PERSPECTIVE

Zinc, Paint loss and Harmony in blue

Degradation problems in Peder Severin Krøyer’s paintings and the possible role of zinc white.

Summary

P.S. Krøyer’s late and most popular paintings have proven very difficult to preserve, and as zinc white has been known to cause structural problems in paintings, the authors investigate if the damage seen in the late paintings can be related to the use of this relatively new pigment. Eight paintings were examined and the results suggest that the shift from using one white pigment to another took place between 1884 and 1889. After 1889, only zinc white was found in the analyzed paint layers. However, the results indicate that the recurring damage in Krøyer’s later paintings cannot be explained by the presence of zinc white alone.

Introduction

Peder Severin Krøyer (1851-1909) was a leading naturalistic painter in Denmark in the late 1800s. Conservators have reported extensive problems with his paintings in conservation reports and condition surveys, which suggests a connection between his painting technique and the reported mechanical damage. Despite this, very little research has been done into the media and painting techniques of Krøyer, nor is a thorough investigation of the preservation of his paintings available.



Fig. 1. Cecil Krarup Andersen and Elizabeth Baadsgaard investigate P.S. Krøyer's *Fishermen hauling a net at Skagen's Northern Beach. Late afternoon.* (1882-83). Skagens Museum, inv. no. 1486. Photo from Skagens Museum during the conduction of some of the analyses mentioned in this article.

New art historical research on Krøyer's late paintings was published in 2001 when Skagens Museum celebrated the 150th anniversary of Krøyer's birth with an exhibition focusing on his late works. The central idea of the exhibition was to place the paintings in a broader artistic – and international – context. The display came in the wake of a general art historical and public interest in Krøyer, which a number of publications and various forms of dissemination illustrate.[1] The exhibition was followed by the 2011-2012 exhibition *Krøyer – an international perspective* shown at The Hirschsprung Collection and Skagens Museum. This exhibition and an accompanying comprehensive publication presented the outcome of further art historical research into the artist and his European connections and sources of inspiration.

During preparation for *Krøyer – an international perspective* conservators from Kunstkonserveringen (The Art Conservation Center, known then as Fælleskonserveringen, in Aarhus) surveyed approximately 130 works by Krøyer, and found recurring damage phenomena in several of his paintings from the 1880s and 1890s. The 1893 painting *Summer Evening on Skagen's Beach* was examined by The National Museum of Denmark in collaboration with Kunstkonserveringen in 2005 to identify why the paint was adhering poorly to the ground.[2] The many tiny losses observed could not be easily explained but attention was drawn to sand grains found in the paint, which were approximately the same size as the losses. The fact that the paint layer contained zinc white was not mentioned as a possible factor in the damage found. Considering the increasing focus on the possible side effects of zinc in oil paint,[3] this study sets out – using non-invasive in situ techniques – to investigate the presence of zinc white and its possible role in the degradation of Krøyer's paintings. [fig.1]

This article will focus on P.S. Krøyer's paintings from the 1880s and 1890s by adding an interdisciplinary technical perspective to the art historical focus of recent years.[4] The ambition is that of identifying and understanding the types of damage phenomena that have proved recurrent in the paintings of the period. These observations of damage and its extent will be described and compared to Krøyer's use of pigments with a particular focus on white pigments.

The preservation state of Krøyer's paintings

Two types of deterioration are dominant on Krøyer's paintings from the 1880s and 1890s; problems that are both related to delamination between the ground layer and the thin and brittle paint layers.

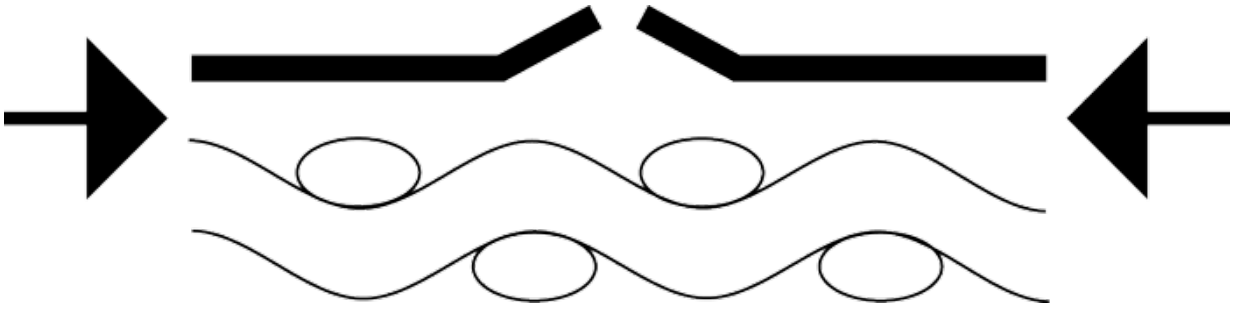


Fig. 2. Shrinkage in the canvas compresses the paint and causes it to rise in tent-like formations.

The first type of deterioration can be described by the term 'tenting'. This phenomenon is characterized by a lifting of the paint and ground layers in the form of a triangular tent, when seen in profile, due to compression caused by dimensional changes in the underlying canvas support. [fig.2]

Because of this compression, there is little or no space for the paint layer to return to its original position. It has been shown that these formations are not only the result of the propensity of the canvas to shrink, but are also related to the properties of the preparation layers, that is, the glue and ground layers applied to the canvas before design layers are added.[5]

The tent formations on Krøyer's paintings are typically the same width as the threads in the canvas weave and most frequently occur parallel to one of the weave directions. Tenting can cause loss of paint, which usually follows the pattern of the canvas weave. [fig.3a and 3b] In some cases, the paint layer seems to be wrinkling as if it is too big for the support. Tenting as described here is seen in many colour are as, but it seems to be more frequent in light colours such as the large blue areas in the beach and fishermen motifs of the artist's paintings from the 1880s onwards.

