

Preserving a Master: Edvard Munch & His Painted Sketches

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Abstract

This paper will give an overview of challenges encountered by the paintings conservators at the Munch Museum in Oslo. The collection contains world-famous artworks. Munch's paintings are often requested for exhibition loans and many travel all round the world. A great deal of the work required of us is linked with such loans. However, the museum also owns approximately 150 canvas sketches, which are even more in need of conservation. Most of them were painted in the period 1909–16; the largest measures up to 5 x 11.5 metres. Munch painted and stored many of them outdoors for years; approximately 51 have been stored on rolls since Munch's day. His handling and painting techniques and storage have led to extreme deterioration of the sketches and from 2006–12 extensive conservation has been conducted. The main challenges were concentrated on the consolidation of considerable areas of unstable paint, but soiling, water damages, salt efflorescence etc. were also attended to.

Keywords: *Munch's Unprepared Cotton Canvases, Porous Paint, Outdoor Environment, Salt Efflorescence, Aerosol Generator*

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Introduction

Munch returned to Norway in 1909 after spending several years abroad, for the most part in Germany. He settled in Kragerø, a small coastal town south of Oslo. When Norway gained independence from Sweden in 1905, the country's national cultural identity bloomed and commissions for official decoration projects were prestigious. Many of Munch's sketches were preparations for a decorative project for the festival hall, the Aula, of the University of Oslo. The area to be decorated consisted of 220 square meters of wall space divided into eleven sections. Munch started painting sketches in 1909 and completed the project in 1916. Munch also painted sketches for other decorative projects which were never realised, among them decorations for Oslo's City Hall.

Munch's Working Methods and Storage of the Sketches

Several friends of Munch wrote about his years in Kragerø. Some of these writings give insights about Munch's handling of his paintings and sketches, some also about his painting techniques and materials. In Kragerø Munch rented a property named Skrubben that had outdoor grounds. He constructed large outdoor studios here and mounted the sketches directly onto the outdoor studio walls (Figure 1). There are indications that he also remounted them several times on the walls, and he never mounted most of them on stretchers or strainers.



Figure 1. Munch in one of his outdoor studios with snow on the ground, Kragerø, 1911.

However, Munch also painted and stored works indoors. In 1910 the Norwegian artist (and Munch's close relative) Ludvig Ravensberg wrote from one of his visits to Skrubben:

“...The large rooms are overflowing with prints... engravings, drawings, paintings, sketches, everything is filled from the large rooms to the upstairs, everything has its place says M. but in reality there is just as much chaos, and Munch[’s] desper-

ate impracticality results in him having to remember everything in his head instead of organising things in another way, writing things down and creating order. But he cannot do this and will not, distracted as he is, yet at the same time he remembers the most incredible small details. How many [?] pictures and engravings has he lost along the way, occasionally whole exhibitions have been lost...”¹

Even if these works were sketches and one could get the impression that he didn't handle them with great care, they must have been significant to Munch. He signed some of them, exhibited 12 of them at the Autumn Exhibition in Berlin in 1913, and moved with them and kept more than 150 until his death in 1944. In 1915, when Munch moved from Kragerø, he rolled up several of the large canvases and stored them in the attic of a Kragerø neighbour's shed (Flaatten 2010: 129). He retrieved them in the 1920s and kept them at his property Ekely on the outskirts of Oslo, which he bought in 1916.

At Ekely the registration of all his works began shortly after his death. Works were found all over his property, both indoors and outdoors (Figure 2).



Figure 2. Munch's indoor atelier at Ekely that was turned into a conservation studio after his death—(frame from an old video).

Painting Techniques and Materials

Ravensberg wrote in his diaries that Munch wanted the paint to soak into the canvases in order to achieve a fresco-like appearance.² Observations and analyses reveal that for these sketches Munch experimented boldly with different materials and methods. Some of his contemporary painters knew and were to some extent skilled in the techniques of fresco painting, but all of Munch's decorations consist of large-format canvas paintings.

Canvases

Munch used different types of canvases for his sketches. They can vary between diverse qualities of linen and cotton canvases with the paint being applied directly to the fabric without prime layers and also some linen canvases with prime layers. The cotton canvases are for the most part thin and sheet-like and most likely not made to be painted on. The sketches on the latter canvases are visually recognised because of all their areas of exposed canvas, areas without paint.

