HISTORISCHE ÖLFARBENTECHNIK
ZUR BESTÄNDIGKEIT VON ACRYLFARBEN
DREI TAGUNGEN: IIC, ICOM-CC, ICOMOS
GEMÄLDEREPRODUKTION MIT DEM SCANNER
FARBENFROHE ANTIKE WELT
VIER ÖLGEMÄLDE VON EDVARD MUNCH
WINTEREINHAUSUNGEN

www.restauro.de

Januar/Februar 2009
Map showing the placing of Edvard Munch's 11 paintings (1909-1916) in the Aula of Oslo University.

So far, little has been published on Edvard Munch's painting techniques of the first decades of the 20th century. This preliminary study, which was conducted using non-invasive examination techniques, suggests the artist's choice of materials and ways of applications for four of the smaller motifs in his large-scale room decoration in the Aula of Oslo University (1909-1916). Observations on previous treatments, the present condition and changes with regard to the original appearance are also included.

Introduction

Background

During the years 1904 to 1923, Edvard Munch made four room decorations, two in Germany and two in Oslo, the capital of Norway. Today, the artist's Aula decoration (1909-1916) is his only cycle of paintings that is still preserved in its original context. The Aula decoration consists of eleven, large-scale, canvas paintings, which cover approximately 220 m² of the hall's three main walls. All paintings are of the same height and are located at the same level. Due to the interior design of the Aula, including the dimensions of the eleven niches in the walls, as well as Munch's choice of motifs and their individual placing, the wall program contains three major canvases and their eight companion pieces. "The Sun", which is the central motif, is situated at the northern wall. Respectively, the two side walls have one main motif each, "History" on the western wall and "Alma Mater" on the eastern. Both paintings have two companion canvases: "History" has "Chemistry" (c. 449 x 226 cm) and "New Rays" (c. 449 x 226 cm); "Alma Mater" has "Women Harvesting" (c. 450 x 225 cm) and "The Fountain" (c. 448 x 225 cm). The present paper focuses on these four side panels.

Visual examinations during a cleaning campaign in 1973 suggested that the eleven paintings could be arranged into six different categories according to their making: Each of the three major paintings were categorized separately, and the eight accompanying motives were arranged in three groups: a) "The Fountain" and "Chemistry"; b) "Women Harvesting", "New Rays" and "Lights in the Flood of Light"; and finally c) "Women Reaching towards the Light", "Men Reaching towards the Light" and "Awakening Men in the Flood of Light". In short, the 1973 report claimed that the four accompanying paintings share some common features: Their support includes two pieces of twill fabric each; their four joints or seams run vertical near the middle of the paintings and the numbers of canvas threads per cm² are almost identical. The report also suggests that the same four paintings can be paired together across the room because of resemblances in materials and techniques (see Ill. 1). "The Fountain" and "Chemistry" was noted to have a thin, light greyish, glue-bound ground. The other two paintings were claimed to have a thin, rather dark, yellowish grey ground of the same binding agent. The report also suggests that the same four paintings can be paired together across the room because of resemblances in materials and techniques (see Ill. 1).
have

him

men

men

them

men

tain

the

rings

com-

hers

men

blood

wards

and

short,

any-

their

each;

mid-

was

port

be

re-

2. Metigo Map of the test areas for the portable XRF, "Chemistry" (c. 449 x 226 cm)

3. Metigo Map of the XRF-tests, "New Rays" (c. 449 x 226 cm)

4. Metigo Map of the XRF-tests, "Women Harvesting" (c. 450 x 225 cm)

5. Metigo Map of the XRF-tests, "The Fountain" (c. 448 x 225 cm)
Previous studies revealed that since 1916 the four paintings have undergone three structural interventions and five cleanings. The last cleaning was performed in 1973. During the fall of 2001, a few cleanings tests were carried out on “New Rays” (III. 6). By then, the dirt accumulation had been going on for twenty-eight years. Today, after seven more years, the four paintings have endured even further visual changes because of the continued soiling by air-borne pollutants. In 2009, all Aula paintings will be disassembled prior to the forthcoming renovation of the room. The evacuation will last for two years and will include conservation treatments.

Research questions
During 2007 and 2008, the four paintings were re-examined in the course of the Aula project. New methods were available (see below), and thus we were able to investigate the following questions: Are the supports as similar as the examination in 1973 suggested; is it possible to categorize the four grounds into two different pairs; which colours were examined in situ from scaffolding.31 Due to present health and safety rules with limitations on working height, the working platform on the scaffold did not allow us to reach the upper parts of the paintings.32 However, on January 15th of the following year, “Chemistry” was dismounted from the wall and transported to our conservation studio. This facilitated a closer look at its entire surface including its reverse side.

Examinations and recordings
During 2007, the four paintings in question were examined in situ from scaffolding.33 Due to present health and safety rules with limitations on working height, the working platform on the scaffold did not allow us to reach the upper parts of the paintings. However, on January 15th of the following year, “Chemistry” was dismounted from the wall and transported to our conservation studio.34 This facilitated a closer look at its entire surface including its reverse side.

In situ, the following non-invasive tools were employed: daylight lamps and flashlights to achieve raking light; head lens, field microscope (20x), a simple thread counter and NITON’s portable X-ray fluorescence instrument (XRF).34 In the conservation studio, the raking light examination was improved and the range of equipment was expanded with a laboratory microscope (4x), a UV-lamp and an IR-camera.35 Both in situ and in the studio, the observations, measurements and test areas were recorded in Metigo Map.36

XRF
A portable XRF analyzer (XLt) provides qualitative and semi-quantitative results. The penetration dept of the X-rays will depend on the elements in the actual test area, its sample matrix and thickness.36 The XRF-spectrum is accumulative, and it is difficult to distinct the contents of the individual layers in a multi-layered structure. These spectrums thus indicate the total amount of elements in this case between Mg (12) with low atomic weight and U (92) with high detectable within the test area.

In 2007, Tine Freysaker published the first overview on the majority of the interventions carried out between 1916 and 2001. This paper was followed in 2008 by an article which included a newly discovered treatment from 1937, most likely an additional cleaning campaign. The last paper by Freysaker regarding interventions on the Aula paintings dealt with the dismantling of one of the smaller motifs, “Chemistry”, in 2008.

Besides Gösta Svenaus’ (1953) and Mohr’s (1960) discussions on how Munch made changes (pimenti) on “History” and “Alma Mater”, little has been published on the artist’s use of materials and techniques on the Aula paintings. In 2000, Poul Erik Tejner edited parts of Munch’s own notes on how he chose his course of action for the Aula decoration. In addition, Freysaker’s papers from 2007 and 2008 include technical aspects from Wiik’s unpublished report (1973) and preliminary findings from the Aula project.

Archives
The archival studies of previous treatments are still in progress. The oldest restoration report was written in 1963 by painting conservator Jan Thurmann-Moe at the Munch-Museum. In 1973 (mentioned above) and 1986, painting conservator Svein A. Wiik at the University Museum of Antiquities (now KHM) wrote the other two reports. Recently, the Archive at Stockholm Nationalmuseum came across an internal report from 1943 on the lining practise of the museum’s restorer Gustav Jaenssson. Other archives have already shown that he played a vital role in the mounting of the Aula paintings on to Masonite boards in 1946. However, Jaenssson’s report from 1943 is the only description found so far on how the contemporary mounting onto Masonite was performed.

Publications
In 1945, the restorer Ole Darje Haug wrote a newspaper article on the various interventions on the paintings during the 1940s. In 1960, the former principal of Oslo University, Otto Lous Mohr, published a book on the history of Munch’s commission for the Aula, including comments on some of the treatments and incidents between 1916 and 1960. In 1997, the painting conservator and art historian Johannes Red provided further information on the treatment history from 1926 up to 1951.
the artist's materials prior to future sampling of cross-sections and further analysis. Due to the thin layers of ground and paint compared to the matrix of canvas, Masonite and wooden framework, we expected the X-rays to penetrate the entire structure of the paintings. The procedure was as follows: The XRF was whenever possible used on single layer structures only; each colour was tested by several XRF-recordings; and every result was compared with the elements found for their individual ground.

By comparing the visual appearance of each colour with their individual XRF-spectrum, it is possible to suggest their components. These interpretations are estimated as initial, and at this early stage, far from conclusive. Since the present XRF cannot detect elements with a lower atomic weight than magnesium, organic pigments cannot be localized. In principle, there might be organic colouring material in all colours in this study. They will however, only be suggested where the XRF-spectrums lack such colouring components, i.e. when a layer of violet only seems to contain a single colorant, an inorganic blue (see below).