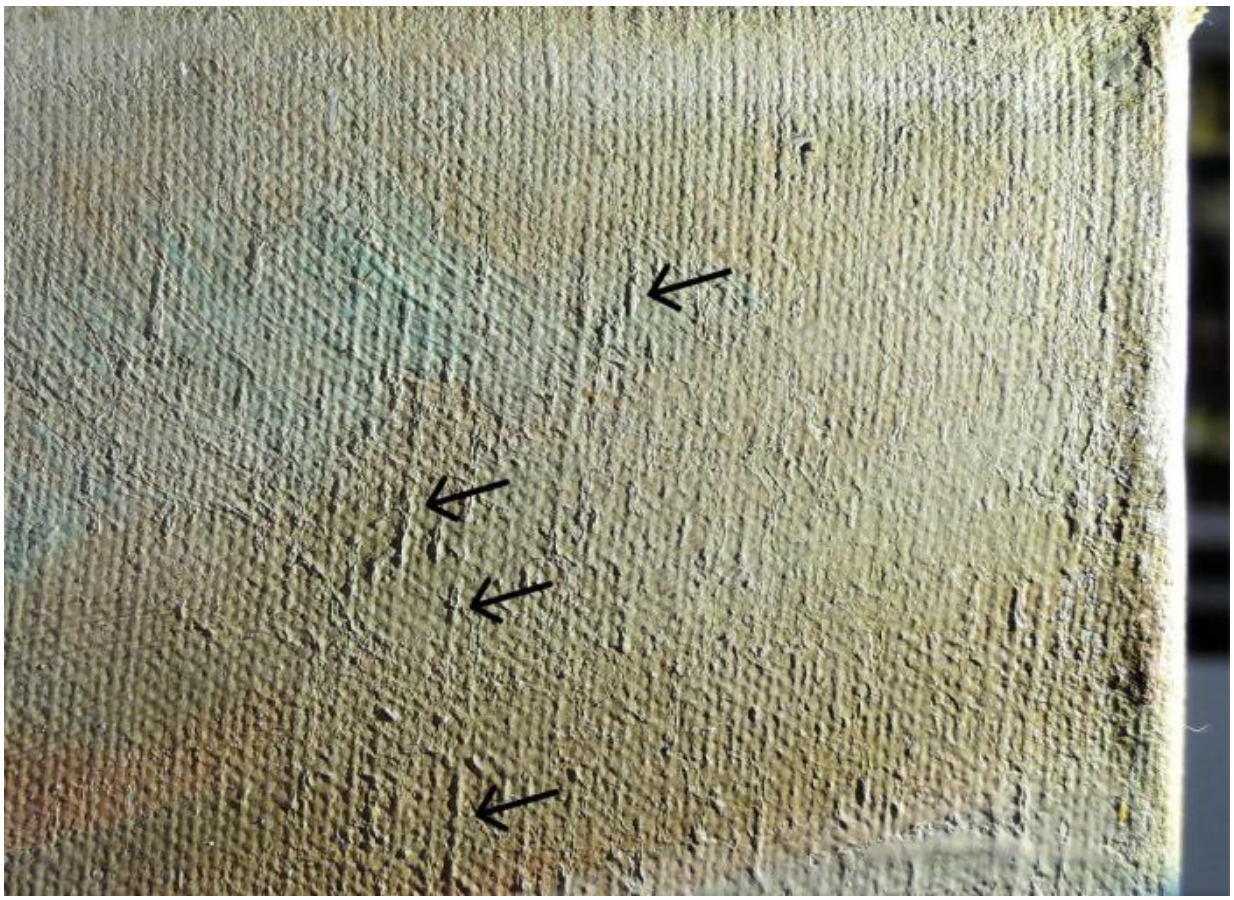


Fig. 3b. Close up of fig. 3a, P.S. Krøyer: *By the fireside. Portrait of Holger Drachmannin a red fez*. Skagens Museum. Photo in raking light from the upper right corner. The painting shows tenting (marked with arrows), which causes small losses in the paint layers. Photo: The Art Conservation Centre 2005.



Fig. 3a. P.S. Krøyer: *By the fireside. Portrait of Holger Drachmann in a red fez*. 1903-07. Oil on canvas. 106,2 x 146 cm. Skagens Museum, inv. no. 1710. Photo: Art Museums of Skagen.

The second type of deterioration observed is minute, but extensive, losses in the paint layer due to poor adhesion between the paint and ground layers. [fig. 4a and 4b] These losses, which are observed in all colours, can occur without visible crack formation or lifting of the paint layer, which are otherwise commonly connected to the occurrence of paint loss. The extent and amount of the losses varies from one painting to another. Both tenting and minute losses have been observed in a number of paintings from the *Krøyer – an international perspective* exhibition, but seem to be found less often in Krøyer's early paintings and in his painted sketches on canvas.

The artist's travels and the hunger for knowledge of materials

A cosmopolitan at heart, Krøyer kept himself apprised on international developments throughout his career. After his first journey to Berlin in 1875 he went abroad every year, with very few exceptions, with the objective of improving his painting skills.[6] He found inspiration in Old Master drawings and paintings, both in his younger years at the Academy of Art in Copenhagen and later on travels abroad.[7] In particular, he obtained skills in colour rendering and painterly techniques as a pupil at Léon Bonnat's school in Paris (from the summer and into the winter of 1877).