Paint layers

Six different paint media or mixtures of these have so far been identified from the paint layers. These include stand oil, linseed oil, raw linseed oil, casein and animal glue, egg and casein, egg and animal glue and animal glue alone (Singer et al., 2010). In addition, lines of charcoal and unidentified coloured crayons are also present, sometimes alone, but usually next to brushstrokes of paint, principally oil paint.

Analyses have revealed that some of Munch's methods for achieving surfaces looking like fresco painting was not only to choose matte painting materials, in addition it involved thinning his paints heavily with turpentine. He also added chalk to some of his paints. This yielded matte and also porous paint layers. These are paint layers with low percentages of binding media, so-called high pigment volume concentration.

The visual appearance of most of the coloured layers does not indicate which binder is used, as the surfaces appear matte and dull regardless of the observation angle (Figure 3). An array of pigments has also been identified, such as synthetic ultramarine, Prussian blue, cobalt blue, zinc oxide, lead white, chrome yellow, yellow ochre, vermilion, Scheele or emerald green and green zinc chromate.



Figure 3. Matte porous green paint layer close-ups. Photo: Emilien Leonhardt, Hirox Europe.

Later Storage and Treatment

During the registration work at Ekely, a conservation studio was set up and some of the sketches underwent structural treatment there (See figure 2). From 1950 to 1960 around 100 of them were mounted on stretchers, and some were lined. The canvases, mainly the monumental sizes that were not mounted continued to be stored on rolls, up to seven canvases on each roll (Figure 4). The rolled sketches were unrolled in 1971 to be photographed, and then rolled up again, thus never underwent conservation treatment. Very few of the other sketches have been treated since the 1960s, until all the rolled sketches and approximately 50 of the mounted ones were treated in the period 2006–12.

Condition of the Sketches

Largely due to exposure to the outdoor elements and inappropriate storage and handling, many of the sketches have water stains, drain marks and large mold damages (Figure 5). Their surfaces were also marred with moss, wood chips, birch catkins, grass, bird feathers, insect residues and bird, mouse, and flies' droppings as well as other patches of unidentified residues. Some sketches had areas with clay and soil which indicate contact with muddy ground. Several of them also have severe amounts of salt efflorescence visible on their surfaces, as shown in figure 6.



Figure 4. Sketches on rolls, before and after treatment. Photos: Eva Storevik Tveit.



Figure 5. Left, Drain marks, water stains, deformations and folds. Photo: Eva Storevik Tveit and

Figure 6. Right, White surface material/salt efflorescence. Photo: Erika Gohde Sandbakken.

Canvases

Several of Munch's cotton and linen canvases are grey in colour and some even brownish. These discolorations are partly due to mold spores, some of which were analysed (Figure 7). Six different mold types were identified.³ The fibres of the canvases are degraded, pH analyses of 24 canvases⁴ show values from 4 to 7. Studies of the correlation between mechanical degradation, pH, and mildew are under progress.

