)	Dark blue	Very water sensitive.	French (synthetic) ultramarine pigment Aluminium hydroxide extender Zinc stearate Zinc oxalate Slightly heat-bodied oil

3.4 The paint recipes

The archive at the Royal Talens factory contains a box of recipes from 1951-52, and a filing cabinet with recipes from 1958. I took scans of the recipes from 1951-52 and 1958-62, to cover the period over which the six paintings were made. Royal Talens produced a number of different paint ranges, but I looked only at those from the Fijne Olieverf (artists' quality) and Studie Olieverf (student quality) ranges, as these are the most extensive and the most studied. The Studie Olieverf range also came under the name 'Coleurs a l'huiles fines' and later 'Van Gogh'. See figs. 14 and 15 for explanations of the information on the cards.

I collated the information on the recipe cards in a spreadsheet (fig. 13). This was necessary in order to get an overview of the ingredients and make comparing the recipes an easier task. It was also fruitful to systematically go through all of the cards in this way not least because the handwriting on the earlier ones was often difficult to read. Ultimately the information on the recipe cards and the scans of the cards will be entered onto the database of Talens recipes; this has already been done for all the ultramarine recipes.

I went through the known catalogues for 1951-1954 to check that the colours listed in the catalogues matched the names and numbers on the tubes. If this was not the case a note was made on the spreadsheet. The RCE has catalogues of Talens paints from several years between 1950 and 1961; there may be catalogues for the missing years that have not been found, or there may not have been catalogues issued for those years.[2] Until this is clarified it is useful to note which paints are in each catalogues, as this can be a way of

[2] Proposed by Bayliss in her report.

dating the tube paints in the archive, and may also confirm or question the dates on the recipes for these paints.

I added sheets comparing the existing analytical results of tube paints with the corresponding recipes for those colours. I then looked in detail only at three colours which had shown degradation in the paintings: ultramarine, black, and green. No specific matches could be made between colours analysed from the paintings by Appel and the Talens recipes between 1951 and 1961, and it was more worthwhile to seek out general trends between the samples from the paintings and Talens recipes, and among the Talens recipes themselves.

3.5 My findings

Some of the conclusions I reached for ultramarine blue are listed below.

Links between the paints and the recipes

1. Chalk was detected in *Stephane Lupasco and Michel Tapie* (1956) and barium sulphate in *Les Animaux* (1961); *People, Birds and Sun* (1954) contained both. However, barium sulphate is not mentioned in any of the blue Talens recipes containing ultramarine, and chalk is mentioned only in one or two of the student quality ones. It cannot be confirmed whether the paint of these samples was directly from the tube, and it could be that ultramarine-containing paints are present in mixture with others that contain these extenders.
2. In *Stephane Lupasco and Michel Tapie* (1956), safflower oil was identified, which was not introduced to Talens paints until 1969. Traces of beeswax and colophony (rosin) were detected in two of the paintings, which are not mentioned in any Talens recipes but were detected in analysis of the tube paints themselves.
3. The extender magnesium carbonate, identified as an additive in Winsor & Newton paints and linked to water-sensitivity, was detected in many of the paintings. However, it is notably absent from all Talens recipes (of any colour) and accompanying tube paint analyses, which suggests that other manufacturers' paints were in use.

Changes between the 1950s and 1960s recipes

1. The ratios of ingredients in some of the recipes between the 1950s and 1960s are similar, but different oils, driers and extenders were introduced or substituted. For

example, for Fijne Olieverf Ultramarijn Licht (11/81), the 1950-4 and 1961 recipes contained almost identical percentages of all ingredients but the later recipe for each substituted pale terebine with siccatief licht (figs. 14 and 15).

2. On the other hand, the ratio of pigment to oil more often than not was slightly reduced in the later recipe. Moreover, for Rembrandt Ultramarijn Licht (10/220 or 505), while linseed oil (a drying oil) was used in the earlier recipe, the later recipe employed a mixture of dehydrated castor oil and, dominantly, poppy oil (a semi-drying oil). Dehydrated castor oil became popular in the paint and varnish industries as a good drying oil from the 1940s. It may be that the combination of dehydrated castor oil and poppy oil was a common one among manufacturers of paints and varnishes in this period.