Some elements will occur in the spectrums of different colours. In this paper, chrome in a green colour will be called chrome green, while chrome in a yellow is interpreted as chrome yellow.

Diverging elements were found in some of the colours investigated by the present approach, pointing at pigments that cannot have a visual influence on the appearance of the colour. Some probable reasons for this are: indistinct measurements, interferences by neighbouring colours within the span of the XRF and eventually, the artist's usage of contaminated brushes. The origin and purpose of such elements and their possible pigments are still open to further interpretations; thus they are being presented in brackets.

Removal of subsidiary material from "Chemistry"

Prior to the dismantling of the painting from the wall, all the zinc strips (from 1946) at its outer edges were removed. During the studio examination, a few cleaning tests were performed: Loose surface dirt was taken off by brush and a low suction vacuum cleaner; darker and firmly attached stripes of dirt accumulation (above the wooden framework) were removed. During the studio examination, a few cleaning tests were performed: Loose surface dirt was taken off by brush and a low suction vacuum cleaner; darker and firmly attached stripes of dirt accumulation (above the wooden framework from 1946) were removed. In addition, some colours were examined after saliva cleaning, and some small areas of retouching (from 1946) were also removed mechanically.

On the reverse side, a layer of disintegrated paper (from 1946) was removed to expose the framework, the Masonite and the insulation which were added during the post war remounting.

Results

Condition

The applied approach provided new insight into the present condition of the paintings. For the first time in more than sixty years, the materials on the reverse side (from the remounting in 1946) were accessible, as well as the brick wall behind "Chemistry" (III. 7). Close to this brick wall there was a thin layer of discoloured and brittle paper (mentioned
left in the lining adhesive by the jagged edge of the application tool (ill. 11). This textural change can indicate that the Masonite mounting was performed with rather light pressure.\(^{40}\)

"Chemistry" has some areas of de-lamination between the canvas and the Masonite (ill. 12). This has never been reported previously,\(^{41}\) and it is difficult to date the de-laminations found. They might have occurred during lining due to insufficient pressure or local lack of glue,\(^{42}\) or they resulted from movements in the wooden framework and canvas caused by changes in the room climate.\(^{43}\) The attachment between canvas, ground and paint layers is however sufficient on all four paintings. Some colours have age craquelures, and only in a few cases are there minor losses of paint. The craquelures and a few lacunas seem to result from dimensional stress in canvas and framework; although most paint losses, especially in one of the paintings, were caused by previous mechanical cleaning. In "New Rays" only, there are several areas where ground and colours are missing on top of the canvas knots.

In 1926, the Aula paintings received a layer of white priming at their reverse side.\(^{50}\) In some areas, drops of priming have penetrated through the canvas weave and the layers of paint. On the paint surface, there were also remnants from the treatments in 1946: discoloured splashes of the mounting adhesive along with overpaints from the colour applications on the zinc strips surrounding each painting.

It has been reported that the Aula paintings were varnished for their first time in 1926.\(^{51}\) Despite possibilities like the later removal of varnish during one of the following cleaning interventions, the visual examination including the UV-lamp revealed no traces of varnish or varnish removal.\(^{52}\)

The recent local removals of dirt and paste from the surface of "Chemistry" show that the painting must have been very clean prior to the mounting onto Masonite (ill. 13). It is obvious that all colours and grounds are heavily soiled and blurred by non-original materials.

Supports
The four paintings are made of two pieces of canvas each, and all eight pieces share the same twill weave pattern (ill. 14). The individual pieces were stitched together in vertical pairs, either with butt joins or with a minimum of extra hems on each side of the seam.\(^{53}\) Some of the eight textiles have quite similar widths, others differ.\(^{54}\) In "Chemistry" the (viewer's) right piece is c. 101 cm and the left is c. 124 cm wide; in "New Rays" and "Women Harvesting" both the right and left textiles are each c. 113 cm wide; and in "The Fountain" the right is c. 94 cm and the left is c. 130 cm wide.

On each piece of canvas the density of the weave was established by the counting of threads per
In all four paintings the white ground is clearly visible because there are many areas without subsequent applications of color. The ground was applied rather thinly and there are no traces left by the application tool (Ill. 16). The texture of the canvas weave was not reduced by this sparse layering, and there are no signs of a sanding down prior to the application of paint.58 In all sections of exposed ground, it is matte, lean and very absorbent. The XRF-examinations of the ground on all canvases indicate zinc; lead and chalk (see Tables 1–4). The only difference noted amongst the grounds is that “New Rays” seems to be the only painting with a higher portion of zinc-containing pigment and with less use of a lead-based component (Ill. 17). No other elements that can be suggested as additional colours or fillers were found.