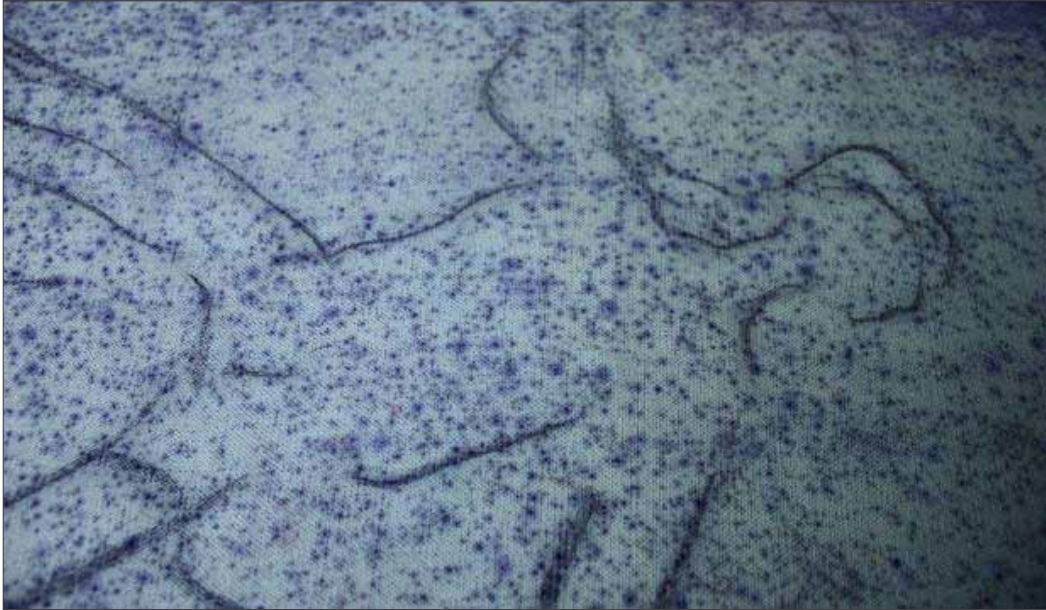


Figure 7. An UV-light capture of mold stains that covered the whole sketch. Photo: Terje Syversen.



Figure 8. Left, *Picture of the Sun* (1912–13), photographed with raking lighting to reveal the large deformations, mostly due to being stored rolled up. Photo: Jaro Hollan and Figure 9. Right, Tears, missing canvas pieces, and folds. Photo: Eva Storevik Tveit.

There were many folds and plastic and elastic deformations in the canvases (Figure 8). The monumental unmounted sketches also exhibit a large number of tears, holes and missing pieces of canvas (Figure 9). Some of these damages probably occurred when Munch repeatedly mounted the sketches, and from the ways the sketches were otherwise handled. The photographs of the sketches made in 1971

were compared with new observations from 2006–12. These studies indicate that the storing on rolls in the period 1971–2007/08 worsened the already existing deformations. This is due to the rolling-up methods, the small diameter of the tubes they were rolled on, and the exposure of some of the canvases to water while being rolled up.

Paint Layers

Permeability in porous paint is higher than in solid paint and deterioration most likely started rapidly in the outdoor environment. Porous paint has weak resistance against climatic influences, because oxygen and humidity easily penetrate the open structure (Echaus, Wollock and Harris 1953: 426; Hess 1979: 178). Porosity surveys and paint binder analyses reveal that almost all the paint layers have poor cohesive forces regardless of the type of binder. This is due both to the fact that when applied the binders got absorbed into the porous, unprimed canvases, and that Munch added chalk or thinners to his paint. In addition, the paint has simply degraded from age.

Porous paint is also less capable of withstanding stress than paint with higher binder content, and has a weaker adhesive strength to the canvas (Hansen and Lowinger 1990: 13; Weldon 2001: 19). The canvases that had never been mounted on stretcher bars have minimal resistance against movement caused by temperature and humidity changes; movements that cause shearing between the paint and canvases. Such shear forces are the main reason why paint loses its adhesion to the support (Keck 1969: 23; Young 2007: 5).

Efflorescence

White surface material on paintings has been widely studied, particularly in the last decades. Many of these studies have focused on findings of metal soaps and fatty acids that have protruded on the surfaces of oil paintings (Noble, van Loon & Boon 2005; Robinet and Cobeil 2003). The first mentioning of white surface material on some of Munch's mounted sketches was reported in the 1980s. In a condition survey from 2004, the efflorescence was noted with the comment: "treatment method unknown."