Organic and inorganic analyses of Talens tube paints from this period do not always reflect the ingredients listed in the corresponding recipes, which suggests that if Appel was using Talens paints this may not be entirely evident from the recipes alone. It was also difficult to make concrete conclusions about the presence/absence of Talens paints in these paintings without also comparing the recipes and tube paint analyses with those of rival manufacturers such as Winsor and Newton, which was beyond the scope of this project but forms line of enquiry in the Cleaning of Modern Oil Paints (CMOP) consortium, an ongoing research collaboration between several European institutions. Furthermore, it has not been possible to establish definite associations of particular ingredients with particular dates or colours, although this may be possible with more time and more in-depth study.

3.6 Other activities

I was given a tour of the reference collections at the RCE and shown its collection of 20th-century tube paints that the previous student had worked with; they were donated by the families of working artists and therefore many are used. The archive is extensive, with cabinets, jars and shelves full of samples of artists’ media and tools, and specimens from the natural world.

I was asked to complete some other, smaller tasks during my placement. One of these concerned the leaching of yellow oil medium in one passage of colour in a modern oil painting. I was asked to undertake analysis with SEM/EDX (see Appendix) on modern tube paints of this colour by a number of different manufacturers. Because there were eleven tube paints to analyse, each the same colour, it was important to label them clearly and draw a diagram of the set-up in the machine (Appendix and fig. 16). Because I was only able to carry out inorganic analysis there was a limit to how much I was able to find out, but I was able to see broad similarities or differences between the compositions of the paints.

During my placement I enjoyed learning about the projects going on around me, by researchers at the Institute and interns. I spoke to Nadja Garthoff, who is photographing paint samples from Rembrandt paintings under the microscope for adding to the Rembrandt Database, an incredible online public and academic resource that is currently under construction. I worked alongside a PhD student researching the causes of medium-leaching in modern oil paintings, the associated problems with dirt imbibement and the implications for conservation. I also worked closely with a conservation student from Stuttgart who was investigating the synthetic organic pigments employed by Talens in the 20th century, and it was useful to exchange ideas and findings from the recipes. I also befriended two Italian students, one of whom was using SEM/EDX for her research into the development of coatings for metal objects to inhibit their corrosion. It was especially interesting to learn about the different training courses and everybody's backgrounds.

I also had the opportunity to contribute to current research into the technique of Jackson Pollock. In recent analysis of a Pollock painting carried out at the Opificio delle Pietre Dure (OPD) in Florence, and separately at the RCE in Amsterdam, the non-invasive technique of X-ray Fluorescence (XRF) was used to identify the elements present at specific points across the painting. From the XRF analysis, the researchers at the OPD identified 17 individual pigments in the painting and generated maps to show the surface distribution of each colour. This clearly reflected Pollock's varied methods of application and range of media including commercial house paints and artists' tube colours. The analysts also took a number of samples from various points in the painting, which were handed to me for analysis with SEM/EDX (Appendix). I embedded the samples in resin before then grinding and polishing them (fig. 17). Some were incredibly small so it was quite challenging and provided excellent practice for sample preparation. It was interesting and rewarding to view and photograph the many-coloured and multi-layered samples under the microscope.

When comparing the colours, I tried to compare those that were analysed at similar places on the painting or appeared to be from the same colour paint. An advantage of SEM/EDX is that not only individual paint and ground layers, but individual pigment particles too can be viewed and targeted (fig. 18), which can help clarify the origin of some of the elements detected in XRF analysis. Elements might also be detected with EDX that were perhaps concealed by other elements in the XRF spectra, which recorded data for a much larger surface area. Accordingly, my SEM/EDX analysis of the samples was useful for confirming and adding to the information that had been collected already with XRF. For example, it was possible to conclude from several samples that the ground layer contained lead and zinc, which would explain why these dominated many of the XRF spectra. In another sample ultramarine blue was tentatively identified from the presence of silicon, aluminium, sodium and sulphur, the former three of which are very light elements and were not detected with the XRF carried out at the RCE. Ultramarine had, however, been proposed as one of the blues present from the mapping carried out by the OPD, so it was useful to back this up with the EDX results. The results of the analyses carried out provide useful insight into the Pollock's technique and materials, which may be useful for future conservation of his paintings.