A glue size layer?
Visual examination of the surfaces revealed no size layer between the supports and the grounds. In addition, in several places the priming (from 1926) on the reverse side of the canvases have penetrated the weave and formed small white pellets on the surface of the paintings (Ill. 15). The pellets are soluble in water, and in the middle they show a small crater with a pinhole. This can be a sign of water evaporation while drying. Often a glue size layer is too thin to be seen, but usually even an extremely thin film is capable of bridging the gaps in the weave of the canvas.57 The pellets might indicate that the priming was applied on the reverse side by the use of pressure which allowed penetration in some areas. There are two possible explanations for this. One is that there was no original size. The other options are that a possible size was unevenly applied or just brittle.
<table>
<thead>
<tr>
<th>S. No.</th>
<th>T. No.</th>
<th>Main Colour</th>
<th>Application area</th>
<th>Applied on</th>
<th>Ni</th>
<th>Mo</th>
<th>O</th>
<th>P</th>
<th>Glass Matte</th>
<th>Gloss</th>
<th>Diluted Semi-solid</th>
<th>opaque</th>
<th>XRF elements</th>
<th>Suggested pigments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>001</td>
<td>Violet</td>
<td>Contours and shadows in the male's flesh colours (+ her hair)</td>
<td>bare ground</td>
<td>D</td>
<td>+</td>
<td>P</td>
<td>+</td>
<td>gloss</td>
<td>opaque</td>
<td>Al, Si, S, Cd, Sn, Cr, Co, Cu, Zn, Pb</td>
<td>Cadmium yellow, Cerusian blue, copper green, chrome green, organic red (707)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>002</td>
<td>Violet</td>
<td>Contours in the male's flesh colours (+ shadows)</td>
<td>light red (+ bare ground)</td>
<td>D</td>
<td>gloss</td>
<td>opaque</td>
<td>Al, Si, S, Cd, Sn, Cr, Co, Cu, Zn, Pb</td>
<td>Emerald or Scheel's green, Cerusian blue, copper green, chrome green, organic red (707)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>003</td>
<td>Blue</td>
<td>Contours in the male's flesh colours (+ shadows)</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Zn, Pb, Cs, Si, Al, F6, Co</td>
<td>Ultramarine, Prussian blue and cobalt blue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>004</td>
<td>Blue</td>
<td>Laboratory flask (+ test tube)</td>
<td>bare ground</td>
<td>Mo</td>
<td>+</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Zn, Pb, Cs, Co, Cu, As, Ba</td>
<td>Cobalt blue, Emerald or Scheel's green + white added</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>005</td>
<td>Blue</td>
<td>Background</td>
<td>bare ground + an green</td>
<td>Mo</td>
<td>+</td>
<td>M</td>
<td>glass</td>
<td>opaque</td>
<td>Al, Si, Sn, Ca, F6, Co, Cu, Zn, Pb</td>
<td>Cerusian blue, some copper green and possibly ultramarine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>006</td>
<td>Blue</td>
<td>Sky</td>
<td>bare ground</td>
<td>M</td>
<td>glass</td>
<td>semi-solid</td>
<td>opaque</td>
<td>Al, Si, Sn, Ca, F6, Co, Cu, Zn, Pb</td>
<td>Ultramarine, Prussian blue and cobalt blue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>007</td>
<td>Green</td>
<td>Contours in the male's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Zn, Pb, Ca, Cr, Cu</td>
<td>Chrome green, copper green</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>008</td>
<td>Green</td>
<td>Contours in the female's flesh colours (+ other colours)</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-solid</td>
<td>opaque</td>
<td>Zn, Pb, Ca, Cr, Cu</td>
<td>Chrome green, copper green</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>009</td>
<td>Green</td>
<td>Laboratory flask</td>
<td>bare ground</td>
<td>Mo</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Zn, Pb, Ca, Cr, Cu</td>
<td>Chrome green, copper green</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>010</td>
<td>Green</td>
<td>Background</td>
<td>bare ground + an green</td>
<td>Mo</td>
<td>+</td>
<td>M</td>
<td>glass</td>
<td>opaque</td>
<td>Si, Ca, Cr, Cu, Zn, As, Pb</td>
<td>Ultramarine, Prussian blue, chrome green</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>011</td>
<td>Green</td>
<td>Contours around the fibre</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>opaque</td>
<td>Zn, Pb, Cs, Cd, S, Hg, Ba, Cr</td>
<td>Cadmium yellow, vermilion, chrome yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>012</td>
<td>Green</td>
<td>The male's hair (+ in the male's hair)</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>opaque</td>
<td>Zn, Pb, Cr, Si, Al, F6, Pb</td>
<td>Cadmium yellow, vermilion, chrome yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>013</td>
<td>Yellow</td>
<td>Contours in the female's flesh colours</td>
<td>light red + on yellow</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Zn, Pb, Ca, Cd, S, Hg, Ba, Cr</td>
<td>Cadmium yellow, vermilion, chrome yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>014</td>
<td>Yellow</td>
<td>Contours in the male's flesh colour</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Zn, Pb, Ca, Cd, S, Hg, Ba, Cr</td>
<td>Cadmium yellow, Vermilion, Chrome yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>015</td>
<td>Yellow</td>
<td>Highlights in the female's flesh</td>
<td>bare ground</td>
<td>Mo</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Zn, Pb, Ca, Cd, S, Hg, Ba, Cr</td>
<td>Cadmium yellow, chrome yellow + zinc white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>016</td>
<td>Yellow</td>
<td>Middle tones in the infant's flesh colours</td>
<td>bare ground</td>
<td>Mo</td>
<td>matte + glossy</td>
<td>semi-transparent</td>
<td>Zn, Pb, Ca, Cd, S, Hg, Ba, Cr, Cu</td>
<td>Cadmium yellow and possibly chrome yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>017</td>
<td>Yellow</td>
<td>Highlight on green laboratory flask and its background</td>
<td>bare ground</td>
<td>Mo</td>
<td>matte + glossy</td>
<td>semi-transparent</td>
<td>Zn, Pb, Ca, Cd, S, Hg, Ba, Cr</td>
<td>Cadmium yellow, chrome yellow + zinc white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>018</td>
<td>Yellow</td>
<td>Flame tailore level</td>
<td>bare ground</td>
<td>Mo</td>
<td>glass</td>
<td>opaque</td>
<td>Zn, Pb, Ca, Cd, S, Hg, Ba, Cr</td>
<td>Cadmium yellow, chrome yellow + zinc white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>019</td>
<td>Yellow</td>
<td>Contours around the fibre</td>
<td>bare ground + on light blue and on green</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>opaque and semi-transparent</td>
<td>Zn, Pb, Ca, Cd, S, Hg, Ba, Cr</td>
<td>Cadmium yellow, possibly chrome yellow, vermilion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>020</td>
<td>Yellowish red</td>
<td>Contours and middle tones in the male's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>opaque and semi-transparent</td>
<td>Zn, Pb, Cs, Cd, S, Hg, Ba, Cr, Al, S</td>
<td>Cadmium yellow, possibly chrome yellow, vermilion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>021</td>
<td>Red</td>
<td>Contours in the female's flesh colours (+ shadows in the male's flesh colours)</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>semi-transparent</td>
<td>Al, Si, S, Ca, Ba, Cr, Zn, Hg, Pb</td>
<td>Vermilion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>022</td>
<td>Red</td>
<td>Contours in the female's flesh colours (+ shadows in the male's flesh colours)</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Al, Si, S, Ca, Ba, Cr, Zn, Hg, Pb</td>
<td>Vermilion + white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>023</td>
<td>Red</td>
<td>Contours in the male's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>opaque and semi-transparent</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Vermilion, cadmium yellow and possibly chrome yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>024</td>
<td>Red</td>
<td>Contours in the male's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>opaque and semi-transparent</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Vermilion, cadmium yellow and possibly chrome yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>025</td>
<td>Red</td>
<td>Highlights in the male's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>opaque</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Vermilion, cadmium yellow and possibly chrome yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>026</td>
<td>Red</td>
<td>Middle tones in the male's flesh colours</td>
<td>bare ground</td>
<td>M</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Vermilion + fillers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>027</td>
<td>Red</td>
<td>Text tube (+ arm-like lines in the brush)</td>
<td>bare ground</td>
<td>M</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Vermilion and possibly fillers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>028</td>
<td>Red</td>
<td>Highlights in text tube (+ laboratory flask + background)</td>
<td>bare ground</td>
<td>Mo</td>
<td>glass</td>
<td>semi-transparent</td>
<td>semi-transparent</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Vermilion, cadmium yellow, vermilion + zinc white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>029</td>
<td>Red</td>
<td>Highlights in text tube (+ laboratory flask + background)</td>
<td>bare ground</td>
<td>Mo</td>
<td>glass</td>
<td>opaque</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Vermilion, chrome yellow or chrome yellow + organic black</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>030</td>
<td>Brown</td>
<td>Shadows in her brood hair + in the colours flesh colour</td>
<td>bare ground</td>
<td>D</td>
<td>matte + glossy</td>
<td>opaque and semi-transparent</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Vermilion, possibly chrome yellow + zinc + chrome yellow and palladium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>031</td>
<td>White</td>
<td>Highlights in the infant's flesh colours</td>
<td>bare ground + on yellow</td>
<td>D</td>
<td>glass</td>
<td>opaque</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Unknown white + vermilion and possibly fillers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>032</td>
<td>White</td>
<td>Background below the female's right foot</td>
<td>bare ground only</td>
<td>Mo</td>
<td>matte</td>
<td>opaque</td>
<td>Zn, Pb, Hg, S, Cd, Ca, Ba, Cr, Al, S</td>
<td>Zinc white, lead white, chalk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tables 1-4: Chronological number of colour applications (S. No.). The first two numbers of (T. No.) refer to the main colour and the last two refer to the individual number of each specific colour. Monochrome (M), modelled (M), drawn lines) (D), the brush was dipped in more than one colour (Pl), hatched (H). Please note that alternative interpretations of the elements found by XRF are possible.

Table 1: Colours, application, elements provided by portable XRF and suggested pigments, "Chemistry"
Underdrawings
All human figures in the four paintings, including the infants in the sky of "Chemistry", were drawn directly on the ground with slender, matte and greyish black lines. In addition, also in "Chemistry", the smoke, the test tubes and the laboratory flasks show those sketched lines. All other kinds of shapes and forms in the four paintings seem to lack any similar underdrawings. Or if present, they are completely covered by the subsequent brush strokes. In "Chemistry" there are no prominent differences between the XRF results obtained from the underdrawings and the bare ground. It is likely that the drawn lines are of organic origin such as carbon-based blacks.

Local underpaints
In "New Rays" there are a few local, white layers below transparent colours. These white layers are brighter and more opaque than the ground and they increase the brilliance of the subsequent transparent colours. Thus these white layers have been interpreted as local underpaints. The larger ones are situated behind the man's right thigh, knee and upper leg and behind the female's left leg as well as between her legs. Due to overlapping contours of the flesh colours it seems like the couple was more or less finished before the application of the white underpaint in their surroundings. In addition, a few local and smaller underpaints of the same colour are scattered in the sky. In a few places close to the couple, the white underpaints remain exposed. In these areas the white colour is monochrome, glossy and rather semi-solid and opaque (see Table 2, T. No. 1002). The XRF-examinations might imply that the underpaints are mixtures of zinc white, lead white and a small amount of chrome yellow. Anyway, alternative interpretations cannot be ruled out.