Due to the increasing industrialization of the production of painting materials in the 1700s and 1800s, direct knowledge of materials and their properties was no longer available to artists in the period in which Krøyer and his contemporaries painted. This knowledge was no longer taught at the art academies, which meant that artists had to obtain it elsewhere.[8] Krøyer's many travels abroad may be seen in this light; this longing for inspiration was perhaps not so much a departure from existing tradition as a simple need to learn about new painting materials and how to use them.[9]

A new white

Lead white had for centuries been the only white pigment that could be used in oil paint, but in 1780 an initial attempt was made to introduce the zinc oxide (ZnO) as a substitute for the highly toxic lead white. Due to economic reasons, however – zinc white being four times more expensive than lead white – this initial attempt was unsuccessful. There was also a difference in the properties of the two pigments in oil: zinc white had a clear white colour and better suspension properties, while lead white had better hiding power and drying attributes. After several attempts in France between 1835 and 1844, the hiding power of the zinc oxide pigment was improved and siccatives were introduced to improve the drying properties of the pigment in oil. As zinc manufacturing methods improved, the cost of zinc oxide decreased, and zinc white pigment became gradually more popular within the artist community. Even though zinc white was known since the Middle Ages, it was rarely used as a pigment before the 1830s. There are reports of the use of zinc white by several of Krøyer's contemporaries in France, including Vincent van Gogh, Paul Cezanne, Édouard Manet and Camille Pissarro.[10]



Fig. 4a. P.S. Krøyer: *Summer evening on the beach at Skagen*. 1899. Oil on canvas. 135 x 187 cm. The Hirschsprung Collection, inv. no. 234. Photo: public domain, The Hirschsprung Collection.

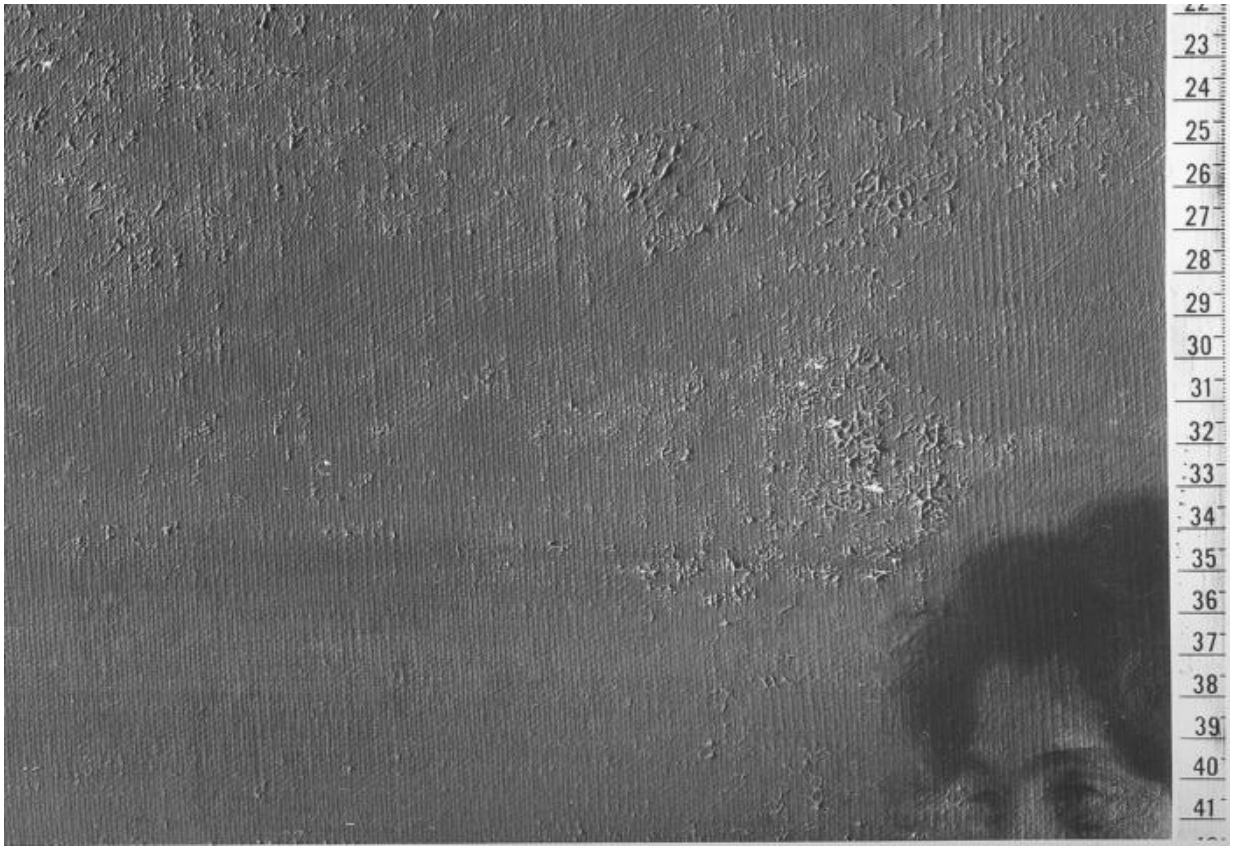


Fig. 4b. Detail of fig. 4a, P.S. Krøyer: *Summer evening on the beach at Skagen*. The Hirschsprung Collection. Before conservation in 1983 (raking light) showing an area with paint layer lifting and numerous minute losses.