4. SPARE TIME

During my trip I had the opportunity to visit the fantastic museums and galleries in Amsterdam and its environs. The Stedelijk museum had a number of Appel paintings on display, which I examined in order to familiarise myself with his style. The collections also enabled me to learn about art in Amsterdam and the Netherlands after 1960 and in the present day. I visited the CoBrA museum in Amstelveen, which was a great opportunity to see several other works by Appel and next to the art of his contemporaries; my visit coincided with an exhibition on the changing oeuvre of Constant Nieuwenhuys, another founder of CoBrA, and in a few paintings I even thought I detected some of the deterioration phenomena that I had been researching. While I was working at the Ateliergebouw, my pass gave me unlimited access to the Rijksmuseum, which was fantastic, although I did not get to take advantage of this freedom as much as I would have liked. During one particular lunchtime visit, however, Dr van den Berg pointed me towards a pair of full-length Rembrandt portraits, which were recently acquired jointly by the Rijksmuseum and the Louvre in Paris and will henceforth be displayed together alternately in each institution for five years at a time. It is an interesting and unusual example of international collaboration to keep a pair of paintings together and in the public domain.

I visited a number of other museums at the weekends. One of my favourites was the Van Gogh Museum for the sheer size of its collection, particularly as The Courtauld holds two Van Gogh paintings, and I had focused on some of his materials and techniques in one assignment during my first year. The museum was also great in all that it taught me about the artist's life and personality. I also visited the Rembrandthuis museum and enjoyed watching demonstrations on the preparation of oil paints and the process of etching, engraving and printing; these augmented my practical and theoretical studies on the techniques of painting and printing during my first year at The Courtauld. Finally, I visited the Zaanse Schans, which is a traditional Dutch village with many restored and working windmills and other buildings that preserve a number of the 18th- and 19th-century industries around which the community grew, including oil, dye, pigment, spice, flour, sand and saw mills, clog and chocolate production and weaving. I visited the pigment mill (delightfully named 'De Kat') and the oil mill De Bonte Hen ('The Spotted Hen'); the latter dates from the late 17th century and both were fascinating insights into the early mechanised manufacture of artists' materials.

During my placement I stayed with a lovely family in Amsterdam Zuidoost (fig. 2), a lively and friendly neighbourhood around 40 minutes away from my place of work by bus and tram. The houses and colourful apartment buildings in Zuid-Oost are built amongst a network of canals and green spaces; I frequently saw herons, swans and cormorants when I set out each morning, and encountered many other birds in the nearby Nelson Mandelapark.

5. CONCLUSION

During this project I developed a number of new skills, met some wonderful people and familiarised myself with a new city. I became more confident when processing and analysing samples with SEM/EDX, which is already helping in my second-year studies at The Courtauld. I am really pleased to have been introduced to the Cleaning of Modern Oil Paints consortium and the ongoing issues surrounding the degradation and conservation of modern oil paints. The consortium and the work on Jackson Pollock have also given me first-hand experience of the international collaboration between institutions to undertake research and analysis and address key issues in the conservation world.

I have also learnt that it is important to set goals and be realistic about what exactly I am able to achieve in the time available. This was especially important during this four-week placement; I had to allow some time in the first week to settle in and familiarise myself with the workplace and equipment that I was using, and I also needed to be fully prepared for the visits to the Talens archive in order to obtain the necessary information from the recipes. Although, unfortunately, I was not able to observe or take part in the conservation of a modern painting, I have learnt that understanding the causes of these phenomena is vital for the development of treatments; and I can appreciate better the ways in which technical analysis can be used to this end.

APPENDIX: Scanning Electron Microscopy/Energy Dispersive X-ray spectroscopy (SEM/EDX) and X-ray Fluorescence analysis.

This is an analytical technique that can be used to identify the inorganic components of a material, such as a sample from a painting. A small sample is taken from a painting with a scalpel, ideally from an area that contains all the layers (of paint and/or ground) that the analyst is interested in. The sample is embedded in clear polyester resin, which is left to set and then ground down and polished on a grinding machine until the paint sample has been ground into to reveal its cross-section; care must be taken to ensure that the sample is not ground away, and frequent checking under the microscope is necessary. The surface with the exposed cross-section is polished further to give a perfectly smooth surface. The resin block is affixed to a metal stub with double-sided carbon tape. The stub is screwed into a slot in the stage and the stage placed inside the vacuum chamber. The stage had seven slots for stubs.