Table 2. "New Rays" [S. No. 1-17]

<table>
<thead>
<tr>
<th>S. No</th>
<th>T. No.</th>
<th>Main colour</th>
<th>Application area</th>
<th>Applied on</th>
<th>M</th>
<th>D</th>
<th>Matte</th>
<th>Diluted</th>
<th>Semi-transparent</th>
<th>Transparent</th>
<th>XRF-elements</th>
<th>Suggested pigments in top layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0101</td>
<td>Violet</td>
<td>Contours and shadows in the man's flesh colours</td>
<td>bare ground</td>
<td>+ M</td>
<td>D</td>
<td>matte</td>
<td>diluted</td>
<td>semi-transparent</td>
<td>transparent</td>
<td>Zn, Pb, S, Hg, Av, Ca, Si, Al</td>
<td>Vermilion, ultramarine, Av?</td>
</tr>
<tr>
<td>2</td>
<td>0102</td>
<td>Violet</td>
<td>Background behind the female's legs</td>
<td>bare ground</td>
<td>+ on red</td>
<td>+ M</td>
<td>glass</td>
<td>diluted</td>
<td>semi-transparent + opaque</td>
<td>transparent</td>
<td>Zn, Pb, S, Co, Hg, Ba, Cr, Si, Al</td>
<td>Vermilion, cobalt blue, chrome yellow, Si + Al fillers?</td>
</tr>
<tr>
<td>3</td>
<td>0103</td>
<td>Violet</td>
<td>Background behind the male's right ankle (at the edge of the motif)</td>
<td>bare ground</td>
<td>+ on white understanding on blue, + on the flesh colours</td>
<td>matte + glass ground, glossy on colours</td>
<td>diluted</td>
<td>transparent</td>
<td></td>
<td>Zn, Pb, Ca, Mn, P, Si, Cu, As</td>
<td>Manganese violet, cobalt blue, Cu + Av?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0201</td>
<td>Blue</td>
<td>Contours in the couple's flesh colours</td>
<td>bare ground</td>
<td>+ on other colours</td>
<td>D</td>
<td>matte</td>
<td>diluted</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0202</td>
<td>Blue</td>
<td>Background behind the male's legs (+ behind the female's left leg)</td>
<td>bare ground</td>
<td>+ on white understanding</td>
<td>M</td>
<td>matte + glassy parts</td>
<td>diluted</td>
<td>semi-transparent + opaque</td>
<td>Pb, Zn, S, Si, Av, Ca, Co</td>
<td>Ultramarine, cobalt blue, lead white</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0301</td>
<td>Green</td>
<td>Background below the male's right elbow (+ behind the femoral's leg)</td>
<td>bare ground</td>
<td>+ on blue</td>
<td>M</td>
<td>matte + glassy parts</td>
<td>diluted</td>
<td>semi-transparent + opaque</td>
<td>Zn, Pb, S, Cr, Ca, Si</td>
<td>Strontium chromate, chrome green, cobalt blue + zinc white added</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0401</td>
<td>Yellow</td>
<td>Middle tones in the couple's flesh colours</td>
<td>bare ground</td>
<td>+ on various colours</td>
<td>D</td>
<td>matte + glassy parts</td>
<td>diluted</td>
<td>transparent</td>
<td>Zn, Pb, Cu, Cd, Hg, As</td>
<td>Cadmium yellow, vermilion</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0402</td>
<td>Yellow</td>
<td>Background behind the couple's lights</td>
<td>bare ground</td>
<td>matte</td>
<td>diluted</td>
<td>transparent</td>
<td>Zn, Pb, Ca, Sr, Cr, Ba</td>
<td>Chrome yellow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0501</td>
<td>Yellow</td>
<td>Contours in the femoral's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-solid</td>
<td>opaque</td>
<td>Zn, Pb, Hg, S, Cd, Si, Ba, Cr, Co, Br?</td>
<td>Vermilion, cadmium yellow, chrome yellow, lead white (i.e. contamination?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0601</td>
<td>Red</td>
<td>Contours in the man's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>diluted</td>
<td>semi-transparent + opaque</td>
<td>Zn, Pb, S, Ca, Hg, Co, Si</td>
<td>Vermilion, cobalt pigment + lead white added</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0602</td>
<td>Red</td>
<td>Shadows in the couple's flesh colours (+ in the sky)</td>
<td>bare ground</td>
<td>+ similar?</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0701</td>
<td>BrownishRed</td>
<td>Contours in the femoral's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent + opaque</td>
<td>Zn, Pb, Cr, S, Hg, Cu, Co, Si</td>
<td>Vermilion, cobalt pigment, copper pigment + zinc white added</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0801</td>
<td>Brown</td>
<td>Contours in the femoral's flesh colours</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>transparent</td>
<td>Zn, Pb, Ca, S, Hg</td>
<td>Vermilion, organic black? + zinc white added</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0802</td>
<td>Brown</td>
<td>Hair on male</td>
<td>bare ground</td>
<td>+ on male with some blue finishing lines on top</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1001</td>
<td>White</td>
<td>Highlights in the man's flesh colours</td>
<td>D</td>
<td>+ H</td>
<td>matte</td>
<td>diluted</td>
<td>opaque</td>
<td></td>
<td>Unknown white</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>1002</td>
<td>White</td>
<td>Bare, exposed underpaint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Zn, Pb, Ca, Ba, Cr</td>
<td>Zinc white, lead white, chrome yellow</td>
</tr>
<tr>
<td>17</td>
<td>1003</td>
<td>White</td>
<td>Background (+ highlights in the couple's flesh colours</td>
<td>bare ground</td>
<td>+ matte</td>
<td></td>
<td></td>
<td>opaque</td>
<td>Zn, Pb, Cu</td>
<td>Zinc white, lead white, chalk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Application of colours
By looking for overlapping brush strokes, it was possible to find some general trends in the sequences of the artist’s applications: First, the contour lines around the figures were painted followed by the rest of the flesh colours (see below). Then their surroundings were applied, and often some new contours were added around the female and the male. In “Chemistry” it seems like the flame below the bowl was amongst the last areas to be painted. In “New Rays” a few contours on top of the transparent yellow layer across the couple’s thighs is likely to be the artist’s finishing brushstrokes. In “Harvesting Women” the large branch with fruits might have been the last application. And finally, in “The Fountain” the ultimate contours seem to be Munch’s final touches.

<table>
<thead>
<tr>
<th>Table 3. “Women Harvesting” [S. No. 1-27]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. No.</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
</tbody>
</table>
| 9      | 0303   | Green     | Light zone below the seated female | yellow | M | matte | opaque + semi-transparent | Pb, Zn, S, Si, Al, Ca, Fe | Chrome-green, copper-green and possibly silver?
| 10     | 0304   | Green     | Dark zone between the females | bare ground | M | matte | semi-transparent | Pb, Zn, Ca, Cr, Ba, Si, Al, Hg, Cu | Chrome-green, Vermilion |
| 11     | 0401   | Yellow    | Contours (and hair) in the standing female’s flesh colours | bare ground | D | glass | semi-transparent (+ semi-solid) | Pb, Zn, Ca, S, Cd, Hg | Cadmium-yellow, some vermilion + zinc white added |
| 12     | 0402   | Yellow    | Contours in the seated female’s flesh colour | bare ground | D | matte | semi-solid + semi-transparent | Pb, Zn, Ca, S, Cd, Fe | Cadmium-yellow |
| 13     | 0403   | Yellow    | Ground below the seated female | bare ground | M | matte | semi-transparent | Pb, Zn, Ca, S, Cd, Fe | Cadmium-yellow, some yellow orange + lead white added |
| 14     | 0404   | Yellow    | Lines in corner below the standing female | light red | on base over light red | glass | opaque | Pb, Zn, Ca, S, Cd, Fe | Cadmium-yellow |
| 15     | 0501   | Yellowish red | Hair on the standing female | bare ground | D | glass | semi-solid | Pb, Zn, S, Hg, Ca, Cr, Cd, Al, Si, Fe | Cadmium-yellow, Vermilion |
| 16     | 0501   | Red      | Contours in the standing female’s flesh colour | bare ground | D | matte | semi-solid | Pb, Zn, S, Hg, Ca, Cr, Cd, Al, Si, Fe | Vermilion, some red ochre? |
| 17     | 0602   | Red      | Contours in the seated female’s flesh colour | bare ground | D | glass | semi-transparent | Pb, Zn, Ca, Hg, Fe | Vermilion, red ochre + zinc white added |
| 18     | 0603   | Red      | Contours in the seated female’s flesh colour | bare ground | D | glass | semi-transparent | Pb, Zn, Hg, Pb, Zn, Ca, Al, Si | Vermilion |
| 19     | 0604   | Red      | Contours in the seated female’s flesh colour | green | D | glass | semi-transparent | Pb, Zn, Ca, P, Si, Al, Mn | Cadmium-blue |
| 20     | 0605   | Red      | Ground below the seated female | green | D | in semi-transparent | Pb, Zn, Ca, Si | Organic red + lead white added |
| 21     | 0606   | Red      | Hair on the standing female | bare ground | M | matte | semi-transparent | Pb, Zn, S, Hg, Ca, Cr, Cd, Al, Si | Vermilion |
| 22     | 0701   | Brownish red | Hair on the seated female | bare ground | M | matte | Cd-matte | Pb, Zn, Pb, Ca, S, Cd, Zn, S | Cadmium-yellow, organic black? |
| 23     | 0801   | Brown    | Contours in the standing female’s flesh colour | bare ground | D | matte | semi-transparent | Pb, Zn, Pb, Ca, S, Cd, Zn, S | Cadmium-yellow, organic black? |
| 24     | 0901   | White    | Highlights in the seated female’s flesh colour | bare ground | H | glass | opaque + semi-transparent | Pb, Zn, Ca, S, Si, Al, P, Mn, Cu, Fe | Lead white |
| 25     | 0902   | White    | Highlights in the standing female’s flesh colour | bare ground | M | matte | opaque | Pb, Zn, Ca, S, Si, Al, P, Mn, Cu, Fe | Lead white, lead white, chalk |
| 26     | 1003   | White    | Water(?) behind the female | bare ground | M | glass | opaque + semi-transparent | Pb, Zn, Ca, S, Si, Al, P, Mn, Cu, Fe | Unknown white and some blue |
| 27     | 1004   | White    | Behind the seated female’s back | bare ground | M | matte | | | |
Visual examination implies that a drying oil was used as binding media for the paint layers above the ground. The surface gloss of the paintings shifts from matte ground and lustreless colours to several nuances of shiny and glossy tints. Gloss is still visible in raking light as well as in a few minor cleaning tests (with saliva) which also revealed high gloss.