Skagen and the light

The pursuit of light was a recurring theme for Krøyer and his international contemporaries. Krøyer travelled to Skagen for the first time in 1882 and his rendering of the evocative twilight blue seems to reflect the myth of a special Skagen light. In fact, he was one of the first to mention a particular light in Skagen,[11] but the suggested theory of an exclusive meteorological phenomenon has been effectively refuted.[12]

In 1889, the newly-wed Krøyer and Marie (née Triepcke, 1867-1940) travelled from Germany to Denmark and then to Italy for their honeymoon. Prior to their return to Skagen in 1890, Krøyer re-furbished his studio readying it for the work he had planned while abroad. In a letter, he requested that the walls of his studio be painted white as he wanted to work using "an entirely new method".[13] He does not explain this new method further, but it can probably be seen as a continuation of his striving to convey a sense of brightness and sun on the canvas.[14] Krøyer's blue beach paintings from the 1890s mark a shift in his colour scheme. Although he had always worked with the rendering of light through the use of colours, in his later beach paintings he shows a special interest in brighter and lighter colours.[15] The sea at Amalfi, one of the places he and Marie visited on their honeymoon, has been named as Krøyer's first big inspiration for paintings dominated by sea.[16]

The difficult task of preserving Krøyer's late canvas paintings

The archives of Kunstkonserveringen contain conservation treatment records from 1978 up to the present. According to the archival material, 74 Krøyer paintings have been treated of which 59 have canvas supports. The paintings date from 1867 to 1909, thus spanning Krøyer's complete oeuvre. Despite a lack of precision in the descriptions of structural damage on the canvas paintings, it is possible to draw some conclusions regarding recurring damage: there are frequent notes reporting weak adhesion between the paint and ground layers, and in addition, twelve records of the 59 state that there are many small losses either locally or all over the painted surface. The conservation

records of Kunstkonserveringen and The National Gallery of Denmark clearly show that water-based consolidants have been avoided for the structural treatment of Krøyer paintings. Conservators are aware of the shrinkage risk associated with these paintings; an awareness that is based on both practical experience as well as knowledge of the negative effect of water treatments on canvas paintings from the 1800s in general.[17] Thus, the files generally show that lining with a mixture of wax and resin was preferred for these paintings up until the 1970s when the conservation praxis changed towards consolidation with an acrylic polymer in solvent instead of lining.[18]

Many of Krøyer's late paintings tell us a story of repeated structural conservation treatments that appear to have had little positive effect on the stability of the paintings over the long term.[19] The 1983 conservation report on the painting *Summer evening on the beach at Skagen*, 1899, states that the paint is falling off in tiny pieces. This is particularly the case in the upper part of the painting, which is dominated by the blue sky and sea. [fig. 4a og 4b] This painting had to be impregnated six times with the acrylic binder Plexisol before the paint was considered reattached. [see table 1]

Table 1 and 2

No.	Museum Inv. no.	Title	Date Size	Condition and conservation
1.	Skagens Museum Inv. no. 1595	Fishermen hauling a net at Skagen's Southern Beach	1882 85 x 96.6 cm	Good condition. Not lined.
2.	Skagens Museum Inv. no. 1486	Fishermen hauling a net at Skagen's Northern Beach. Late afternoon	(1882-1883) 135 x 190.5 cm	Tenting in areas of different colors. No recorded structural conservation treatment.
3.	National Gallery of Denmark Inv. no. KMS1233	Fishermen at Skagen Beach. Late summer evening	1883 148 x 202.5 cm	Poor binding between paint and ground. Larger and smaller losses in the sky. A number of fine wrinkles in the paint layer. Strip lined with Plextol D541. Impregnated with Plexisol P550.
4.	The Hirschsprung Collection Inv. no. 3092	Summer day at the South Beach of Skagen.	1884 154,5 x 212.5 cm	No tenting. Good condition. Wax-resin lined (year unknown).
5.	Skagens Museum Inv. no. 978	Marie Krøyer. Stenbjerg	1889 46 x 28.4 cm	Good condition. No tenting. No recorded structural conservation treatment.
6.	The Hirschsprung Collection Inv. no. 217	The beach at Amalfi. Boys bathing	(1890) 28,8 x 48.4 cm	Wax-resin lined twice, including in 1988 due to flaking and loss of paint. No tenting found.
7.	Skagens Museum Dep. no. 2 (Deposit from Ny Carlsberg Glyptotetek, Inv. no. MIN0905)	Summer Evening at Skagen	1892 206 x 123 cm	Tenting in all colors. 1968: Lined with wax and dammar. 1982: Plexisol P550 impregnation and heating under pressure. 2000: Partial consolidation of paint with Plexisol P550. The paint layers are still not adhering well to the ground.
8.	The Hirschsprung Collection Inv. no. 234	Summer evening on the beach at Skagen.	1899 135 x 187 cm	Colour losses in tiny fragments. 1983: Plexisol impregnated 6 times. Lined with Plextol and polyester fiber interleaf.

Table 1. Selected paintings by P.S. Krøyer and their conservation history.

No.	Potential pigments detected based on elemental analysis of the ground and paint layers
1.	Ground: lead white Sky: cobalt blue, lead white Other pigments: chromium oxide green*, iron earth pigment, vermilion, possibly cadmium yellow
2.	Ground: lead white Water: cobalt blue, lead white, iron earth pigment, vermilion
3.	Ground: lead white, chalk Sky: cobalt blue, lead white, (possibly Naples yellow) Water: cobalt blue, lead white, (possibly Naples yellow) Beach: cobalt blue, iron earth pigment, lead white
4.	Ground: lead white, chalk Sky: cobalt blue, lead white, Naples yellow Water: cobalt blue, lead white, Naples yellow Other pigments found: iron earth pigment, vermilion
5.	Ground: lead white Blue dress: cobalt blue, zinc white, chrome oxide green, possibly iron earth pigment Background: cobalt blue, zinc white, chrome oxide green, possibly iron earth pigment
6.	Ground: lead white Sky: cobalt blue, zinc white
7.	Ground: lead white Water: cobalt blue, zinc white Water close to beach: cobalt blue, zinc white, cadmium yellow Other pigments found: iron earth pigment
8.	Ground: lead white Sky: cobalt blue, zinc white, cadmium yellow Water: cobalt blue, zinc white, cadmium yellow, iron earth pigment

* Chrome was detected and most likely comes from chrome oxide green or viridian (chrome oxide hydrate).