When I was looking at fresh tube paint, the SEM/EDX set-up was slightly different to the usual analysis of aged paint samples embedded in resin. A small square of carbon tape was placed on each of the stubs and, using a pin, tiny dots of each of tube paint placed directly onto the carbon tape. I had eleven tube paints to analyse and so I paired the dots on the stubs. Because all of the tube paints were the same colour and looked similar in the backscattered image, it was important to label the stubs clearly and draw a diagram, so that I was knew which paint was being viewed. It was also important to place the dots close together and in the middle of each stub, to make it easy to find them in the backscattered image.

Inside the chamber, most of the air is removed to create a 'low vacuum'. An electron gun fires a beam of electrons at the sample, which contains atoms of the various elements that are present in the pigments. The electrons in the beam are scattered within the sample and many are reflected back out of the sample and detected as 'backscattered electrons'. The heavier elements (lead and metals, for example) create more backscatter than lighter elements (such as carbon), and thus appear brighter in the resulting image. For this reason, inorganic pigments often appear bright while organic pigments appear dark.

On the surface of the sample, 'secondary electrons' are also emitted. When the electrons in the beam hit the atoms on the surface of the sample, they displace electrons from the inner shell of the atoms, and the resulting vacancy in the inner shell is filled by an electron from one of the atom's outer shells. The displaced electrons are emitted from the sample surface as 'secondary electrons' and are detected by a secondary electron detector. Only secondary electrons produced at the surface of the sample are detected, because secondary electrons produced deeper within the sample are absorbed by the sample material before they can be detected. Therefore, this enables something of the surface topography of the cross-section to be determined from the resulting image; highlights and 'shadow' are produced and affected by the angle of the electron beam.

This translation of an outer electron to the inner shell in the surface atoms causes the emission of a photon of energy, which equals the difference in energy between the outer and inner shell. This energy is unique to each element, and the photon is known as a 'characteristic X-ray'. The characteristic X-rays of the various elements present are detected by a detector and recorded as a series of peaks for each element.

Computer controls are used to move the stage around inside the chamber until the sample appears on the backscattered image. Sometimes this takes a while because even the lowest magnification is quite high. A virtual diagram on the computer screen showed which part of the stage was being viewed at any one time, which made it easier to move between stubs and locate the samples.

X-ray Fluorescence

In X-ray fluorescence, a beam of electrons is fired from a gun at a point on the painting. As the electrons collide with the atoms in the paint, they displace some electrons from the atoms' inner shells. The resulting vacancies in the inner shells are 'filled' by individual electrons from the atoms' outer shells, and in the move from an outer to an inner shell a photon of energy is released, known as a 'characteristic X-ray'. The characteristic X-rays are recorded in a spectrum as a series of peaks that is specific to the element in question, with the position of each peak determined by the energy difference between the various shells. The equipment is portable and provides instant information *in situ* about the inorganic pigments present. However, the area analysed is approximately $6mm^3$, and therefore it is impossible to determine information about individual paint and ground layers unless a sufficiently large area of exposed ground can be targeted.

Figure 1. The Ateliergebouw building

Figure 2. Map of Amsterdam, with a star over the Ateliergebouw building. http://amsterdammap360.com/carte/image/en/amsterdam-neighborhood-map.jpg

Figure 3. Map of Europe, with The Netherlands highlighted in red square.
http://www.yourchildlearns.com/online-atlas/images/map-of-europe.gif

Figure 4. Detail of the area highlighted in previous map, with red dots locating Amsterdam and Apeldoorn, the location of the Talens archive.
http://netherlandsmap.facts.co/netherlandsmapof/NetherlandsPoliticalMap.png

Figure 5. Entrance to the Royal Talens factory and archive building in Apeldoorn.

6. Karel Appel, *People, Birds and Sun*, 1954.
http://www.tate.org.uk/art/images/work/T/T04/T04163_10.jpg

7. Karel Appel, *Stephane Lupasco and Michel Tapie*, 1956.
http://www.stedelijk.nl/kunstwerk/3040-stephane-lupasco-et-michel-tapie

Figure 8. Karel Appel, *Les Animaux*, 1961. From Appendix 4b in Mills (2008), p. lxxxiv.