Most colours were applied as a single layer on bare ground. A few are transparent (see III. 13); the majority is either semi-transparent or opaque (III. 20). The colours have been brushed onto the ground either as lines, hatchings (III. 21), monochrome layers or as modelled applications including other colours. Sometimes, and especially in drawn lines, the brush has been dipped in more than one colour.

Table 4. “The Fountain” [S. No. 1-25]

<table>
<thead>
<tr>
<th>S. No.</th>
<th>T. No.</th>
<th>Main colour</th>
<th>Application area</th>
<th>Applied on</th>
<th>M</th>
<th>Mt</th>
<th>Di</th>
<th>Gloss</th>
<th>Matt</th>
<th>Semi-solid</th>
<th>Opaque</th>
<th>Semi-transparent</th>
<th>XRF elements</th>
<th>Suggested pigments in top layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0101</td>
<td>Violet</td>
<td>Contours in the</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>+ glossy</td>
<td>in painted</td>
<td>areas</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, cobalt + lead white added</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0102</td>
<td>Violet</td>
<td>Shadows in the</td>
<td>bare ground</td>
<td>Mc</td>
<td>gloss</td>
<td>diluted</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, cobalt blue, copper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0103</td>
<td>Violet</td>
<td>Middle tone in</td>
<td>bare ground</td>
<td>Mc</td>
<td>gloss</td>
<td>semi-solid</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, cobalt blue, a copper pigment + white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0104</td>
<td>Violet</td>
<td>Rock below the</td>
<td>bare ground</td>
<td>Mc</td>
<td>gloss</td>
<td>diluted + semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, cobalt blue, a copper pigment + white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0105</td>
<td>Violet</td>
<td>Water below and</td>
<td>bare ground</td>
<td>Mc</td>
<td>gloss</td>
<td>opaque</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, cobalt blue + Lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0201</td>
<td>Blue</td>
<td>Dark blue water</td>
<td>bare ground</td>
<td>Mc</td>
<td>gloss</td>
<td>semi-solid</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Cobalt blue, possibly some ultramarine + lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0202</td>
<td>Blue</td>
<td>Somewhat lighter</td>
<td>on light violet</td>
<td>Mc</td>
<td>gloss</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Cobalt blue + zinc white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0203</td>
<td>Blue</td>
<td>Dark water between</td>
<td>bare ground</td>
<td>Mc</td>
<td>gloss</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Cobalt blue, possibly some ultramarine + lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0204</td>
<td>Green</td>
<td>Contours in the</td>
<td>bare ground</td>
<td>Mc</td>
<td>matte</td>
<td>+ glossy</td>
<td>in painted</td>
<td>areas</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Cerulean blue, Emerald or Scheibler’s green</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0205</td>
<td>Green</td>
<td>Hair on the</td>
<td>on red</td>
<td>Mc</td>
<td>gloss</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Cerulean blue, Emerald or Scheibler’s green</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0206</td>
<td>Green</td>
<td>Green below the</td>
<td>bare ground</td>
<td>Mc</td>
<td>matte</td>
<td>(+ semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Cerulean blue, Emerald or Scheibler’s green</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>standing person</td>
<td>(+ on the hills above?)</td>
<td>Mc</td>
<td>matte</td>
<td>(+ semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Cerulean blue, Emerald or Scheibler’s green</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0207</td>
<td>Green</td>
<td>Light green behind</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Green earth + zinc white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0208</td>
<td>Yellow</td>
<td>Contours in the</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Chrome yellow, cadmium yellow, some vermilion + lead white added (Cd?)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0209</td>
<td>Yellow</td>
<td>Hair on the</td>
<td>on yellow</td>
<td>M</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Chrome yellow, cadmium yellow, some vermilion + lead white added (Cd?)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>0210</td>
<td>Red</td>
<td>Contours on the</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, red ochre + fillets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0211</td>
<td>Red</td>
<td>Contours in the</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, red ochre, Cr?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>0212</td>
<td>Red</td>
<td>Middle tone in</td>
<td>bare ground</td>
<td>Mc</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, cobalt blue, manganese violet, Cr?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>0213</td>
<td>Red</td>
<td>Shadows in the</td>
<td>bare ground</td>
<td>Mc</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, cobalt blue, manganese violet, Cr?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0214</td>
<td>Red</td>
<td>Contour on rock</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, cobalt blue, manganese violet, Cr?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0215</td>
<td>Brown/m</td>
<td>Shadow in the</td>
<td>bare ground</td>
<td>D</td>
<td>glass</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, chrome green, an earth pigment, cadmium yellow + lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>0216</td>
<td>Brown/m</td>
<td>Contour on rock</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, chrome green, an earth pigment + lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0217</td>
<td>White</td>
<td>Highlights in the</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, chrome green, an earth pigment + lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>0218</td>
<td>White</td>
<td>Highlights in the</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, chrome green, an earth pigment + lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>0219</td>
<td>White</td>
<td>Upper waterbowl</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, chrome green, an earth pigment + lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>0220</td>
<td>White</td>
<td>Highlights in the</td>
<td>bare ground</td>
<td>D</td>
<td>matte</td>
<td>semi-transparent</td>
<td>Ph, S, Zn, Cu, Hg, Si</td>
<td>Vermillion, chrome green, an earth pigment + lead white added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Colours, application, elements provided by portable XRF and suggested pigments, "The Fountain"
(ill. 22). In other modelled parts the applications must have been performed wet-in-wet, wet-beside-wet or as wet-on-dry.

Some colours were diluted, probably with turpentine to form thin and fluid paints with the same surface texture as the bare ground (ill. 23). Others have a range of impasto from low to high (ill. 24), or they were applied as semi-solid strokes only covering the knots of the canvas weave (ill. 25). Hairs from the paint brush are embedded in almost all types of colours, especially in "Chemistry" (ill. 26). The diluted colours, however, bear no evidence of brush-marks, in contrast to the less viscous ones.

Colours
The XRF examinations suggest that the majority of colours are composed of more than one individual pigment:

Violets: "Chemistry" seems to have the most complex mixtures of violet (see Table 1, T. No. 0101 and 0102): One contains Cerulean blue and perhaps organic red (and possibly cadmium yellow)

Copper green and chrome green; the other also seems to have Cerulean blue and an organic red (as well as Emerald or Scheele’s green, copper green and chrome green). In addition, in "New Rays" one of the violets is composed of cobalt blue and red vermilion (and chrome yellow. Table 2, 0102).