Table 2. List of pigments in the eight selected paintings by P.S. Krøyer (see Table 1) based on the chemical elements detected. All of the analyses were done in situ with XRF.

Krøyer’s palette

Given the existence of numerous new industrially-produced painting materials in the 1800s, it is interesting to explore if Krøyer employed these new materials and if the use of new materials had consequences for the paintings’ technical conditions. Of the 130 Krøyer paintings surveyed, eight paintings on canvas from the 1880s and 1890s were selected to be investigated further. [see table 1]



Fig. 5a. P.S. Krøyer: *Summer evening at Skagen*. 1892. Oil on canvas. 206

x 123 cm. Ny Carlsberg Glyptotek, inv. no. MIN 0905, dep. at Skagens Museum, dep. no. 2. Photo: Art Museums of Skagen.

The conservation histories of the eight art works are well documented. Paintings dominated by blue colours were selected in order to simplify the pigment examination, and of the eight paintings five showed or have in the past shown the previously-described damage phenomena in the paint layers (nos. 2, 3, 6, 7 and 8), whereas three were in a good state of preservation (nos. 1, 4 and 5).

The pigments in the eight selected paintings were examined non-destructively using a handheld X-ray fluorescence (XRF) instrument.[20] [fig. 5a og 5b] The results are summarized in table 2. Blue areas were tested on all of the paintings, and in cases where other colours were examined as well, those pigments are also listed in the table. The paintings were either in storage or removed from the wall so that the canvas could be examined. The ground layers were analyzed along the tacking margins, and it was found that Krøyer used white primed canvases. The supports are assumed to be cut from rolls of pre-primed canvas, based on the fact that a smooth, continuous ground layer is present around the sides and the back of the stretcher, and no bare canvas is seen. This indicates that the canvases were not prepared directly on the stretchers. A strong lead signal was found in each case suggesting that lead white is a major component in the ground layer. The same type of ground was found by Mads Chr. Christensen and his colleagues in 2005.[21]



Fig. 5b. XRF analysis of a blue area in the painting P.S. Krøyer: *Summer evening at Skagen*. Ny Carlsberg Glyptotek, dep. at Skagens Museum. See fig. 5a.

The most significant result of the XRF analysis is that sometime in the late 1880s, Krøyer switched from lead white ($2PbCO_3.Pb(OH)_2$) to zinc white (ZnO) in his paint layers. None of the earlier paintings tested contain zinc, whereas all of the later artworks show the presence of zinc. There is

no evidence of a mixture of white pigments in the paint layers. The shape of the XRF spectrum indicates that the lead signal in the later paintings comes from a layer behind the surface (i.e. the ground layer). [fig. 6a og 6b] A single test was performed on a painting with a wooden support, which would not have the prepared lead white layer, and the only element detected that could be attributed to a white pigment was zinc. Christensen et al. found only zinc in the paint layers when they examined cross-sections using SEM-EDS.

Krøyer used cobalt blue ($CoO.Al_2O_3$) in all of the analyzed paintings, and iron was found in several paintings, suggesting the use of iron earth pigments.[22] Chromium was found in greener areas and is likely due to chrome oxide green or viridian (chrome oxide hydrate ($Cr_2O_3.2H_2O$)). Antimony was identified in one early painting (no. 3) and cadmium in several. These two elements are used in the yellow pigments Naples yellow ($Pb(SbO_3)_2$) and cadmium yellow (CdS), respectively. Vermilion (HgS) was found in several of the early paintings, but in none of the later ones. Analyses of red and purple areas in the portrait of Marie Krøyer (no. 5) found none of the inorganic elements usually associated with red pigments, which suggests that Krøyer used organic reds in this painting.