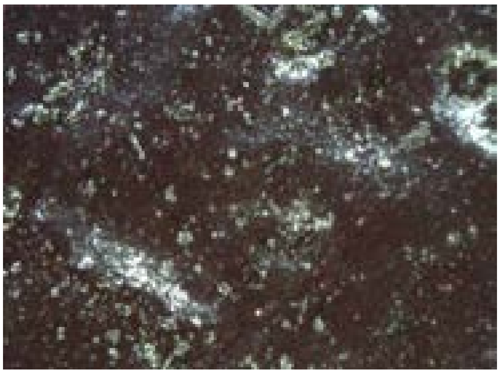

Figure 9. Micrograph of imbibed dirt in tacky black paint in *People, Birds and Sun.* From Cooper (2012), Appendix 3e, p. 159.

Figure 11. Wrinkling and oil yellow medium exudate on white paint in *People, Birds and Sun*. From Cooper (2012), Appendix 3e, p. 159.

Figure 10. Flaking ultramarine paint revealing underbound paint in *Les Animaux*. From Mills (2008), Appendix 4b, p. lxxxvi.

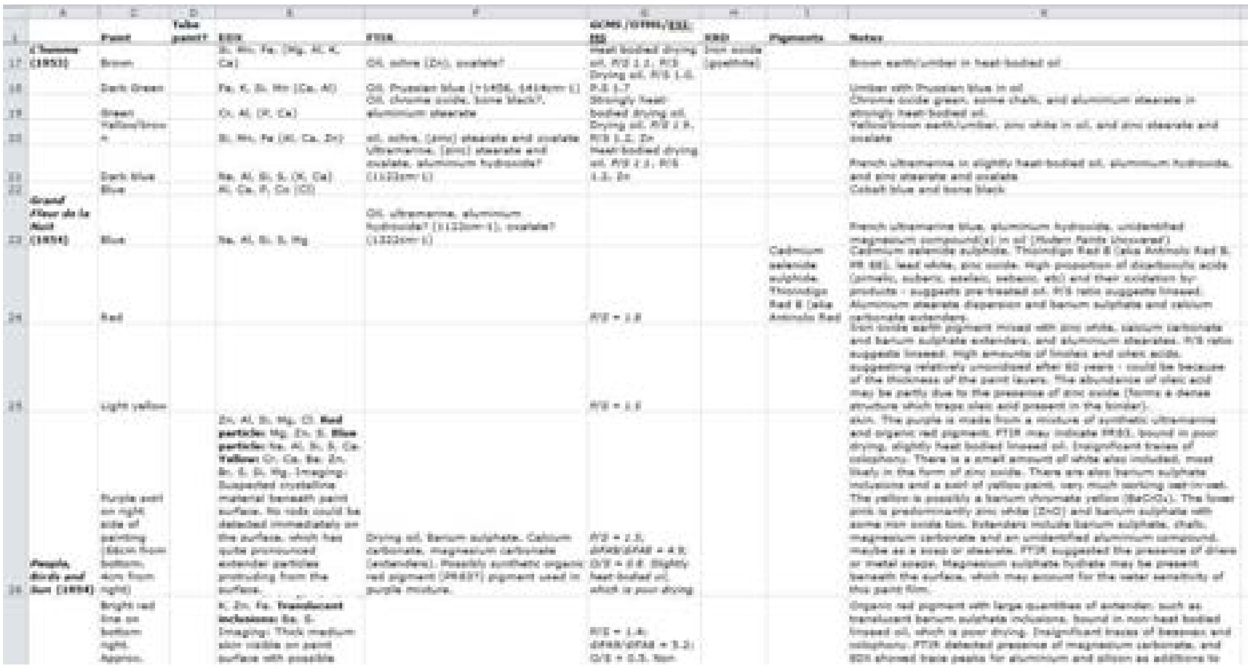

Figure 12. Screen shot of my spreadsheet with summary of results from past organic and inorganic analysis on six paintings by Karel Appel.