Apart from additions of white pigments for the light shades, the other violets probably are mixtures of two individual pigments: manganese violet and cobalt blue (Table 1, 0201, 0202, Table 3, 0203). It seems like "Chemistry" also has a mixture of ultramarine and Cerulean blue (and some copper green. Table 1, 0204). In addition, "Harvesting Women" has light shades of ultramarine and Cerulean blue (Table 3, 0202, 0204). Both "New Rays" and "The Fountain" display cobalt blue and vermilion (Table 2, 0103, 0105). As well as cobalt blue, vermilion and a copper pigment (Table 4, 0104)

Blues: Both "Chemistry" and "Harvesting Women" contain blue colours consisting of ultramarine, Prussian blue and cobalt blue (Table 1, 0201, 0202, Table 2, 0103). It seems like "Chemistry" also has a mixture of ultramarine and Cerulean blue (and some copper green. Table 1, 0204). In addition, "Harvesting Women" has light shades of ultramarine and Prussian blue (Table 3, 0202, 0204). Both "New Rays" and "The Fountain" display mixtures of ultramarine and cobalt blue (Table 2, 0202, Table 4, 0201).

Two paintings contain blue colours which include Emerald or Scheele’s green: In "Chemistry" the green is mixed with cobalt blue (Table 1, 0203); whereas in "The Fountain" it seems to be mixed with Cerulean blue (Table 4, 0203). The only blue colour with a single blue pigment found so far, is a light blue in "The Fountain", where the tint seems to contain cobalt blue and zinc white (Table 4, 0202). Green: Emerald or Scheele’s green was also found among the green colours: In "Chemistry" it was mixed with chrome green (Table 1, 0303, 0304, 0307); in "The Fountain" it appears as a single green pigment (Table 4, 0303). In the latter painting, also a single green earth pigment was apparently used (Table 4, 0304).

Chrome green is present in the other greens: In "Chemistry" and in "Harvesting Women" it is mixed with copper green (Table 1, 0301, 0302, 0305, Table 3, 0303); in the latter it is also mixed with some iron (Table 3, 0302, as well as with cadmium yellow; and with vermilion. Table 3, 0301, 0304); in "New Rays" it might be mixed with strontium chromate and cobalt blue (Table 2, 0301).

Yellows: Cadmium yellow seems to be present in all the yellow colours except one of the yellows in "New Rays" where it only contains chrome yellow (Table 2, 0402). "Chemistry" and "The Fountain" seem to have mixtures of cadmium yellow and vermilion (Table 1, 0401, 0402 and Table 4, 0401). "Chemistry" also displays mixtures of cadmium yellow and chrome yellow (Table 1, 0404-0406). New
Rays” and “Harvesting Women” probably have mixtures of cadmium yellow and vermilion (Table 2, 0401 and Table 3, 0401). “Harvesting Woman” seems to be the only painting in which cadmium yellow is mixed with yellow ochre \(^7\) (Table 3, 0403); as well as cadmium yellow being the only yellow pigment in another yellow colour in the same painting (Table 3, 0402).

Yellowish reds: Few colours can be characterized as yellowish red. None of them seems to be displayed in “The Fountain”. In “Chemistry” the yellowish red is a mixture of cadmium yellow, possibly chrome yellow and vermilion (Table 1, 0501); in “New Rays” it contains vermilion, cadmium or chrome yellow (and maybe some cobalt blue. Table 2, 0601); and finally, in “Harvesting Women” it seems to be a mixture of cadmium yellow, vermilion and perhaps an ochre \(^8\) (Table 3, 0601).

Reds: Vermilion is probably present in all the red colours except for single organic reds in “Chemistry” and in “Harvesting Women” (Table 1, 0605, Table 3, 0605); as well as in a light red shade with cobalt blue or violet and/or manganese violet together with lead white in the latter (Table 3, 0604).

The other reds in “Chemistry” are either mixtures of vermilion with chrome yellow, with cadmium yellow, with cobalt phosphate, or vermilion is the only individual red (Table 1, 0602, 0603, 0609, 0607 and 0608 respectively). Likewise, in “Harvesting Women”, there is a pure vermilion colour (Table 3, 0603). In addition, both “Harvesting Women” and “The Fountain” mixtures of vermilion and red ochre were used (Table 3, 0601, 0602. Table 4, 0601, 0602). Finally, three red mixtures of vermilion and a cobalt pigment were found: In “New Rays” there is a light red shade (Table 2, 0601); in “The Fountain” there are two: one of vermilion, cobalt blue and maybe manganese violet; the other either contains cobalt phosphate and/or organic red together with vermilion (Table 4; 0601, 0602).

Brownish red: This colour is rare, but it has been used in limited areas on all four paintings. Except for the brownish red hair on the seated female in “Harvesting Women”, three brownish reds have been examined by XRF. They are mixtures of vermilion and other pigments: In “Chemistry it also contains chrome yellow or chrome green (Table 1, 0701); in “New Rays”, vermilion is mixed with pigments of cobalt and copper (Table 2, 0701); and in “The Fountain”, chrome green and an earth pigment as well as cadmium yellow seem to be present together with vermilion (Table 4, 0701).

Browns: Brown has been used only to a limited extent: In “Chemistry”, it is a mixture of vermilion, possibly some chrome green or chrome yellow and potassium (Table 1, 0802); in “New Rays”, it seems to contain vermilion and an organic black \(^9\) (Table 2, 0601); in “Harvesting Women” it might be a mixture of cadmium yellow and an organic black (Table 3, 0801); and finally, in “The Fountain”, vermilion and an earth pigment are suggested.

Blacks: None of the paintings have colours that can be characterized as black (or dark shades of grey).

Whites: Except for large areas of exposed white ground and some limited areas of local white underpaints (see above), all paintings have additional white colours: In “Chemistry”, “Harvesting Women” and “The Fountain” there are whites that seem to be mixed with small amounts of red or blue pigments (Table 1, 1002, Table 3, 1003 and Table 4, 1003). The three latter ones also seem likely to have white colours that could contain white pigments only (Table 2, 1001, Table 3, 1001 and Table 4, 1003). So far, lead white and zinc white are the only white pigments suggested for the white and the light shades of mixed white applications above the ground (Tables 1-4).

Flesh colours: All humans are depicted with multicoloured contours, light highlights, a few middle tones and shadows, with the bare ground as their main component (Tables 1-4).
Discussion
Supports
Tøjner has found two statements on the Aula canvases among some of Munch’s own notes: “I had the best canvas brought from Holland” followed by: “They are painted on Block-Brussel, huge canvases which were unobtainable after the war”. Maybe, the artist wanted to stress that he had used high quality material only. He did not mention whether the canvases were made of linen or hemp. Usually, the latter was darker, stronger and less expensive than linen. Since Munch spent seven years on the whole room decoration including the large number of painted drafts, he presumably bought canvas on more than one occasion. His supplier(s) could also have changed the assortment during the same period. This might be some of the reasons why the eleven Aula paintings are made of canvases of both twill and tabby weave.

As mentioned above, all the four paintings contain twill canvases throughout. In addition, “New Rays” and “Women Harvesting” share the fact that their vertical seam between their two pieces of canvases is located along the middle of their motifs. The other two have their seams somewhat further to the right of the middle of their motifs, although at “Chemistry” a bit less than “The Fountain”, and only with a difference of just a few cm.

Due to the substantial height of the paintings, in all likelihood the vertical canvas threads represent the warp and the horizontal ones the weft. The average numbers for warp vary from 12.7 to 14 and the average for wefts vary from 12.4 to 13.9. Taking into account that these eight pieces of canvases cover c. 40 m² and that their total length all together is c. 36 m, such variations might be considered to be too small to be of any important significance. It is worth mentioning, however, that except for a minor difference in the average numbers of weft in the two canvas pieces in “New Rays” (13.1 and 12.7), each of the four paintings contain almost identical pairs of canvas density. In addition, none of the paintings share the same average number of threads pr. cm².

Ground and colours
The present study could not reveal any significant differences in the four grounds. Below the dirt layer accumulated during the last thirty-five years, the grounds appear to have the same white colour, they seem to have been applied with similar thickness, and they contain the same inorganic elements. According to Munch’s notes he used oil colours for easel painting from Windsor and Newton when he executed his Aula-paintings. Munch also mentioned his usage of turpentine with no explanation beyond calling it: “in his own distinctive manner.”

Above the ground and the underdrawings, the surface characteristics of the four paintings in question bear no signs of other materials than oil colours. Their colours also share many of the same application techniques and successions, the majority of pigments and some more or less similar mixtures of pigments. The only technical difference found so far, is the local white underpaints in “New Rays”.