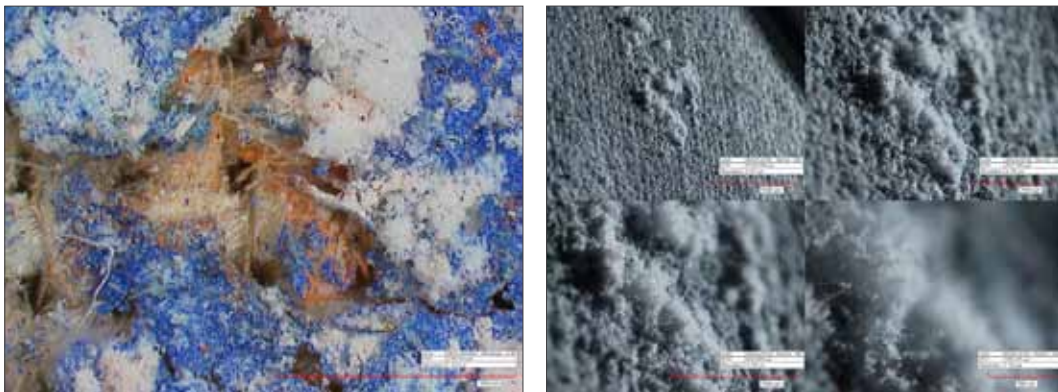


Figure 10. Left, Efflorescent salt crystals on a blue paint layer seen under the microscope. Photo: Emilien Leonhardt, Hirox Europe and Figure 11. Right, Surface crystals, four different magnifications. Photo: Emilien Leonhardt, Horox Europe.

Examinations and analyses were conducted to identify the efflorescence prior to making a decision on treatment or not. Several samples from eight affected sketches were analysed and the material was suggested to be hydrated zinc sulphates and more certain the presence of magnesium sulphates was proved. Both compounds are water soluble salts (Figure 10 and 11). The investigations concerning the nature of these salts are ongoing.

In earlier publications concerning findings of zinc sulphates on oil paintings, high humidity has been regarded as an important factor (Singer and Liddie 2005; Koyano 1987). Chemical reactions between zinc oxide and sulphur-containing pollutant gases as well as the possible sulphur content from a paper support have been launched as theories (Singer and Liddie 2005).

Both zinc sulphate and magnesium sulphate are highly chemically active salts as they are very hygroscopic. However, today, we still lack a clear picture on the chemistry and physics involved in the efflorescence seen on some of Munch's sketches, and this requires further study. One hypothesis is especially interesting – Munch might have applied something to some of his cotton canvases, e.g. a casein solution, which again could have triggered the reactions. Other agents could also have been added during the manufacture of the fabrics. Other material properties could albeit to a smaller extent, also have contributed to these chemical reactions. Suspects include the sulphur contents in some pigments such as cadmium yellow and ultramarine or the possibilities of the paint industry's use of zinc oxide and zinc sulphide as lightening agents for certain paints or Munch's possible extra use of zinc oxide for his paints. Zinc oxide is extremely sensitive to humidity and has other properties that often causes less durable paints. It is also necessary to emphasise external factors such as repeated exposure to extremely fluctuating humidity and temperatures, sulphur bearing pollutant gases in the environment as well as the sea air in the very early life of these sketches.

However, the white deposits on Munch's mounted sketches, now so extensively visible, have most likely developed after the 1950s. Prior to then most of the sketches were either rolled up or piled up in cardboard boxes. Then they were mounted and a few were also lined. It is difficult to believe that the sketches could be submitted to that type of stress and simultaneously leave the crystal compounds with the undisturbed appearance they have today.

Presently, the efflorescence on many of Munch's sketches is so extensive it disturbs Munch's original colour scheme. Should the efflorescence be seen as part of the sketches from Munch's lifetime? Tide lines and other disturbing spots, in general, are often retained on Munch's art, not removed or disguised, to respect artistic integrity. During examination it was, however, observed that on top of and in between the salt crystals there were pigment grains and the paint beneath was powdery (Figure 12). It was considered necessary to increase the stability of the layers, and possible treatment methods were discussed.