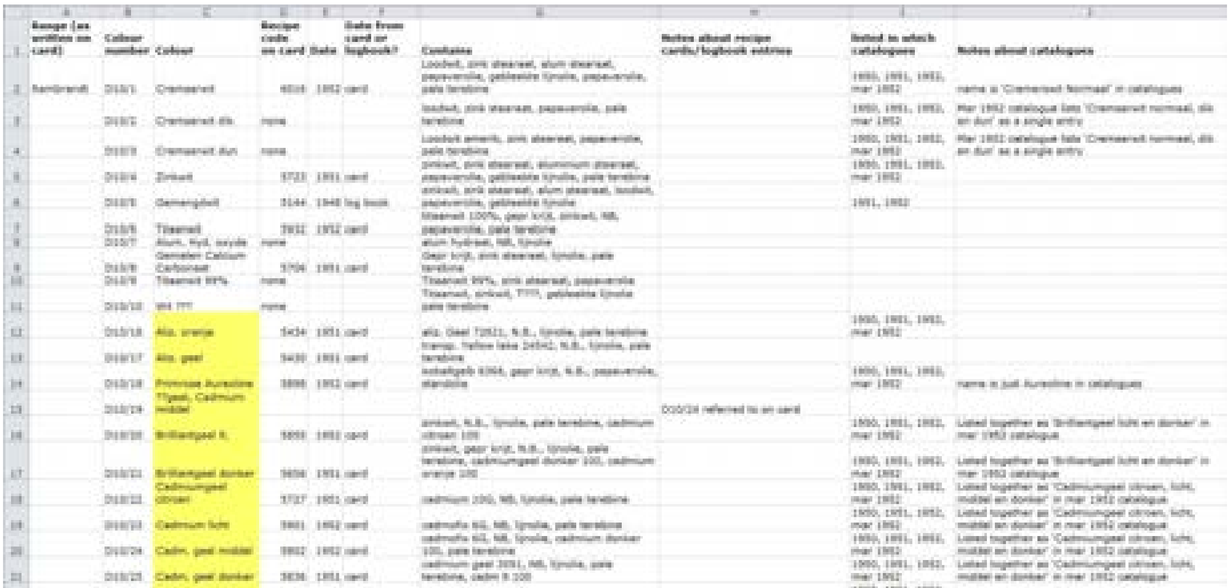

Figure 13. Screen shot of my spreadsheet with summary of ingredients in the Talens recipes.