Original appearance
Originally, the paintings were mounted on to stretchers (or strainers), and remained in this state for more than twenty-four years. A canvas painting that is fastened on to a stretcher looks different when glued on to an additional, rigid support. Solid mountings will lend the appearance that the motif has...
been painted directly onto a solid wall, especially when seen from a distance. Munch did make a point of this issue himself when he wrote that he had produced the Aula motifs as easel paintings in the same way as all other easel paintings that he ever made.\(^9\)

At present, there are no known photographs or reports that clearly and with precision demonstrate the manner in which the paintings were installed in the Aula in 1916.\(^9\) Some of the photos taken by the photographer O. Verring can be dated to the same year, e.g. this black and white picture of "Women Harvesting" (ill. 27).\(^2\) The photo does not reveal the installation of the painting; it shows, however, that the motif was surrounded by a thin and somewhat rounded frame. The reflections of light visible on the frame suggest that it was covered by a metal foil, or that it was made of solid metal. Anyway, any frame of this type would support the impression of a flexible canvas being stretched.

The latest cleaning tests reveal that both the exposed ground and the colours look very different below the accumulations of air-born dirt, the random splashes of paste and the darkened overpaints along the edges of the paintings. The dirt pollution on the painted surfaces obscures the original variations of saturation and gloss from matt ground to shiny tints. Equally, the soiled condition masks the fact that these paintings never have been varnished.

Below the dirt and the non-original materials the colours are still lighter, brighter and their contrasts are more striking than what ordinary viewers can observe.\(^3\) The light colours appear to have been more affected than the darker ones. On a general level, the non-original materials on the paintings obscure Munch's depiction of the effect of the Nordic sun on a bright summer day, bathing the coastal landscapes and the figures within it with a sparkling light.

Conclusions

In the case of "Chemistry", "New Rays", "Women Harvesting" and "The Fountain" Munch used twill weave canvases of minor variations; white grounds contain zinc, lead and chalk; greyish black underdrawings of organic material; and colour applications of similar chronology. In all, the XRF-analysis indicates that the various mixtures of colours might contain at least eighteen individual pigments.\(^4\)

The findings of this preliminary study do not support the previous arrangement of these four accompanying paintings into two related pairs. On the contrary, their materials and techniques show more similarities than differences in the artist's choice of execution. Still, the forthcoming examination of the other four side panels\(^5\) may reveal other technical features that are more suitable for suggestions on chronology and group order amongst the eight lateral motifs.

Acknowledgements

Dr. Jillean Nadolny and Dr. Hartmut Kutzke for valuable comments and suggestions to the text.
References

1. Apart from Munch's first large scale decorative project in 1896 for the hallway in the "Franzebrøten" villa at Sandvika (outside Oslo), which consisted of a single painting only. Berman 1989: p. 94, 95, 106. The painting was commissioned to occupy a trapezoidal space beneath the rafters in the room, but was removed from the house in 1938. Tucker and Penn 2005: p. 48


4. In 1934, the Freia Freeze was moved to another dining hall in another building at the Freia factory. Rolfsen 1955 (not paginated)

5. Froyssaker 2007: p. 247

6. "Chemistry" was measured manually from a scaffold in 2007. The measures include the zinc stripes added in 1946.

7. The other three accompanying paintings were measured from the Aula floor in 2007 by means of a theodolite Leica TPS1203. They also include the zinc stripes, and thus the exact measures cannot be determined before all paintings are detached from the Aula walls.

8. The report contains no information on the examination methods. Wiik 1973

9. Wiik 1973

10. Three paintings have 12 x 12 threads pr. cm², and "Women Harvesting" has 13 x 12. Wiik 1973

11. Wiik 1973

12. "The Fountain": Thin and lean paint with areas of bare ground. Pastose and opaque paint was found only in one head (of the left figure). The figures are modelled with transparent flesh colours towards light and shade, including full outlines. The landscape is made by transparent, hatched strokes. "Chemistry": Mainly as "The Fountain", except that the areas around the two main figures have fewer hatched strokes. "Women Harvesting": In general, the colours were applied
in lean, short strokes with some pastosity. Main parts of figures and landscape contain bare ground. The figures have full outlines. The modelling of forms is made by sparse hatchings in lean, short strokes with some pastosity. Main parts of figures and landscape contain bare ground. The figures have full outlines. Their surrounding environment contains tints and lines of thin, aminations). Three of the cleaning campaigns involved structural treatments: In 1926, the original stretchers were replaced by new ones; in 1940, the paintings were cut down and the outer edges of their motifs and their tacking edges were lost; in 1946 the paintings were glued on to Masonite boards. Frøyaker 2007: pp. 249-250, 252

13 The paintings will be reinstalled in the Aula before the 200 years anniversary of Oslo University in 2011.


17 Wiik however observed some de-laminations during the cleaning of 1973. Personal communication with Svein A. Wiik, 2007.

18 Froysaker 2007: pp. 11-17

19 Froysaker 1993: pp. 11-17

20 Froysaker 2007: pp. 234-237

21 When the present examination of the entire Aula decoration is finished, selected sampling for cross-sections will take place. Intended analysis methods are: SEM-EDX, FTIR and micro-XRD. During the first week of July 2008, “Chemistry” and “Women Harvesting” was examined by MOLAB with their non-invasive equipment, but this is yet to be published.

22 The function of these zinc strips was to cover the gap between the marble wall and the painting.

23 And by the use of the laboratory microscope

24 For the history on previous treatments see Froysaker 2007 and 2008 (l)

25 The raised nails are also visible in ordinary light because they have accumulated more dust than their surroundings. In 1943, Jaensson reported that he had thirty-five year of experience in the field of painting restoration and that he had used Masonite for the last twelve years. He described his lining onto Masonite by the use of low heat and light pressure. The iron shall be moved around back and forth in a careful manner over several layers of soft paper above the painted surface without the flattening of brushstrokes. He also added that the Masonite could be removed as easy as a cardboard disk. In Swedish: “Men en rentoilering skall icke ske med hårda tryck och stark varme, utan med svag värme och lätt hand. Järnet skall försiktigt föras fram och åter över tavlan och flera lager mjukt papper bör under styrningen skydda penseltagen i färghinnan från att plattas till [...] Masoniten kan avspjälas i skikt lika lätt som en pappskiva.” Jaensson 1943

26 Froysaker 2007: pp. 8, 16

27 Froysaker 2008(iii): p. 8


29 Tojnert 2000


31 The scaffold had to be small and easily removable since it could be moved around by a single person.

32 Underneath “New Rays” and “Women Harvesting” there is a stage floor which is 50 cm higher than the lower floor underneath the two other paintings. The extent of examination of the latter two was restricted accordingly.

33 The planning for the building renovation necessitated access to the brick wall behind the painting. Frøyaker 2008(iii): p. 8

34 The XRF (a handheld Niton XLt1880DHeW) with Helium flush can detect elements from Mg (12) to U (82): www.niton.com/Default.aspx (August 2008)

35 The Artist PRO camera: www.art-innovation.nl (August 2008)


37 Ferretti 1993: pp. 11-17

38 Ferretti 1993: pp. 11-17

39 Stuart 2007: pp. 234-237

40 The present survey of the painted surfaces also revealed some small areas of flattened impasto. Usually, this is regarded as a damage caused by exaggerated pressure and heat during lining. In this case however, the flattened impasto can also be a result of the artist’s own handling: When freshly painted, Munch must have transported them on rolls between his studios and the Aula. In addition, only twenty-four years after execution the paintings were kept on rolls for at least five years during the Second World War.

41 During a year, the relative humidity fluctuates between 8 to 80 %. Frøyaker 2008 (ii): p. 12

42 Rod 1997: p. 59


44 UV-lamp examinations on “History” and “The Sun” revealed green fluorescence in a few limited areas. This indicates a possible varnish of natural resin.