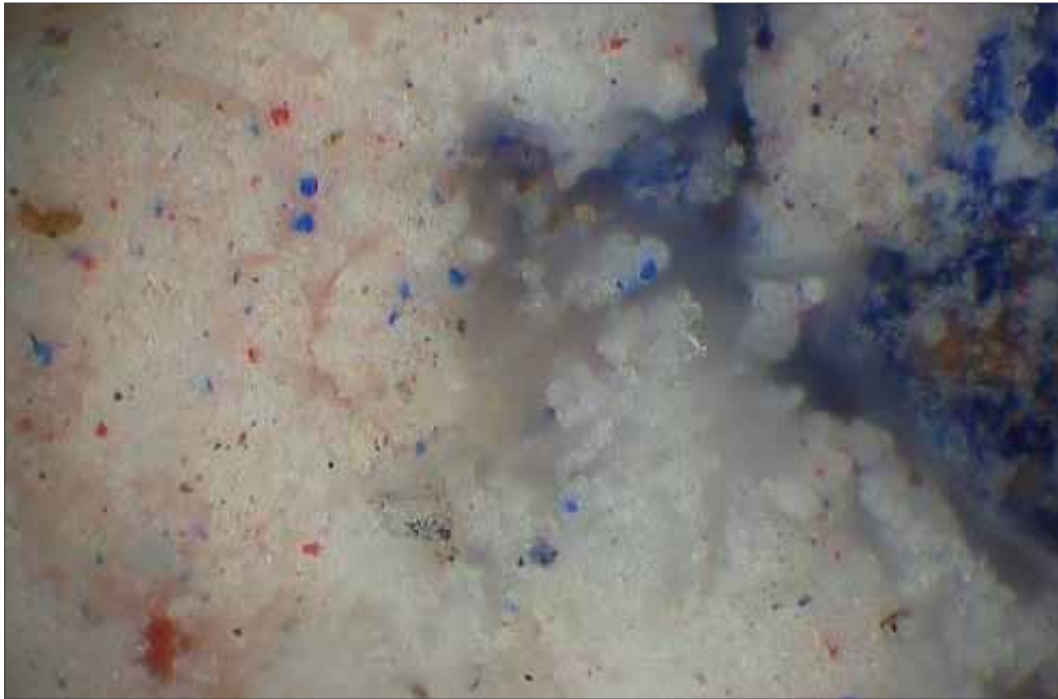


Figure 12. Microscopic photo of salt crystals with pigment grains on the surface of a blue paint layer. The crystallization processes and the protrusion through the paint layers have disrupted the paint. Photo: Emilien Leonhardt, Hirox Europe.

Aging and Climatic Conditions

In addition to Munch's choices of materials and storage conditions, the chemical and mechanical degradation of the canvases and paints have been caused by ultraviolet light, moisture, particularly above 80% relative humidity, and sub-zero temperatures, approaching the glass transition temperature (T_g) of some of the materials, such as the T_g of oil which is around -10° to 0°C (Mecklenburg 2011: 15, 51). However, the greatest mechanical changes are caused by the materials' disparate dimensional responses to temperature and moisture.

Other factors have probably also led to the degradation of the canvases: The starch and the soil in the canvases could have accelerated the mold growth because these are food sources for mildew (Hamlyn 1983: 73). The mold may further have degraded the cellulose in the canvas. Such degradation is aggravated by acid rain (sulphur dioxide + nitrogen oxides) (ICOM 1960: 141), and the levels of breakdown caused by cellulolysis increase if the climate is humid, particularly if the canvas contains soil and bacteria (Srivastaya 1979: 14). In addition, ultraviolet energy may break the molecular chains in fibres (Landi 1998: 18), a process that can be expansive and it is believed that cotton exposed for only four months to UV light loses half of its strength (Michalski 1987: 8). Moisture can accelerate chemical reactions initiated by UV-energy (Michalski 1987: 8; Landi 1998: 18).

The already porous paint was further decomposed due to common aging processes and the exposure to large climatic changes outdoors. In general the formation of volatile components can be regarded as the beginning of the decomposing of paints. Fourier Transform Infrared Spectroscopy (FTIR) analyses of the paints show changes in the binders' composition.⁵ These changes may indicate the oxidation of the oil paint. The oxidation process could have accelerated outdoors, because water and oxygen easily penetrated the structures. This implies that common aging also contributes to developing porous paint layers, since the initial concentration of binder content degrades. This process occurs faster in thinned paint than in oilier paint (Hess 1979: 44).

The effects of humidity on the paintings' components may be separated into two mechanisms (Kockott 1989: 199). The first involves mechanical stresses resulting from the fact that material physically swells and shrinks (Kockott 1989: 199). The other effect impacts in the form of chemical reactions between the water molecules and the binder. These reactions can be divided into hydrolysis, breakdown of the ester linkages in the oil, and photochemical reactions producing free radicals (Feller 1994: 20). These reactions will gradually decompose the binder (Bierwagen 1987: 181f; van den Berg, van den Berg and Boon 1999: 49).