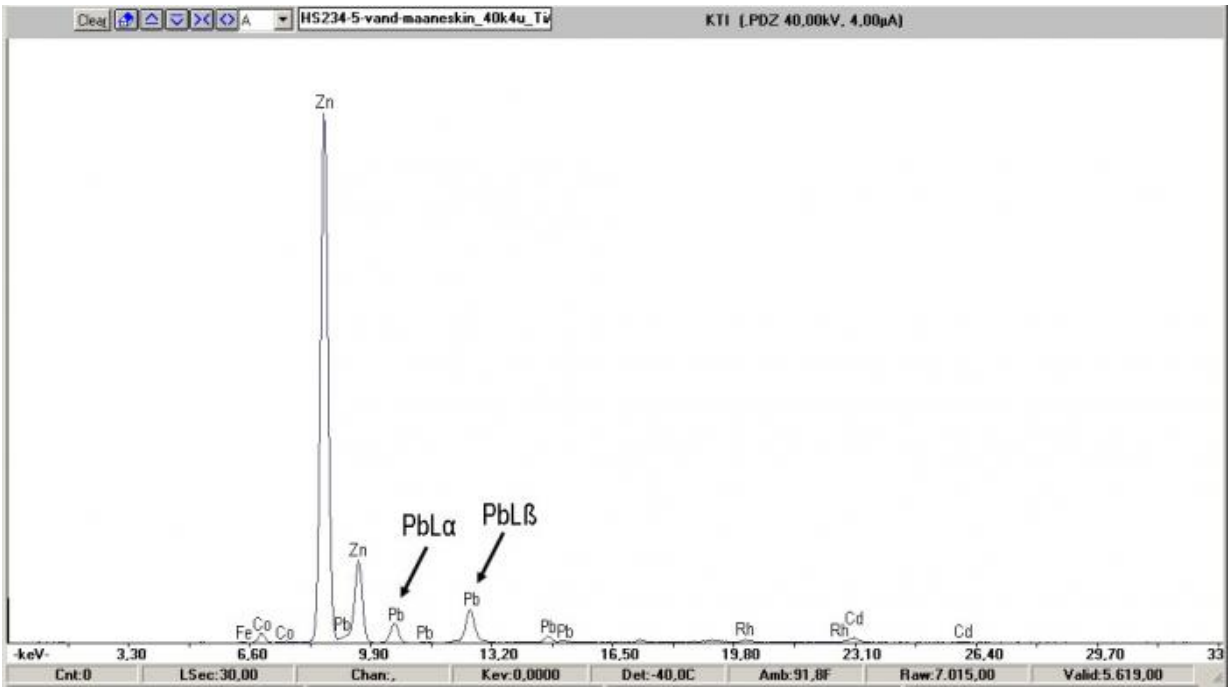


Fig. 6b. XRF spectrum taken in a section depicting water in P.S. Krøyer: *Summer evening on the beach at Skagen*. 1899. Oil on canvas. 135 x 187 cm. The Hirschsprung Collection, inv. no. 234. See Table 1, painting no. 8 (reproduced in the article as fig. 4a). In this case, the lead Lβ peak is higher. This pattern is seen when the lead signal travels through another layer before reaching the detector. The more energetic Lβ x-rays are more likely to penetrate the overlying material, which is the zinc-containing paint layer in this case.

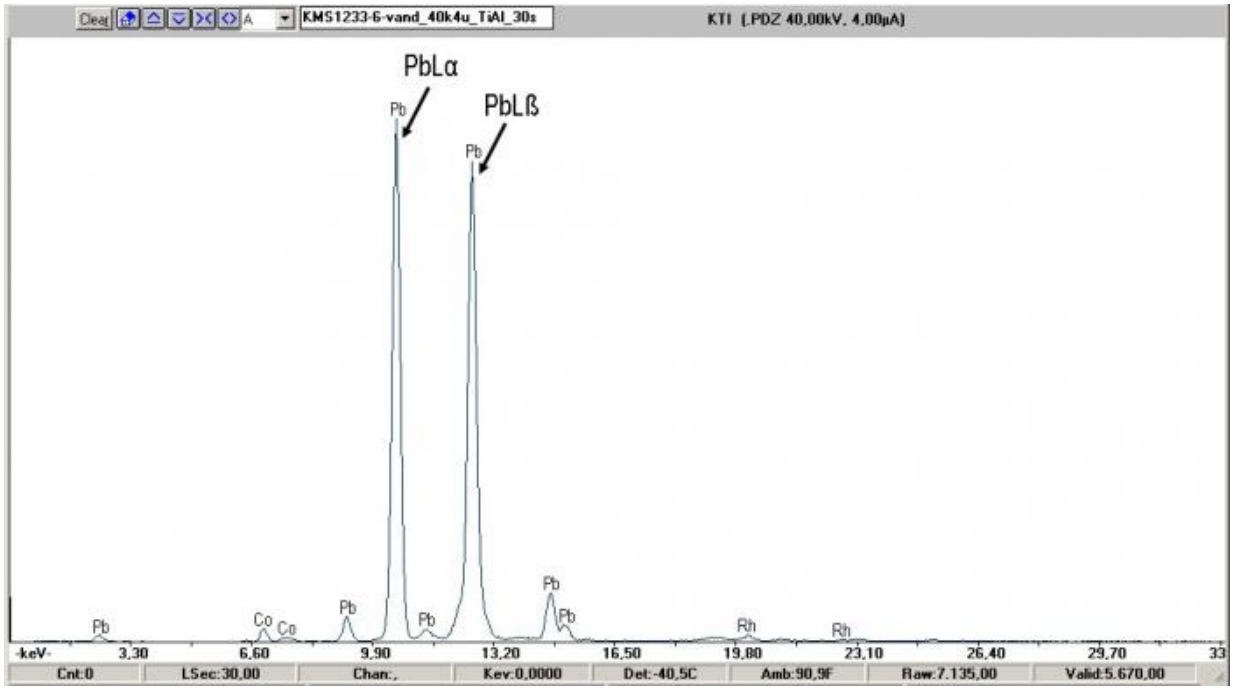


Fig. 6a. XRF spectrum taken in a section depicting water in the painting P.S. Krøyer: *Fishermen at Skagen Beach. Late evening.* Oil on canvas. 148 x 202,5 cm. National Gallery of Denmark, inv. no. KMS1233. See Table 1, painting no. 3. Note that the lead Lα peak is higher than the lead Lβ peak.

Conclusions and future perspectives

Non-invasive in situ analysis of the eight paintings selected for this preliminary study showed that all of the ground layers contained lead, whereas zinc was present only in the paint layers of the investigated paintings made after 1889. The question remains as to when exactly Krøyer started to use zinc white, and the answer is likely to be somewhere between 1884 and 1889. The introduction of this new pigment to Krøyer's palette in the late 1880s could be a result of a familiarity with zinc white obtained while he was in France. He may have wished to take advantage of the properties of this white pigment, as it provides a cooler white tone and he may have wanted to use this quality to convey the light at Skagen in his paintings. Compared to the more opaque lead white, due to its translucency zinc white gives a brilliant and cool hue when mixed with other pigments. This property makes zinc white well-suited for depicting brightness when rendering colour without introducing too much 'whiteness' to the overall colour scheme. Visually the brightness in the colour tone of Krøyer's late beach paintings is likely due to the use of zinc white. Krøyer's wish to redecorate and repaint his studio white after his honeymoon and his mentioning of a new method may be directly reflected in his choice of pigments when he took up his Skagen motifs again.

Krøyer's later palette could be examined further. This initial study found a change in his use of white pigments, but it has not yet been determined whether he altered his palette overnight or whether there was a gradual change between 1884 and 1889. This study also shows that he switched from older yellow and red pigments to newer ones, including organic reds.