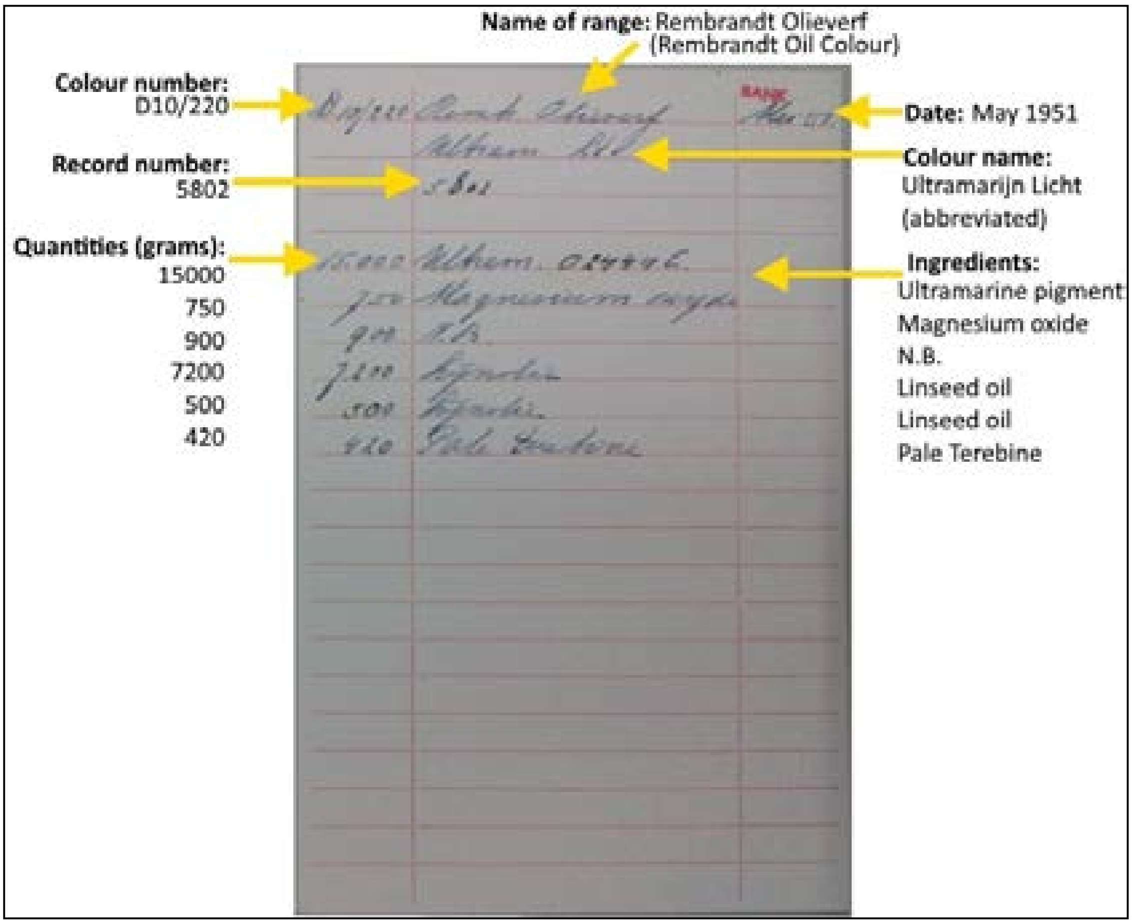

Figure 14, above: A recipe card from 1951. **Figure 15, below**: A recipe card from 1960.