Ethical and Conservation Guidelines

From a 2004 condition survey on all the Munch paintings in the museum's collection, the following guidelines were issued... "Only tide lines, spots, and holes which can be dated to after they came under the ownership of the City of Oslo, should be repaired or removed. Flaking areas (from Munch's days) should not be retouched..."⁶ However, we encourage keeping the discussion open concerning methods and what we should or should not treat in Munch's paintings, as well as to emphasize each painting's integrity. Therefore, in regards to treatment no painting should necessarily be viewed in the same way as another.

Before selecting various treatments we had to test and evaluate methods and some different materials described in literature. Each sketch exhibited variations in materials and in conditions which required repeated testing. Both the canvases and the paint layers were very sensitive to water and solvents, which limited the amount of possible treatments. The chosen methods were not supposed to change the surface texture, or structure, nor make it glossy or saturate the colours. It was also important to avoid creating tide lines or using high concentrations of adhesives which would make the treated areas stiffer than the surrounding ones. Pressure on the paint layers had to be avoided because of the soft and porous structures with low mechanical strength. The large dimensions of many of the sketches made it impossible for example to perform the consolidation work in saturated vapor atmospheres. It was also considered desirable to avoid the use of hazardous solvents, as many of the sketches would have to be treated with the conservators lying horizontally above them on bridges and the inhaling of these solvent gases was not desired (Figure 13).



Figure 13. Treatment of one of the unmounted sketches conducted from bridge.
Photo: Eva Storevik Tveit.

Treatment

The main challenge concerning the treatment of all the sketches was the large extent of porous unstable paint. As mentioned earlier in the text, many of the paint layers have high pigment volume concentration, most of them are water sensitive, no matter which binder is present. However, the porous paint in Munch's sketches has different characteristics which required slightly different consolidation methods and consolidants.

Consolidation

We used funori (up to 2%) to consolidate particles and aggregates. The funori made no surface changes, and provided sufficient adhesive and cohesive strength for the porous paint layers. To consolidate smaller particles, meaning powdery chalking surfaces, we used low concentrations of sturgeon glue applied by an Aerosol generator. The adhesion between the pigment particles improved, but the method did not give sufficient cohesive strength to the support. For thicker loose paint, we applied funori by brush while the sketch was placed on a pressure table. The results of the consolidation depended on the properties of the paint; level of porosity, thickness of paint, and canvas weave.

Flattening Deformations and Folds

The unmounted sketches had very many folds and deformations that needed to be flattened. All the deformations that were possible to treat from the edges were flattened by the same method: A slightly moistened blotting paper was put under the canvas deformation. A dry blotting paper was placed above the deformation; a plate that distributed the loads of the weights was placed on top of the plate (Figure 14). The weight pressure was left for up to 24 hours and repeated if necessary, in general we had to repeat the procedure two or three times. The folds and deformations further in from the edges could not be treated with a moistened

blotting paper, as it was difficult to get the paper underneath the canvas. Instead these areas were moistened with an aerosol generator and flattened with the help of a hot spatula. Between the spatula and the canvas a sheet of polyester plastic was placed to avoid surface changes on the canvas texture.



Figure 14. Flattening the folds with weights. In the background measurements with a hand-held x-ray fluorescence analyzer (XRF-instrument). Photo: Lina Flogstad.

Mending Tears and Holes

Tears, holes and areas lacking pieces of canvas, mainly along the edges of the sketches, were stabilized so that they would stay in place during the rolling up of the paintings, and also to avoid causing new damages and folds. It was emphasised that the applied methods should not change the paintings appearance and to minimise the number of added secondary materials. The aesthetic of the repairs became secondary.

In most cases the holes and tears got supported with Japanese paper glued on to the back of the canvas with Lascaux acrylic based glue.⁷ The paper was cut to fit the shape of the damage and the thickness of the chosen paper varied depending on the thickness of the canvas. In some cases it was also used polyester meshes instead of Japanese paper.