45 Or the hems were cut away prior to the lining onto Masonite.
Literature and unpublished reports

- Berman 1989
  Berman, Patricia Gray: Monumentality and historicism in Edvard Munch's University of Oslo Festival Hall Paintings, New York University, New York, 1989 (= unpublished PhD dissertation, New York University)

- Bomford et al. 1999
  Bomford, David; Kirby, Jo; Leighton, John and Roy, Ashok: Art in the Making: Impressionism; Yale University Press, New Haven and London 1990

- Bøø 1986
  Bøø, Alf: Edvard Munch and his Art after 1900; in: Scandinavian Review, Spring 1986; pp. 19–32

- Dørje Haug 1945
  Dørje Haug, Olei: Munchs Aula-bilder reddet fra eksplosjonen; in: Dagbladet, 14.11. 1945

- Eastaugh et al. 2004

- Ferretti 1993
  Ferretti, Marco: Scientific Investigation of Works of Art; ICCROM, Rome 1993

- Freysaker 2007

- Freysaker 2008 (I)
  Freysaker, Tine: Bevaring av Edvard Munchs Aulamalerier før og nå; in: Kunst og Kultur, 2008; pp. 2–17

- Freysaker 2008 (II)
  Freysaker, Tine: Konserveringsstudiers Aulaprosjekt; in: Norske Konserves NKF-N, 2008; pp. 7–9

- Hougen 1962
  Hougen, Pål: Langaards og Revolds bok om Aula dekorasjonene; in: Aftenposten 16.06. 1962

- Jaenson 1943
  Jaenson, Gustav: Bilaga från konservator vid nationalmusei nämnds sammanträde onsdag den 29 september 1943; dated September 28th 1943; Stockholm Nationalmuseum arkiv, Stockholm (unpublished report)

- Lundmark 1917
  Lundmark, Ephraim: Edvard Munchs vägsmälningar i Kristiania universitet och nutida norsk konst i Stockholm; in: Konst, 1917; pp. 12–17

- Mecklenburg 2007
  Mecklenburg, Marion F.: Micro climates and moisture induced damage to paintings; in:


- Mohr 1960
  Mohr, Otto Louis: Edvard Munchs aula-dekorasjon i lys av ukjente utkast og sakens akter; Gyldendal norsk forlag, Oslo 1960

- Rolfsen 1955

- Rød 1997

- Schaefer et al. 2008

- Stuart 2007

- Svensøs 1953
  Svensøs, Gösta: Idé och innehåll i Edvard Munchs konst. En analys av aulamålningarna; Gyldendal norsk forlag, Oslo 1953

- Thumann-Moe 1963

- Topalova-Casadio
  Topalova-Casadio, Biljana: De to malte versjonene av Skrik; in: Skrik; Munch-Museum, Vigmostad & Bjørke AS, Oslo, Bergen 2008; pp. 87–99

- Tucker and Penn

- Tejnner 2000

- Wiik 1973

- Wiik 1986
The measures include the zinc stripes. The numbers are not exact because the canvas seams are irregular; it is very unlikely that a ruler was used when the paintings were cut down in 1940.

Since all weaves differ in density throughout, the counting of threads was performed at least three times or more in different places on all eight textiles to find an average for each piece of cloth.

The first numbers represent the horizontal threads and the latest the vertical ones.

Mecklenburg 2007: p. 20

In “Alma Mater”, all exposed areas of bare ground have bare knots in the canvas weave due to sanding.

Preliminary drawings in other colours were found in the contemporary “Scream” owned by The Munch-Museum.

“De er malte på Blok-Bryssel kempelerred og som efter krigen ikke mer er at få”. Tojner 2000: p. 163

From the 1840s, also hemp was recommended for large size paintings. Bomford et al. 1990: p. 46

Fibre origins of the Aula canvases will be identified by microscopy subsequent to their forthcoming evacuation.

Manganese violet (\((\text{NH}_4)_{2}\text{Mn}_2(\text{P}_2\text{O}_7)\) is suggested where the XRF indicated manganese and phosphor. Eastaugh, et al. 2004: pp. 95, 96

“Billederne er malt som alle mine billeder [...] som staffelmalerier.” Tojner 2000: p. 162

Because it belongs to a group of similar photos which shares some of the same features as the photos in a contemporary Norwegian journal called ‘Arkturkt og Dekorativ kunst’ 8’, 1916: pp. 129-134

For other examples on the effect of dirt on an Impressionist painting see Schaefer et al. 2008: pp. 188-189, 202-203

The XRF-analysis suggested the following pigments: Manganese violet, ultramarine, Prussian blue, cobalt blue, Cerulean blue, Emerald or Scheele’s green, chrome green, green earth, cadmium yellow, chrome yellow, yellow ochre, vermillion, organic red, red ochre, organic black, lead white, zinc white and chalk.

“Women Reaching towards the Light”, “Men Reaching towards the Light”, “Awakening Men in the Food of Light” and “Spirits in the Flood of Light”.

Even a contemporary Norwegian novel from 2007 refers to the Aula paintings as frescos: In Henrik H. Langeland’s book entitled “Francis Meyers lidskap”, the author lets the guest lecturer (Umberto Eco at page 384) use the word fresco by saying: “Og quanto vi j eg takka det store geni Eduardo Munch for disse praktfulle freskene!”
The problem of surfaces containing acrylic paint – Part 1: Background information about the resistance of acrylic paint

The first part of the article summarizes the history and composition of acrylic paint. Different surfaces of oil and acrylic colours are presented. The cleaning of surfaces containing acrylic paint is very difficult due to their complex composition, and grime and dirt are a greater hazard to soft and sticky surfaces containing acrylic paint than to surfaces composed of oil colours. The application of the painting technique and different mixtures and additions to acrylic paint by the artists can disturb the drying process and affect the lifetime and resistance of the vulnerable surfaces. It is not possible to adapt cleaning techniques, which are successful on oil colours to acrylic paints because the latter react more sensitively to every dry and wet surface cleaning.

Keywords: surface cleaning, binding systems, artist paints, resistance and composition of acrylic paint, paintings, varnish, 3D examination, 3D profiles, MicroCAD

Tine Frøysaker and Mirjam Liu
Vier (von elf) ungefärbten 6lgemälden auf Leinwand von Edvard Munch in der Aula der Universität Oslo – Erste Notizen zu ihren Materialien, Techniken und ihr ursprüngliches Aussehen


Keywords: optischer Befund, tragbare Röntgenlampe, Untergrund, Grundierung, Unterzeichnungen, Pigmente

Abstracts

page 30
Paul-Bernhard Eipper

The problem of surfaces containing acrylic paint – Part 1: Background information about the resistance of acrylic paint

In conclusion an attempt is undertaken to further examine the aesthetic-theoretical effects of this reproduction on the museum- and exhibition-business as well as on aesthetics and art history and the science of conservation. Those effects are to be expected in the light of the opposition »original-reproduction«, which up to the present day excludes itself, as well as of Walter Benjamin’s essay »The work of art in the age of mechanical reproduction«.

Keywords: San Giorgio Maggiore, digital high-tech copy, facsimile, Veronese, Wedding at Cana, Factum Arte, Adam Lowe, 3D scanning, photo-scanning, colour matching, print, Walter Benjamin

page 44
Tine Frøysaker und Mirjam Liu

Vier (von elf) ungefärbten 6lgemälden auf Leinwand von Edvard Munch in der Aula der Universität Oslo – Erste Notizen zu ihren Materialien, Techniken und ihr ursprüngliches Aussehen


Keywords: optischer Befund, tragbare Röntgenlampe, Untergrund, Grundierung, Unterzeichnungen, Pigmente

Weitere Termine finden Sie unter www.restauro.de

Januar 2009
Kurs »Sanierungsmöglichkeiten bei feuchte- und salzbelastetem Mauerwerk«
20. 01. 2009, Fulda
Veranstalter und Info: Propstei Johannisberg GmbH, 36041 Fulda, Tel. 06 61/9 41 81 3-0, Fax -15, info@propstei-johannisberg.de, www.propstei-johannisberg.de

Vorlesung »Die Kunstversicherung und die Relativität der Werte«
21. 01. 2009, Kassel
Veranstaltungsort: Kunstschule Kassel, Hörsaal, Menzelstraße 13 (Eingang A), 34109 Kassel, (19 Uhr)
Info: ulli.seegers@uni-kassel.de, www.kunstschule-kassel.de

Workshop »Partielles Färben von Protein- und Cellulosefasern«
23.–24. 01. 2009, München
Veranstaltungsort: Textilatelier Bayerisches Nationalmuseum, Oettingenstraße 15, 80538 München
Veranstalter und Info: VDR, Fachgruppe Textil Ansprechpartner: Cornelia Hornig, Schweizerisches Landesmuseum, Lindenmoosstraße 1, CH-8910 Affoltern a. Albis, Tel./Fax 00 41/44/76 21-3 85, carolin.hornig@sim.admin.ch

E-learning-Kurs »Conservation of Globes«
26. 01.–22. 03. 2009
Sprache: Englisch