Since damage was found in paintings from both before and after this change to zinc white, there is no basis to conclude that the delamination problems in Krøyer's paintings can be explained exclusively by the use of zinc white, though it may add to an already existing problem. The painting formats may also be a matter of concern: smaller paintings seem to be less damaged, but the degree of slackness as well as the potential for shrinkage is greater when the formats are larger. Changing canvas production methods may be a possible explanation for the contractions causing tenting in the paint layers, but as mentioned earlier it is also necessary to look towards possible degradation phenomena in the paint film itself.[23] The small losses may be caused by metal soap formation in the paint due to a chemical reaction between the zinc or lead in the pigments and free fatty acids from

the degraded oil film.[24] However, this still remains to be investigated.

In other words, further studies are needed to provide a more complete explanation for the paint layer damage seen in many of Krøyer's late paintings – and in the paintings of his contemporaries. The detailed chemical and physical degradation processes in the paint film remain to be understood in order to provide a theoretical basis for future conservation of Krøyer's works and for defining recommendations for the climatic conditions in which the works should be kept in the future. ▢

Acknowledgements

The title of the article refers to A. Johansen and M.B. Jensen: *Harmony in blue, P.S. Krøyer's Poetic Paintings from the 1890s*, exhibition catalogue, Skagens Museum, Denmark 2001.

The title illustration is a detail of P.S. Krøyer: *Summer evening at Skagen*. 1892. Oil on canvas. 206 x 123 cm. Ny Carlsberg Glyptotek, inv. no. MIN 0905, dep. at Skagens Museum, dep. no. 2. Photo: Art Museums of Skagen.

The authors wish to thank Skagens Museum, The National Gallery of Denmark, The Hirschsprung Collection and the Art Conservation Centre for kindly allowing us access to paintings and conservation records. A special thanks to Miriam Watts for art historical assistance and to Mikkel Scharff and Jørgen Wadum for help and inspiration.

Notes

1.
The somewhat fragmented endeavor on the subject of Krøyer was summed up in the significant monographic volume *Peder Severin Krøyer* by Peter Michael Hornung in 2002.

2.
M.C. Christensen: *Analyse – maleri på lærred af P.S. Krøyer Sommeraften på Skagen Sønderstrand*, unpublished report, The Conservation Department, the National Museum of Denmark, Brede 2005.

3.
D. Rogala et al.: "Condition problems related to zinc oxide underlayers: Examination of selected abstract expressionists paintings from the collection of the Hirshhorn Museum and sculpture garden, Smithsonian Institution." *Journal of the American Institute for Conservation*, vol. 49, 2010, pp. 96-113; C.A. Maines, et al.: “Deterioration in Abstract Expressionist Paintings: Analysis of Zinc Oxide Paint Layers in Works from the Collection of the Hirshhorn Museum and Sculpture Garden”, *MRS Fall Meeting – Symposium WW – Materials Issues in Art and Archaeology IX*, Smithsonian Institution 2010, Cambridge University Press, published 2011; G. Osmond: "Zinc white: a review of zinc oxide pigment properties and implications for stability in oil-based paintings.", *AICCM Bulletin*, 33(1), 2012, pp. 20-29; E. Pratali: “Zinc oxide grounds in 19th and 20th century oil paintings and their role in picture degradation processes. Literary review, paint failure mechanisms and conditions of potential risk”, *CeROArt. Conservation, exposition, Restauration d'Objets d'Art*, CeROArt asbl. 2013.

4.
When conducting interdisciplinary investigations as these, it is slightly discouraging to realize that reflections over choice of medium and technique are seldom mentioned by Krøyer in his letters and diaries. Therefore an understanding of his technique must rely primarily on empirical investigations and analyses in combination with seeking out the more restricted recordings of his practical considerations regarding modes of execution as well as looking at contemporary painters’ techniques.

5.
S. Rehbein and M. Huisgen: „Modellversuche zu Grundierungstechniken der Leinwandgemälde im 19. Jahrhundert“, H. Althöfer, ed.: *Das 19. Jahrhundert und die Restaurierung: Beiträge zur Malerei, Maltechnik und Konservierung*, Callwey, Munich 1987.

6.
For an exact and comprehensive log of the whereabouts of Krøyer, see Jesper Svenningsen: “Chronology”, M. Saabye et al., eds., *Krøyer – an International Perspective*, The Hirschsprung Collection and Skagens Museum, 2012, pp. 328-333.

7.
Several quotes from Krøyer’s letters and travel diary in the catalogue *Krøyer – an International Perspective*’ show his admiration of the old masters from the renaissance and baroque period. This is also confirmed by Jan Gorm Madsen’s contribution to the catalogue, ”Out into the world” p. 16: “Apparently Krøyer was particularly interested in the old masters, whose names appear again and again on the pages of the travel diary.” And further: “But otherwise it was again names like Titian, Correggio, Giorgione, Ribera, Rubens, Rembrandt and Van Dyck that monopolized their attention.” (”Krøyer har tilsyneladende været mest optaget af de gamle mestre, hvis navne igen og igen dukker op i siderne i rejsedagbogen”; ”Men ellers var det atter navne som Tizian, Corregio, Giorgione,

Ribera, Rubens, Rembrandt og Van Dyck, der stjal opmærksomheden.”)

8.
T. Filtenborg and V. Petersen: *J.F. Willumsens maleteknik*, Willumsens Museum, Frederikssund 1992, p. 12.

9.
Contemporary painters and scholars abroad had pointed to the problem of lack of knowledge regarding painting materials and techniques. J.G. Vilbert’s *La Science de la Peinture* was written on the basis of teaching at the Ecole des Beaux Arts in Paris in the 1880s, and the British painter William Holman Hunt gave lectures on the topic in 1880 at the Royal Society of Arts in London. See T. Filtenborg: “J.F. Willumsens teknik”, in T. Filtenborg and V. Petersen 1992, p. 12.