Since the aim of the treatment primarily was to stabilise the loose threads and pieces of canvas, we used a minimum number of attachment points. We had to mend threads of polyester to the original threads in the area where big pieces of canvas were missing. Some tears were treated with a method based on the Heiber method.⁸ In areas with sufficient original threads, these were mended with a mixture of (1:1) sturgeon glue (20%) and wheat starch (10%) or where the water-based glue mixture caused surface changes we used Lascaux Polyamid Textil schweisspulver.

Treatment of Soil, Mold, and Stains

The oversized canvases were particularly prone to have severely soiled surfaces and moldy areas. In many cases the whole canvas was mold infested. Loose soil was removed, or often because of the sensitive surfaces only reduced, with a soft brush and a museum vacuum cleaner. Most of the mold stains were impossible to remove, but some could be reduced in areas where there was no paint. In such unpainted areas we used polyurethane sponges and soft brushes and vacuum cleaners (Figure 15). Many of the spores were totally removed with a dry cleaning powder (DraftCleanPowder) on one sketch with a rather solidly grounded support, to which the mold spores adhered weakly.



Figure 15. Cleaning of mold and soil with a brush and a Museum vacuum cleaner. Photo: Lina Flogstad.

Most of the tide lines, water stains and drain marks were impossible to reduce because of the surfaces' sensitive properties. We tested both dry and wet cleaning methods without success. But we managed to reduce the tide lines in one sketch that was lined and mounted on a stretcher. A large and dark tide line resulted from water leakage in the museum in 1982, following a heavy rain in Oslo (Figure 16). The sketch is on permanent display in the museum's Festivity Hall.

Treatment methods described in literature included using a combination of water and a low-pressure table. This method can be effective, as the suction underneath the textiles relatively quickly extracts the humidity and the dissolved discolouring substances through the textile, thus preventing it from flowing into other areas. However, this method could not be used because of the size of Munch's sketches and the fact that it is lined to a relatively thick canvas as a ground layer.



Figure 16. Left, Detail of a tide line. Photo: Erika Gohde Sandbakken

Different thicknesses of blotting paper were tested and the thinnest ones seemed to work better on the canvas areas. Small pieces of slightly moistened blotting paper were then used to wet the tide line and pick up some of the dirt. This was repeated several times as very little moisture was applied at the time in order to prevent the water from flowing outside the tide line area. After each moist application the area was immediately dried with warm air. This was a very time consuming method and we had to avoid applying too much warm, dry air because the stain was adjacent to fragile paint and ground layers. After a few treatments, wear of the canvas could also be noticed under magnification.

In areas where the tide line was broader we could work with more moisture and for longer periods without widening the tide line. The idea about not widening the stain into other areas was after conversations with a textile conservator less strict. We continued adding moisture, but applied by brush, and we let the moisture work a few seconds before extracting some of the moisture with an ordinary tissue paper. We realised early in the process when working on this tide line that it would be too difficult to wholly remove it or render it totally invisible (Figure 17).

After treatment, parts of the tide line were reduced and in some places were more or less invisible at a distance. (The tide line is in the upper edge of the painting and from the floor it's more than five metres away). A prospective continuation of treatment, such as retouching the still visible parts of the tide line, was rejected, as a retouching would dye the canvas and be totally irreversible. Bleaching methods were considered as not suitable; one reason was that such treatment, in this case, would be difficult to control.



Figure 17. The whole tide line during treatment. Photo: Erika Gohde Sandbakken

Treatment of Efflorescence

Treatment descriptions for similar problems with efflorescence on paintings seem limited. Only a limited number could be tried because potential treatment methods were to be tested on the original material. Some mechanical removal tests proved unsuitable for both the exposed canvas areas and for the unstable powdery paint. Colbourne (2010) recommended, among other methods, using an aerosol generator and simply dissolving the efflorescence with deionised water. As the zinc sulphate and magnesium sulphates are water-soluble, this treatment method was deemed possibly to be a suitable method for Munch's sketches.



Figure 18. Treatment of efflorescence with an Aerosol Generator AGS 2000. Photo: Erika Gohde Sandbakken.