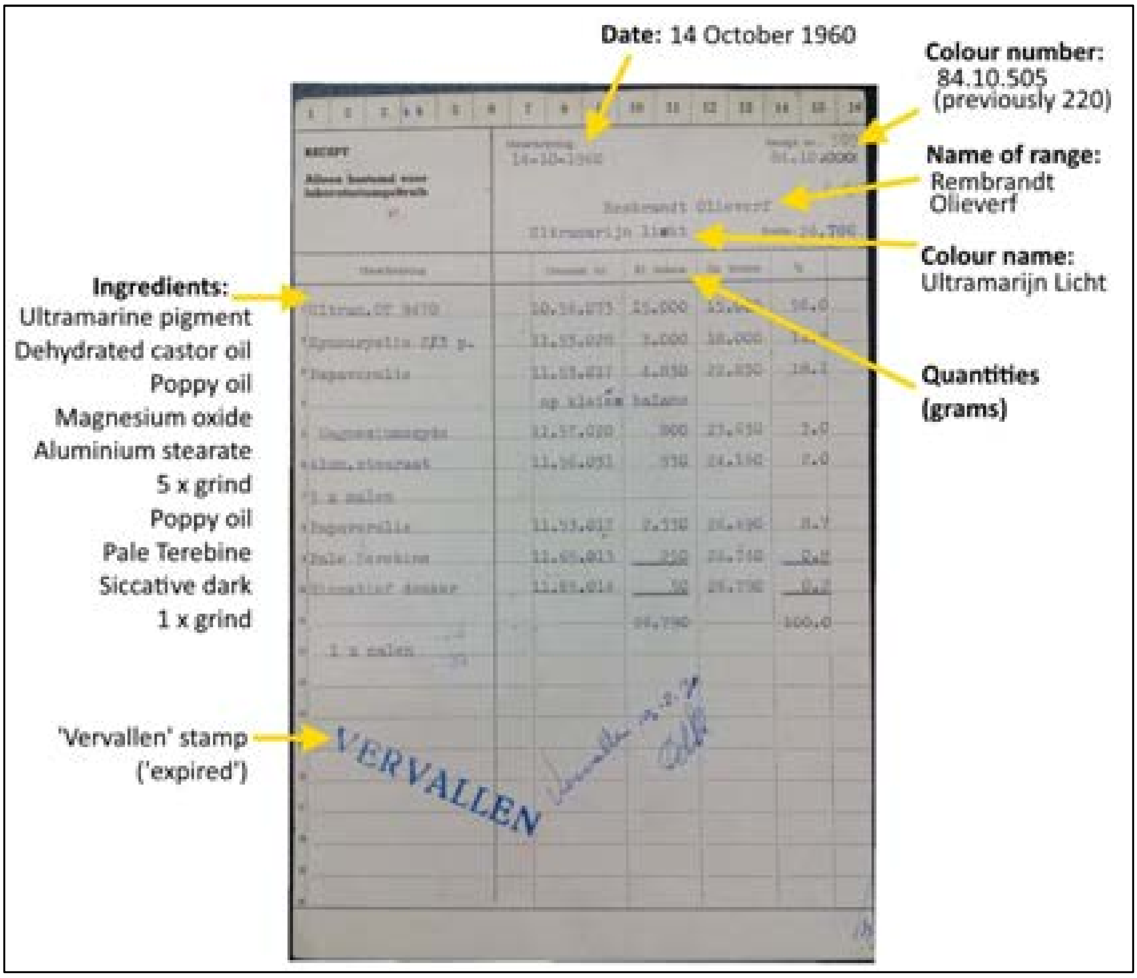

Figure 16. The stage on which samples are placed for SEM-EDX analysis. Here the stubs have double-sided carbon tape on them, onto which a sample embedded in resin can be placed, or pinpoint samples of fresh tube paint.

Figure 17. Grinding a Pollock sample for analysis with SEM/EDX.

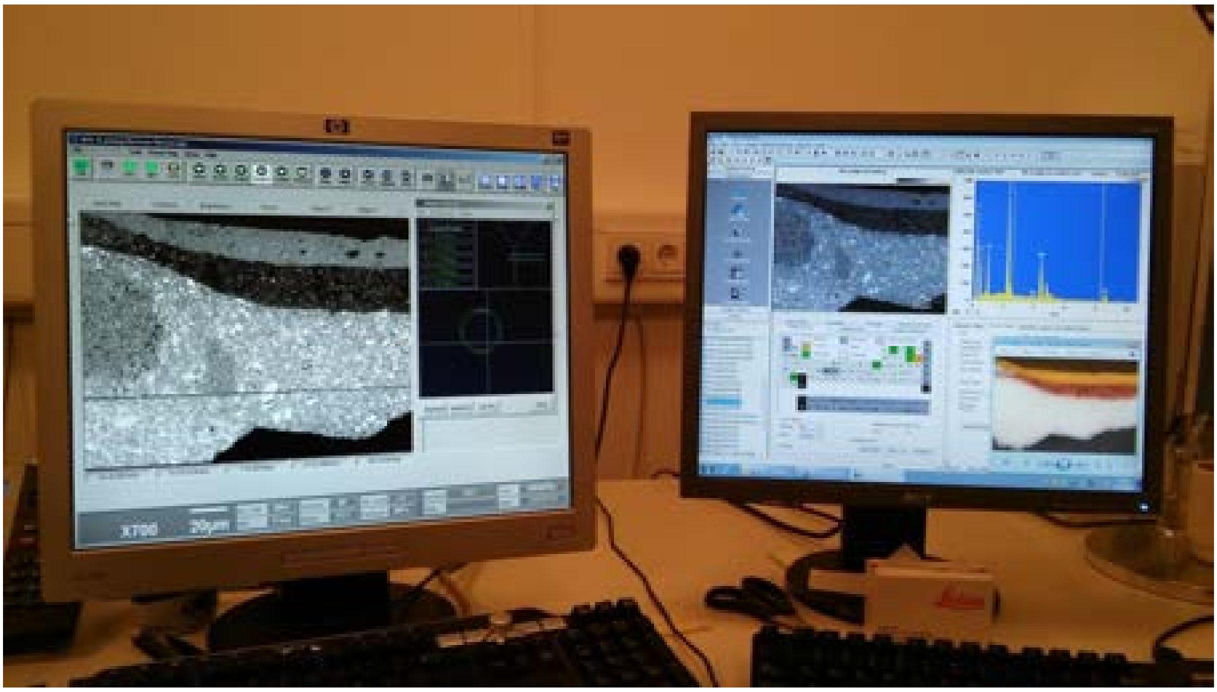

Figure 18. During SEM-EDX analysis. The screen on the left shows the backscattered electron image of a Pollock paint sample embedded in resin, and a diagram locating the exact place pictured on the stage. The screen on the left depicts the spectrum obtained when a specific point is selected for analysis, with peaks representing the elements present.

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