10.
H. Kühn: *Zinc white, in Artists’ pigments – a handbook of their history and characteristics*, R.L. Feller, ed., National Gallery of Art, Cambridge 1986; D. Bomford et al.: *Art in the making: Impressionism*, National Gallery, London, Yale University Press 1990.

11.
The tendency to adopt the notion that a certain light and tonality exist exclusively in the Nordic countries still dominates the international approach of the past decades to the art of the Modern Breakthrough in this region (c. 1870-1910). See for example K. Varnedoe: *Northern Light: Realism and Symbolism in Scandinavian Painting, 1880-1910*, Brooklyn Museum 1982. Varnedoe’s publication was the forerunner for later years’ presentations of ideas of an exclusive Nordic light and sensitivity and melancholia that fascinated an international audience.

12.
See eg. J. Theilgaard: “Lyset over Skagen”, L.V. Ebbesen, ed.: *SKM 100*, Skagens Museum Jubilæumsskrift 2007, pp. 128-141.

13.
Krøyer, letter to Axel Prior, Civita d’Antino, 17.9.1890. PSK Archive 125,1, The Hirschsprung Collection: “But before I move in, there is something I would like to have done: I would like to have the studio whitewashed [underlined twice], instead of the rather grey colour it has now. The space is of course hardly in a condition for a ’regular’ repainting, but work I intend to do in the winter makes it essential that I have a white space, at least a white base for the studio. […] When I return home during the month of November the studio should be ready for me to arrange things anew [difficult to read] —that I furnish ’according to a brand new method.’” (”Men inden jeg flytter ind var der en Ting, jeg gjerne vilde have gjort: jeg vilde gjerne have Atelieret hvidtet [underlined twice], istedetfor den ganske graa Farve det nu har. Rummet er jo neppe i saadan Tilstand at det er modent til en ’regulær’ Overmaling, men Arbejder jeg tænker at foretage i Vinter gjør mig det magtpaaliggende at have et hvidt Rum, ialfald Atelieret hvidt i sin Grund-Tone. […] Naar jeg saa kommer hjem i løbet af November Maaned vil Atelieret kunne være parat til at ordne mig paanyt [difficult to read] – indrette mig ’efter ganske ny Methode.’”)

14.
Katrine Halkier also speculates that Marie Krøyer may have initiated the idea for a change of the studio upon their return from their honeymoon, as her interest in the international Arts and Crafts movement could have meant a predilection for an austere mode of furnishing as seen in contrast to the more heavy taste of the bourgeoisie of the time. See K. Halkier “The studio at Bredgade 33”, in M. Saabye et al., eds., 2012, p. 68.

15.

A shift in Krøyer’s palette in his late paintings has been put forward by Anette Johansen in “’As usual, Paris has had its effect.’ P.S. Krøyer and International Art of His Day”, in A. Johansen og M.B. Jensen, *Harmony in blue, P.S. Krøyer's Poetic Paintings from the 1890s*, exhibition catalogue, Skagens Museum, Denmark 2001, p. 63. However, Krøyer does not adapt the overall painterly brushwork towards complete disintegration of form that characterises impressionistic painting technique.

16.
P.M. Hornung: *Peder Severin Krøyer*, Forlaget Fogtdal 2002, pp. 238-239.

17.
C.K. Andersen, et al: "The industrialisation of canvas production in Denmark and its implications for the preservation of Danish nineteenth century paintings", M. Ryhl-Svendsen, K. Borchersen, W. Odder, eds., *Incredible industry – preserving the evidence of industrial society*, NKF-DK, Copenhagen 2009, pp. 39-49.

18.
11 of the 12 impregnations (mainly done in the 1980s and 1990s) involved the synthetic, solvent based adhesive Plexisol P 550 which was introduced in the 1980s by Arthur Ketnath: "Acrylhartser ved konservering af malerier på lærred under anvendelse af ’heat seal’ metoden", *Meddelelser om konservering*, 2(7-8) 1976, pp. 223-235. Five of 23 lined paintings were lined with glue-paste adhesive and one of 12 total impregnations involved sturgeon glue.

19.
For example: *Boys bathing at Skagen. Summer Evening*, 1899, The National Gallery of Denmark inv. no. KMS1658; *Summer evening on Skagen’s South Beach*, 1893, Skagens Museum, inv. no. 1288; *Summer evening at Skagen*, 1892, Ny Carlsberg Glyptotek, inv. no. MIN 0905, dep. at Skagens Museum, dep. no. 2; *Fishermen at Skagen Beach*, 1883, The National Gallery of Denmark, inv. no. KMS1233; *Summer evening on the Beach of Skagen, the painter and his wife*, 1899, The Hirschsprung Collection, inv. no. 234.

20.
X-ray fluorescence (XRF) measurements were made in situ using a Bruker Tracer III-V/III-V+ handheld XRF spectrometer. All of the spectra were recorded using an accelerating voltage of 40 kV for 30 seconds (live time).

21.
M.C. Christensen 2005.

22.
Cobalt blue, a mixture of cobalt and aluminum oxides, was developed by the French chemist Thenard early in the nineteenth century. This pigment was used by the French painters Corot (as early as 1835) and Daubigny (in the 1850s) of the Barbizon School. See Andreas Burmester and Claudia Denk: “Blue, Yellow and Green on the Barbizon Palette”, *Zeitschrift f. Kunsttechnologie und Konservierung*, Jhr. 13, 1999, heft 1. French impressionists such as Manet, Monet, Renoir and Sisley also used the pigment, see Nicholas Eastaugh et al.: *Pigment Compendium. A Dictionary of Historical Pigments*, Elsevier. Butterworth-Heinemann, Great Britain 2004.

23.
Andersen et al., 2009.

24.
K. Keune: *Binding medium, pigments and metal soaps characterised and localised in paint*

cross-sections, PhD thesis, University of Amsterdam 2005.

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