The test result from using the aerosol generator to dissolve the efflorescence worked out well and was used on the three sketches (Figure 18). Locally some of the efflorescence was more resistant –it was observed to be more crusty. In these areas it was necessary to apply more humidity. It was, however, important to avoid wetting the surface too much at one time, as this could create tide lines or darkening of the canvas or the paint layers. In the more resistant areas the application had to be repeated up to three times; the areas were left to dry between each application. The paint layers that were unstable were consolidated, after having dissolved the efflorescence, in the same way described earlier regarding consolidation with the aerosol generator.

The Most Ideal Storage Solutions

Due to insufficient storage space the largest sketches that previously had been rolled needed to be re-rolled after conservation. The results of the consolidation of the different paints were examined on eight sketches after three to four years, when the sketches were unrolled for exhibition. Even though the materials and rolling methods were improved and the diameter of the rolling tubes was enlarged, this is far from optimal storage for such fragile materials. Loose paint consolidated with funori was for the most part still adhered to the support. Areas with the most powdery paint, which had been consolidated with the aerosol generator, seemed to have lost cohesion and adhesion. The result is not surprising considering the initial strength of the paint was weak, the aerosol generator only added small amounts of glue and in low concentrations, and rolling subjects the canvas and paints to great tensile, compressive, and shear forces. However, it shows that the funori in a 2% solution has provided both good cohesion and adhesion for the majority of the areas with porous paints. Most likely the porous property of the paint and non-varnished surfaces has made it easier for efflorescence to migrate through the paint, and might partly explain the extreme extent of salt efflorescence seen on some of the mounted sketches. Efflorescence is also present on the rolled sketches, but not so extensively. This can indicate that the rolled surfaces have been partially protected from later exposure to extremely fluctuating humidity. The sketches that were treated for efflorescence will be monitored in the coming years as the long-term results of the treatment are unknown. Other possible treatment methods are searched and it is hoped that further findings and investigations can help us understand the chemical and physical processes that have taken place. However, we wonder if the controlled museum environment could act as a preventive factor curtailing efflorescence or not?

Endnotes

- 1 Ludvig Ravensberg's diaries: LR 536 (5.1.1910), the Munch Museum archives. (The text is reproduced more extensively in Frydenberg Flaatten, H.-M. (2009): *Soloppgangi Kragerø, Historienom Edvard Munchs liv på Skrubben 1909-1915*, the Municipality of Kragerø, Kragerø, p. 47.)
- 2 Ludvig Ravensberg's diaries: LR 536 (5.1.1910), the Munch Museum archives
- 3 The analyses were done with tape sampling: "Mycotape" distributed by Mycoteam, and analyzed by Mycoteam. With RH around 100% and a T of 26°C the mold may developing just in two days (Alten

2008: 3). RH 85–100%, and T 10–40°C, are considered optimal growing conditions for the (Alten 2008: 3). None of the identified mold types were cellulose cleavages but some of them could cause cellulolyse (Srivastaya 1979: 14)

- 4 ISO standard 3071
- 5 For example suggested by the infrared spectrum for one sample that shows that the carbonyl band at 1738 cm⁻¹, is much smaller than the peak for the C-H-stretch, around 2919 cm⁻¹ (unconjugated double bond, fatty acid).
- 6 Stein, M.: *Konserveringsplan for Munch-maleriene in Oslo kommune Kunstsamlingene*. Sluttrapport April 15, Oslo: NIKU/Munch-museet (2005)
- 7 The holes and tears were supported with Tengu- Jo- papier (11g/ m²) and Lascaux 498HV/ Lascaux 360HV (2:1).
- 8 The Heiber method is described in Heiber, W.: "Die Rissverklebung," *Zeitschrift für Kunsttechnologie und Konservierung*, 1 (1996) 117–146.

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Materials and Suppliers

Sturgeon glue: ArkivprodukterAS, post@arkivprodukter.no

Funori: Kremer Pigmente, info@kremer-pigmente.de

Aerosol Generating Systems, AGS 2000: ZFB GmbH. Mommsenstrasse 7, D-04329 Leipzig, Germany

Belo Low Pressure Heating Table: Lascaux Colours, belogmbh@aol.com

SADT GT60N Glossmeter: Corrosion ControlAS, post@ccas.no

Lascaux PolyamidTextilschweisspulver, ArkivprodukterAS, post@arkivprodukter.no

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